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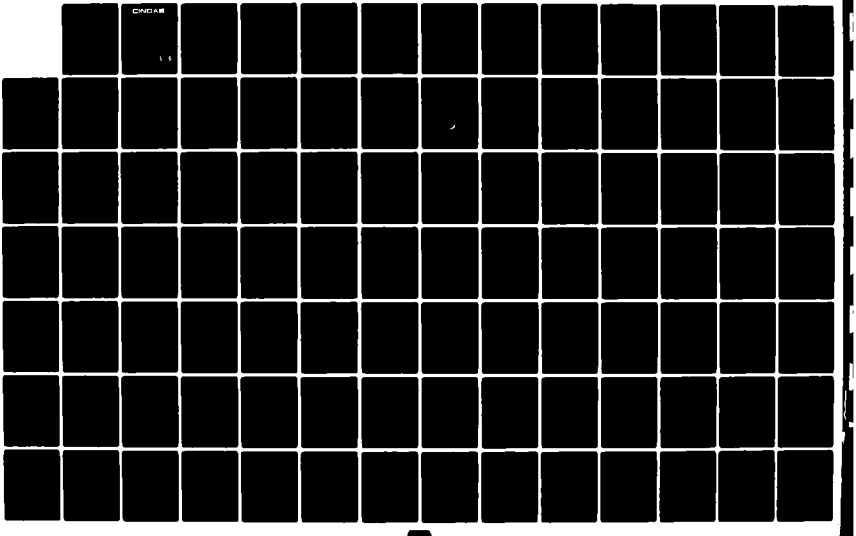

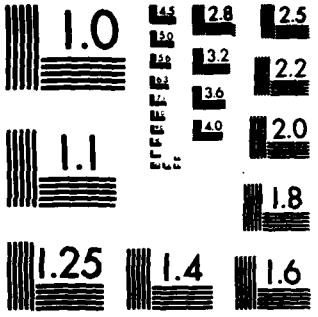

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REFRACTIVE INDEX OF ZnS, ZnSe, AND ZnTe AND ITS WAVELENGTH AND TEMPERATURE DERIVATIVES

By

H. H. Li

CINDAS REPORT 64

May 1982

Prepared for

OFFICE OF STANDARD REFERENCE DATA
National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20234

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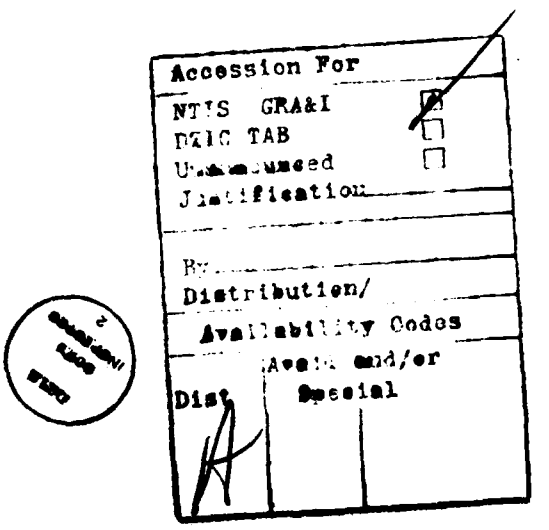

Key Words: refractive index, temperature coefficient of refractive index, optical constants, zinc sulfide, zinc selenide, zinc telluride.

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LIST OF SYMBOLS

a	Adjustable constant
A	Adjustable constant
b	Adjustable constant
B	Adjustable constant
C	Adjustable constant
E	Adjustable constant
E_g	Energy gap
F	A function of wavelength
k	Adjustable constant
n	Refractive index
n_a	Refractive index of ambient air
N	Oscillator strength
R	A function of wavelength
S	A function of wavelength
t	Temperature relative to 293 K
T	Absolute temperature

Greek Symbols

α	Linear thermal expansion coefficient
δ	Damping factor
ε	Complex dielectric constant, value of dielectric constant
ε_1	Real part of ε
ε_2	Imaginary part of ε
ε_0	Static dielectric constant
ε_∞	High-frequency dielectric constant
κ	Extinction coefficient; oscillator strength
λ	Wavelength of light
λ_I	Wavelength of the ith absorption band
Δ	Change in a quantity
ω	Frequency
Ω	Equals λ_i/λ

1. Introduction

The refractive index of a material is one of its fundamental and useful optical properties. Accurate knowledge of refractive index over a wide range of wavelength and temperature is indispensable for many applications. Although this property continues to receive attention for both its industrial as well as scientific applications, the current state of the available data for many widely used materials is less than adequate. While experimental results for the refractive index of these materials are reported by many investigators claiming high internal accuracy and agreement, the data as a whole in many cases are in disagreement.

In this study, an attempt is made to consolidate all of the published refractive index data for zinc chalcogenides and to critically evaluate the raw experimental data and techniques of measurements. A modified Sellmeier type dispersion relation is utilized to describe the available body of data. The resultant equations are used to generate the most probable values which agree with the selected experimental data to within estimated uncertainties based on reported experimental errors.

2. Theoretical Background on Refractive Dispersion in Solids

2.1. Refractive Index

For pure substances, the wavelength or frequency dependence of the optical constants may be described by the classical treatment of Lorentz. The theory assumes the solid to be composed of a series of independent oscillators, which are set into forced vibrations by the incident radiation. The Lorentz theory of absorption and dispersion for both insulating and semi-conducting materials is expressed by two familiar relations:

$$n^2 - \kappa^2 = 1 + \sum_i \frac{N_i \lambda_i^2 (1-\Omega^2)}{(1-\Omega^2)^2 + \delta_i^2 \Omega^2}, \qquad (1)$$

and

$$2n\kappa = \sum_i \frac{N_i \lambda_i^2 \delta_i \Omega}{(1-\Omega^2)^2 + \delta_i^2 \Omega^2}, \tag{2}$$

where n is the refractive index, κ the absorption index, N_i, λ_i, and δ_i, respectively, the parameter associated with the oscillator strength, the resonant wavelength, and the damping factor of the i-th oscillator, $\Omega = \lambda_i/\lambda$, and λ the wavelength of incident radiation. In the transparent wavelength region, eq (1) can be reduced to the well-known Sellmeier type equation by neglecting the absorption and the line width of the oscillators, thus leading to:

$$n^2 = 1 + \sum_i \frac{a_i \lambda^2}{\lambda^2 - \lambda_i^2} + \sum_j \frac{b_j \lambda^2}{\lambda^2 - \lambda_j^2}. \tag{3}$$

Terms in the first summation are contributions from the ultraviolet absorption bands and those in the second are from the infrared absorption bands. From eq (3), the optical and static dielectric constants, ε_∞ and ε_0, of the material under consideration are defined as:

$$\varepsilon_\infty = 1 + \sum_i a_i,$$

and (4)

$$\varepsilon_0 = 1 + \sum_i a_i + \sum_j b_j.$$

In an ideal application of eq (3), one would need to know the wavelengths of all of the absorption bands in the absorption regions. This is very difficult in practice because out of the large number of absorption bands only a few of them are accessible for experimental observation. It is also observed that among the absorption bands, only those located closest to the transparent region have noticeable effect on the refractive index in the transparent region. In order to simplify the calculations of the effect due to unobserved absorption bands and those other than the ones which affect most the refractive index in the transparent region, the following considerations are taken. Each term in the first summation from eq (3) is rewritten as:

$$\frac{a_i\lambda^2}{\lambda^2-\lambda_i^2} = a_i + \frac{a_i\lambda_i^2}{\lambda^2-\lambda_i^2} . \tag{5}$$

Since λ_i's are usually considerably smaller than λ's in the transparent region, a good approximation of the first summation is

$$\sum_i \frac{a_i\lambda^2}{\lambda^2-\lambda_i^2} = \sum_i a_i + \sum_i \frac{a_i\lambda^2}{\lambda^2-\lambda_i^2} = \sum_i a_i + \frac{a_u\lambda_u^2}{\lambda^2-\lambda_u^2} , \tag{6}$$

where a_u and λ_u are the effective quantities equivalent to the total contribution from all ultraviolet bands. The terms in the second summation from eq (3) account for the effects of the absorption bands beyond the long wavelength limit of the transparent region. It is generally observed that only a single term due to the transverse optical mode (TO mode) of fundamental phonon at wavelength λ_I is sufficient to account for the effects. Therefore, the contribution from second summation is simplified to

$$b_I + \frac{b_I\lambda_I^2}{\lambda^2-\lambda_I^2} , \tag{7}$$

with b_I and λ_I associated with the TO mode phonon. Since refractive index data for zinc chalcogenides are also available in the range beyond the reststrahlen region from 100 up to 600 μm, this TO mode phonon should serve as the absorption band in the short wavelength side of this wavelength region. It is, therefore, conceivable to expect that the refractive index data in both of these two spectral regions can be described by a single dispersion equation with some modification. In order to achieve such connection, the first thought was that the damping factor should be included in that term to avoid the singularity between these two regions. With this consideration, eq (7) should be replaced by the corresponding term in eq (1):

$$\frac{b_I(1-\Omega^2)}{(1-\Omega^2)^2 + \delta^2\Omega^2} , \tag{8}$$

where $\Omega = \lambda_I/\lambda$. However, the real data fitting calculations for zinc chalcogenides indicated negligibly small values for δ. Substituting eqs (6) and (7) into eq (3), we have the simplified dispersion equation at room temperature as:

$$n^2 = \varepsilon_0 + \frac{A}{\lambda^2-\lambda_u^2} + \frac{B}{\lambda^2/\lambda_I^2 - 1}, \tag{9}$$

where A and B are treated as adjustable constants and B is related to the dielectric constants by the condition:

$$\varepsilon_\infty = \varepsilon_0 - B. \tag{10}$$

The parameters ε_0, A, B, λ_u, and λ_I in eq (9) can be expressed in terms of temperature based on the considerations given below. There are four sorts of physical effects which influence the parameters in eq (9). One is the thermal expansion; the material becomes less dense as temperature increases. Were this the only mechanism operative, it would reduce the refractive index as temperature increased. The fact that the refractive index of zinc chalcogenides increases with temperature, implicates that other mechanisms are predominant. The second is the thermal occupancies of the energy levels of the material as a function of temperature; the total number of the i-th oscillator varies with temperature. It is apparent that the thermal occupancies increase with temperature as evidenced by the observed positive values of $\Delta n/\Delta T$. The third is the change of refractive index of ambient air. Since the refractive index of a material is actually measured relative to air, i.e., n/n_a, to determine the temperature variation of refractive index of the material it is necessary to take into account the corresponding change in the refractive index of the ambient air. In expression we have

$$\frac{d}{dT}\left(\frac{n}{n_a}\right) \simeq \frac{dn}{dT} - n\frac{dn_a}{dT}, \tag{11}$$

where dn_a/dT is about 0.11×10^{-5} which is usually masked by the uncertainties in the data. The fourth is the thermal shifts of characteristic absorption bands. For most materials, both λ_u and λ_I increase with temperature. Both of these shifts tend to increase refractive index in the transparent region. In the extreme limits where λ is close to either λ_u or λ_I, the refractive index at λ increases rapidly with temperature. It is experimentally observed that λ_u is approximately a linear function of temperature [1] over a wide temperature region so does the λ_I [82].

Since adequate expressions of thermal expansion and thermal occupancy of zinc chalcogenides as a function of temperature do not appear available and the

correction due to index change of ambient air is approximately a constant, it is therefore possible to treat each of the parameters in eq (9) as a polynomial function of temperature to account for the first three effects combined. Thus, the parameters in eq (9) are replaced by:

$$\begin{aligned} \varepsilon_0(t) = E(t) &= E_0 + E_1 t + E_2 t^2 + E_3 t^3 + E_4 t^4, \\ A(t) &= A_0 + A_1 t + A_2 t^2 + A_3 t^3 + A_4 t^4, \\ B(t) &= B_0 + B_1 t + B_2 t^2 + B_3 t^3 + B_4 t^4, \\ \lambda_u(t) &= \lambda_{u0} + \beta_u t, \\ \lambda_I(t) &= \lambda_{I0} + \beta_I t, \end{aligned} \tag{12}$$

where $t = T-293$ K, and E's, A's, B's, and β's are constants with E_0, A_0, B_0, λ_{u0}, and λ_{I0} determined at 293 K, i.e., $t = 0$. Only up to the fourth degree of t is retained in the above expressions as it was found that the inclusion of higher degrees or reducing to lower degrees did not yield adequate data fitting. With all these considerations, eq (9) can be expressed in a general form as:

$$n^2(\lambda,t) = E(t) + \frac{A(t)}{\lambda^2-\lambda_u^2} + \frac{B(t)}{\lambda^2/\lambda_I^2-1}, \tag{13}$$

which is reduced to eq (9) for T = 293 K or t = 0.

Equation (13) is a preferred empirical expression for the refractive index in terms of both temperature and wavelength as it offers advantages in identifying the physical meaning of various constants and in calculating the derived quantities. Among other things, the dielectric constants at room temperature can be obtained by a glance of values of E_0 and B_0. If sufficient amount of accurate data are available, the constants E's and B's thus determined can be used to calculate the dielectric constants at other temperatures. With the constants appropriately determined, dn/dT and $dn/d\lambda$ can easily be calculated by taking the first derivative of eq (13) with respect to T and λ. The choice of t, relative to 293 K, rather than the absolute temperature T is based on the fact that data on the refractive index and related physical properties at room temperature are either available or can be estimated with relative ease. It is, therefore, highly appropriate to choose room temperature as the starting point on which temperature variation of the

refractive index can be built with availability of adequate temperature dependent data.

2.2. Temperature Derivative of Refractive Index

Ramachandran [2] presented a semiempirical theory of thermo-optical effects in crystals, in which the dispersion was fitted to experimental data, employing a series of oscillator wavelengths and strengths as adjustable parameters. A relation was found between temperature shifts of various parameters and fundamental oscillator wavelengths as shown below:

$$2n \frac{dn}{dT} = C - 3\alpha(n^2-1) + \sum_i F(\lambda,\lambda_i) \left(\frac{1}{\lambda_i} \frac{d\lambda_i}{dT} \right), \tag{14}$$

where C is effectively a constant over a limited temperature range and $F(\lambda,\lambda_i) = 2k_i\lambda^4/(\lambda^2-\lambda_i^2)^2$ with k_i being a constant. However, the parameters chosen were rather numerous and often not unique; no general prescription was presented for determining their temperature variations which are necessary for the calculation of dn/dT. Harris et al. [3] proposed an empirical relation without theoretical justification for the dispersion of dn/dT. It relates the observed values of dn/dT to the wavelength, λ, and the wavelength corresponding to energy gap, λ_g, by the expression:

$$\frac{dn}{dT} = a R^b , \tag{15}$$

where a and b are constants and $R = \lambda^2/(\lambda^2-\lambda_g^2)$. This relation was later re-examined by Johnston [4] in light of some phenomenological calculations of Tsay et al. [5] in which the following equation was derived:

$$2n \frac{dn}{dT} = K^2 \left(-3\alpha R + \frac{2}{\lambda_g} \frac{d\lambda_g}{dT} R^2 \right) , \tag{16}$$

by neglecting the small contribution from lattice. For practical data interpolation, eq (16) was simplified by Johnston to

$$2n \frac{dn}{dT} = AR + BR^2 . \tag{17}$$

In comparison, one can notice that eq (14) and eq (17) can be arrived by differentiating the second term of eq (9) with respect to temperature. It should be pointed out that most of published works, including references [2-5],

treat dn/dT of semiconductors generally assuming that dn/dT data are nearly independent of temperature over a fairly wide range of temperature and that lattice contributions to dn/dT are negligible. No consideration was given to the effect of thermal occupancies. As a result, much of the reported dn/dT data remains nearly a constant over a temperature range of a few hundred degrees. In real situation, however, all these assumptions become inadequate as will be discussed in a later section in dealing with the available data.

Differentiating eq (13) with respect to temperature, we get:

$$2n\frac{dn}{dT} = A_0S_u + B_0S_I + E_1 + E_2p_2 + E_3p_3 + E_4p_4 + A_1(R_u+S_ut) + A_2(R_up_2+S_ut_2) + A_3(R_up_3+S_ut_3) + A_4(R_up_4+S_ut_4) + B_1(R_I+S_It) + B_2(R_Ip_2+S_It_2) + B_3(R_Ip_3+S_It_3) + B_4(R_Ip_4+S_It_4) \quad (18)$$

where $p_2 = 2t$, $p_3 = 3t^2$, $p_4 = 4t^3$, $t_2 = t^2$, $t_3 = t^3$, $t_4 = t^4$, $R_u = \frac{1}{\lambda^2-\lambda_u^2}$,

$$S_u = \frac{dR_u}{dT} = \frac{2\lambda_u\beta_u}{(\lambda^2-\lambda_u^2)^2},\ R_I = \frac{1}{\lambda^2/\lambda_I^2-1},\ S_I = \frac{dR_I}{dT} = \frac{2\lambda^2\beta_I}{\lambda_I^3(\lambda^2/\lambda_I^2-1)^2},$$

$\lambda_u = \lambda_{u0} + \beta_u t$, and $\lambda_I = \lambda_{I0} + \beta_I t$.

Either eq (13) or eq (18) can be used for linear regression to determine the constants E's, A's, and B's depending on the type and quality of available data; if reliable temperature-dependent dn/dT data are available, eq (18) should be used after the values of E_0, A_0, B_0, λ_{u0}, and λ_{I0} are determined at room temperature.

3. Presentation of Numerical Data

Reference values are generated here through critical evaluation, analysis, and synthesis of the available experimental data. The procedure involves critical evaluation of the validity and accuracy of the available data and information, resolution, and reconciliation of disagreements in cases of conflicting data, correlation of data in terms of various controlling parameters, curve fitting with theoretical or empirical equations, and

comparisons of experimental values with predictions. No attempt was made to analyze the data of thin films and those in the regions of strong absorption, because of the scantiness of reliable information. However, experimental data of thin films and in absorption regions are also presented along with those of the transparent region in the tables reporting experimental data for the purpose of comparison and completeness.

A number of figures and tables summarize the information and give data as a function of wavelength and temperature. The conventions used in this presentation, and specific comments concerning the interpretation and use of the data are given below. The subsections for each of the substances contain all available information and data for a given material and cover the following:

a. A text discussing the data, analysis, and recommendations,

b. A figure of experimental n values (wavelength and temperature dependence),

c. A figure of experimental $dn/dT = f(\lambda)$,

d. A figure of experimental $dn/dT = f(T)$,

e. A table of experimental data on $n = f(\lambda)$, given in Appendix,

f. A table of experimental data on $n = f(T)$, given in Appendix,

g. A table of experimental data on $dn/dT = f(\lambda)$ given in Appendix,

h. A table of experimental data on $dn/dT = f(T)$ given in Appendix,

i. Figures of recommended values of n, dn/dT, and $dn/d\lambda$,

j. Tables of recommended values of n, dn/dT, and $dn/d\lambda$.

Since a reader may be interested in a specific substance, it is felt highly desirable to include important information and discussion in each subsection even if it may be repetitions of some of the subject matter found in other subsections. In figures containing experimental data, selected data sets are labeled by appropriate legends corresponding to those in the corresponding tables of experimental data given in Appendix, where specifications for individual data sets are also included. This was done to make each subsection self-contained.

There are a number of experimental methods used for the determination of refractive index, among which the following are those commonly used:

Deviation method
Interference method
Transmission and Reflection method
Brewster angle method
Thickness determination method
Multilayer method

The methods listed above are arranged in the order of their inherent accuracy or popularity. The deviation method is the most popular means of determining the refractive indices, but the accuracy of the results depends on the conditions of the prism specimen. The highest precision that can be attained is a few units in the fifth decimal place. The interference technique can be used to obtain data significant to the fourth decimal place. Transmission and reflection method yields results significant to the second place, while the multilayer results are no better than the second place. For a comprehensive, yet concise, review of all these methods, the reader is referred to references [6] and [7].

Dispersion equations for each of the substances have been proposed from time to time in earlier studies. These available relations are collectively presented in a table to facilitate comparison. Refractive indices for most of selected data sets are reported to the fourth decimal place. However, detailed compositions and characterizations of the specimens were usually not clearly given. Since impurities in the sample and conditions of the surface are factors affecting the accuracy of the observed results, such highly precise data cannot be applied to a sample chosen at random. For this reason no attempt is made to recommend any particular set of data with the reported high accuracy, but to generate the most probable values for the pure samples. As a result, the estimated uncertainties in the recommended values on the refractive index are higher than those reported for the data obtained by high-precision measurements.

3.1. Zinc Sulfide, ZnS

There are 59 sets of experimental data available for the refractive index (wavelength dependence + temperature dependence) of zinc sulfide as tabulated in tables A-1 and A-2 and plotted in figures 1 and 2 where some of the data

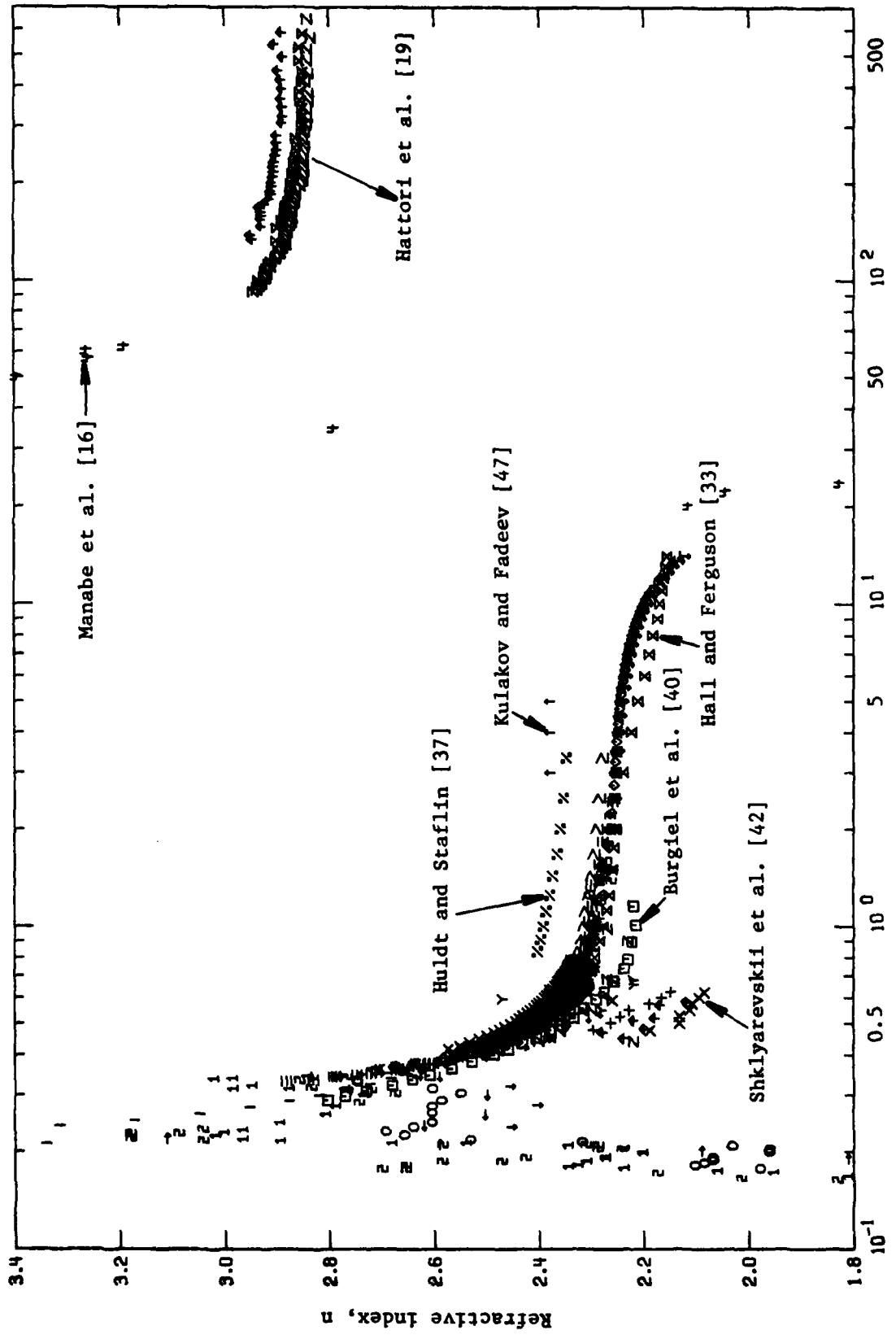

Figure 1. Available experimental refractive index of ZnS (wavelength dependence).

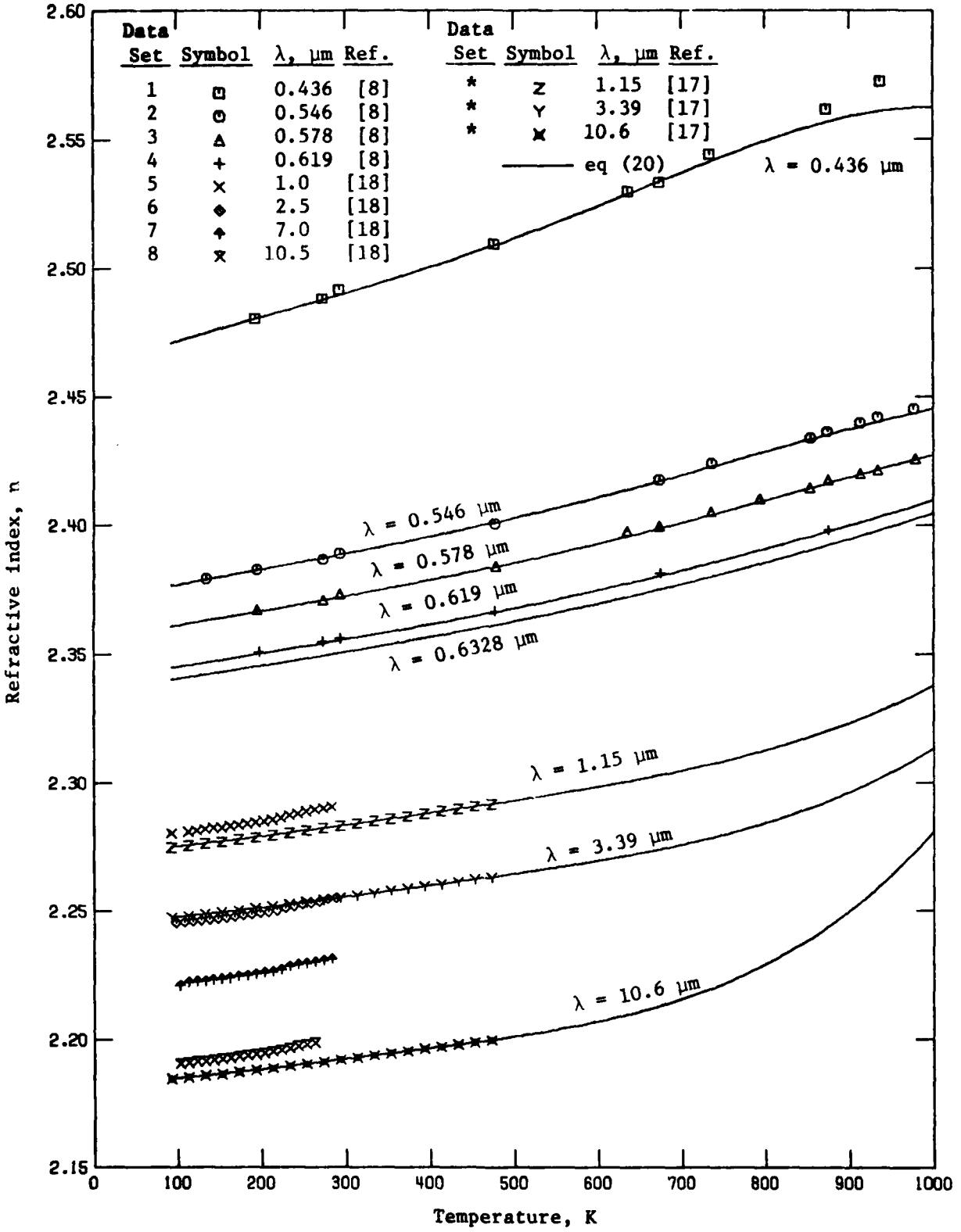

Figure 2. Experimental and calculated refractive index of ZnS (temperature dependence). Refer to table A-2 for the corresponding data sets. Data sets "*" are derived from dn/dT data given in table A-4.

sets are for thin films or multilayers included here for the purpose of comparison. After a careful review and evaluation of the available data and information, it was found that data sets reported by Mell [8], DeVore [9], Czyzak et al. [10-12], Bond [15], Manabe et al. [16], Feldman et al. [17], and Wolfe and Korniski [18] are representative for the available refractive index of zinc sulfide in the fundamental transparent region. Data sets reported by Hattori, et al. [19] are the only available material in the wavelength range from about 100 to 650 μm. Refractive index data of hexagonal ZnS crystals were measured by Bieniewski and Czyzak [14] and by Piper et al. [13].

Early measurements on the refractive index of ZnS over the visible spectrum covering a large temperature range were reported by Mell [8] for samples of natural crystal, a sphalerite with green hue. These data indicate that not only is the dispersion of ZnS very large, but also the refractive index varies appreciably with temperature. At room temperature, n changes from 2.5240 at wavelength 0.4162 μm to 2.3263 at 0.732 μm; while at wavelength 0.546 μm, n varies from 2.3867 at 273 K to 2.4452 at 977 K. Several prismatic specimens were used, and the results were consistent to the third decimal place. Mell also showed that the data at 273 K can be fitted by a Sellmeier type formula as given in table 1, and the data at several selected wavelengths were found to vary quadratically with temperature. Although the data were obtained several decades ago and were for natural crystal with evident impurity, they are quite compatible with the data obtained for samples purified and grown by the best techniques presently available. The differences between Mell's data and the recent data in the overlapped region are within two units in the third decimal place.

DeVore [9] measured refractive indices for a clear, water-white natural sphalerite crystal at room temperature over a wavelength region between 0.365 and 0.578 μm and at 1.5296 μm. The data points were fitted well to a dispersion equation (see table 1) similar to that of Mell. Numerically the data from these two sources are discrepant in the overlapped region by several units in the third decimal place which may be attributed to the impurities and experimental errors. Both of the dispersion equations of Mell and of DeVore suggest an effective ultraviolet absorption band at about 0.27 μm and did not account for the contribution from infrared absorption bands. It should be pointed out that in spite of the fact that DeVore's data are represented by a

Table 1. Comparison of dispersion equations proposed for ZnS

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Mell, M., 1923 [8]	0.4162-0.7320 μm 273 K	$n^2 = 3.0221 + \frac{2.0998\,\lambda^2}{\lambda^2 - (0.2532)^2}$
DeVore, J.R., 1951 [9]	0.3650-1.5296 μm 298 K	$n^2 = 5.164 + \frac{0.1208}{\lambda^2 - (0.27055)^2}$
Czyzak, S.J., Baker, W.M., Crane, R.C., and Howe, J.B., 1957 [10]	0.44-1.4 μm 298 K	$n^2 = 5.131 + \frac{0.1275}{\lambda^2 - (0.27055)^2}$
Czyzak, S.J., Payne, H., Crane, R.C., and Baker, W.M., 1957 [11]	0.365-4.0 μm 300 K	$n^2 = 5.0475 + \frac{0.2645}{\lambda^2} - \frac{0.0947}{\lambda^4} + \frac{0.0427}{\lambda^6} - \frac{0.0079}{\lambda^8} + \frac{0.0005}{\lambda^{10}}$
Manabe, A., Mitsuishi, A., Yoshinaga, H., 1967 [16]	19-62 μm 300 K	$n^2-k^2 = \varepsilon_\infty + \frac{N\,(1-\Omega^2)}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ $2nk = \frac{N\delta\Omega}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ for cubic structure: $\varepsilon_\infty = 5.7$, $\lambda_I = 35.46$, $\delta = 0.024$, and $N = 3.2$ for hexagonal structure: $\varepsilon_\infty = 5.7$, $\lambda_I = 36.496$, $\delta = 0.017$, and $N = 3.9$

Table 1. Comparison of dispersion equations proposed for ZnS--Continued

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Kodak publication U-72, 1971 [21]	1.0-13.0 μm 300 K	$n = 2.2569735 + \frac{3.2640935 \times 10^{-2}}{\lambda^2 - 0.028} + \frac{6.0314637 \times 10^{-4}}{(\lambda^2 - 0.028)^2} - 5.2705532 \times 10^{-4}\lambda^2 - 6.0428638 \times 10^{-7}\lambda^4$
Hattori, T., Homma, Y., Mitsuishi, A., and Tacke, M., 1973 [19]	134-584 μm at 300 K 132-578 μm at 80 K 92-641 μm at 2 K	$n^2 = \frac{\varepsilon_0 - \varepsilon_\infty \Omega^2}{1 - \Omega^2}$ at 300 K: $\varepsilon_0 = 8.34$, $\varepsilon_\infty = 4.7$, and $\lambda_I = 38.462$ μm; at 80 K: $\varepsilon_0 = 8.10$, $\varepsilon_\infty = 4.8$, and $\lambda_I = 38.168$ μm; at 2 K: $\varepsilon_0 = 8.04$, $\varepsilon_\infty = 4.9$, and $\lambda_I = 38.023$ μm.
Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]	0.55-10.60 μm 295 K	$n^2 = 1 + \sum_{i=1}^{3} \frac{A_i \lambda^2}{\lambda^2 - \lambda_i^2}$ for one sample at 294.6 K: $A_1 = 0.33904026$ $A_2 = 3.7606868$ $A_3 = 2.7312353$

Table 1. Comparison of dispersion equations proposed for ZnS--Continued

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Feldman, A., et al., 1978 [17], cont.		$\lambda_1 = 0.31423026$ $\lambda_2 = 0.17594174$ $\lambda_3 = 33.886560$ for second sample at 294.9 K: $A_1 = 0.24199447$ $A_2 = 3.8575584$ $A_3 = 2.5433609$ $\lambda_1 = 0.33005445$ $\lambda_2 = 0.17899635$ $\lambda_3 = 32.849275$
Present work, 1982	0.5-14.0 μm 93-1000 K	$n^2(\lambda,t) = E(t) + \frac{A(t)}{\lambda^2 - \lambda_u^2} + \frac{B(t)}{\lambda^2/\lambda_I^2 - 1}$ $t = T - 293$ See eq (20) in text for the expressions of λ_u, λ_I, E(t), A(t) and B(t).

simple equation, the predicted refractive indices at wavelengths near 1.5296 μm are not reliable. At that wavelength, the effect from infrared absorption bands is significant and is negative; a simple dispersion equation without taking into account the effect from infrared will predict a higher result as can be seen by comparing it with the data of Czyzak et al. and Feldman et al. at corresponding wavelength.

Bond [15] attempted precise measurement significant to the fourth decimal place on the refractive index of ZnS using minimum deviation method. Since the natural specimen from San Antander, Spain was impure as evidenced that the crystal was not transparent beyond 2.4 μm; and as a result, the values obtained were expected to be more uncertain than those of transparent specimens. However, his data were quite consistent in comparison with the data reported by Feldman et al., and the discrepancy in the overlapped wavelength region was within two units in the third decimal place.

Refractive index data of synthetic single cubic crystals of ZnS covering a spectral range from 0.365 to 4 μm at room temperature were found in references [10-12,20]. These data sets were measured basically by the same group of investigators but were reported at various periods. Spectroscopic analysis of the crystals showed a total analyzed impurity content of less than 0.0001%, indicating that the data obtained were supposedly to be representative for pure single cubic crystal but for unknown reasons the data showed large discrepancies. The data in the visible region were fitted to a Sellmeier type dispersion equation, and for the extended wavelength region the data were fitted to a polynomial equation of negative even powers of wavelength as shown in table 1. When compared with the data reported by Mell and by DeVore, the differences are in the third to second decimal place and show a large scattering. It is interesting to note that the dispersion equation for the visible region is very similar to that found by DeVore and both indicate an effective ultraviolet absorption band at 0.2755 μm.

Manabe et al. [16] studied optical constants in the reststrahlen region, 20 μm up to about 100 μm, by means of infrared lattice reflection spectra. Both synthetic cubic and hexagonal crystals were investigated and the spectra were analyzed using the Drude dispersion relation. Oscillator strength, N, optical dielectric constant, ε_∞, damping factor, δ, and wavelength of

transverse optical phonon, λ_I, in the Drude equations shown in table 1 were determined by a least-squares fit of reflectivity data. In the case of hexagonal crystal, the wavelength of TO mode phonon is the same for both polarization. The TO mode phonon wavelength was also obtained directly from transmission spectrum of an evaporated thin film and was found to be in good agreement with that obtained from the reflection spectra analysis. The static dielectric constant, ε_0, was determined by substituting $\lambda = \infty$ in the resulting Drude equation assuming zero absorption, i.e., $\varepsilon_0 = n^2 = \varepsilon_\infty + N\lambda_I^2$.

Refractive index of CVD ZnS was measured by Feldman et al. [17] as part of the effort in the characterization of high-power laser window materials. Two CVD ZnS samples were measured with high-precision minimum deviation method over a wide wavelength region, 0.55-10.6 μm, of laser interest. The room-temperature data were reported significant to the fifth decimal place and were fitted to a three-term Sellmeier type dispersion equation (shown in table 1). Since the parameters in their dispersion equation were not intended to have physical significance but a mathematical fit to the observed data, the parameter values determined for these two samples were considerably different though the difference in refractive indices at any wavelength was only about one unit or less in the fourth decimal place. In view of the reported average absolute residuals of n from the best fit equation of each data set, 5.4×10^{-5} and 4.6×10^{-5} respectively, the difference of one unit in the fourth decimal place should be regarded as experimental uncertainty and either of the two data sets closely represents the refractive index of CVD ZnS at room temperature.

Wolfe and Korniski [18] reported refractive index data for a sample of Irtran 2, a hot-pressed microcrystalline compact of ZnS, over a spectral region between 0.6328 and 14 μm at room temperature and at 84.9 K. The precision of the measurement is a few parts in the fourth decimal place, namely 2.86×10^{-4} rms deviation. Intercomparison with the data of Irtran 2 reported earlier by Eastman Kodak Co. [21], there are discrepancies of as much as 4.8×10^{-3} at the shorter wavelengths decreasing to 2.8×10^{-3} at the longer wavelengths; this is an order of magnitude larger than the experimental uncertainty. Such difference is likely to be attributed to difference in the samples. Comparison of the data sets of Irtran 2 and CVD ZnS is shown in figure 3 where the data of Irtran 2 disagree with those of CVD ZnS by amounts far more than experimental uncertainties.

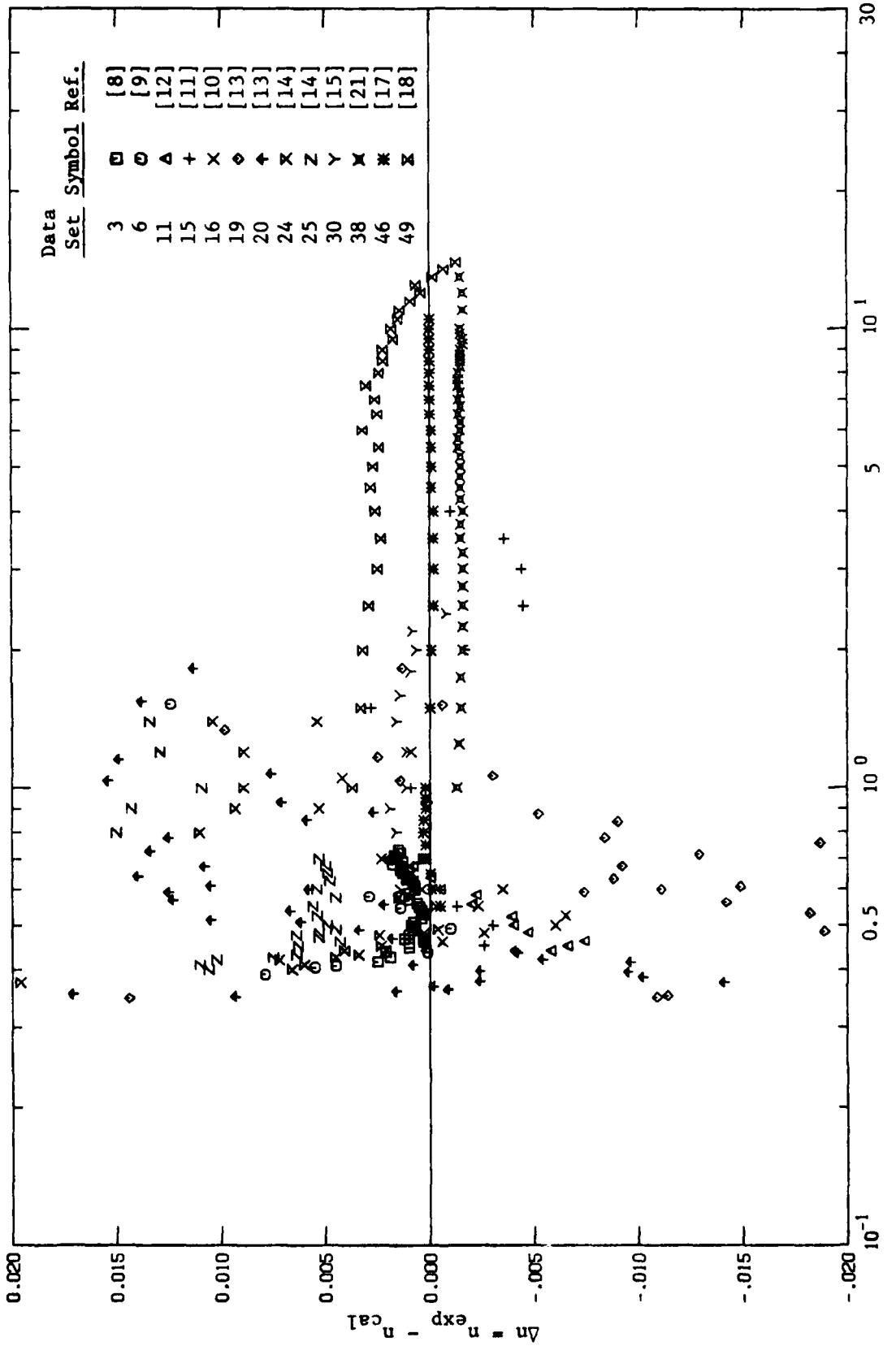

Figure 3. Comparison of experimental and calculated refractive index values of ZnS at room temperature. The calculated values from eq (19) are represented by the line $\Delta n = 0$. Refer to table A-1 for the corresponding data sets.

The indices of refraction of ZnS in the far infrared spectral range from 100 to 600 μm were measured by Hattori et al. [19] at temperatures 2, 80, and 300 K. The crystal used in the experiment was of mixed cubic and hexagon type. The obtained indices of refraction were described by a simple dispersion equation, shown in table 1, for an undamped harmonic oscillator from which the dielectric constants and wavelength of TO mode phonon were determined with least-squares fit. The static dielectric constant serves as a check for the values obtained from various optical methods. Since the n data were measured by interference method and the value of ε_0 was obtained in the long wavelength region, it is believed to be reliable and should be adopted as a known parameter in the dispersion equation of ZnS.

Data for hexagonal ZnS crystals were reported by Bieniewski and Czyzak [14] over a wavelength range from 0.36 to 1.4 μm and by Piper et al. [13] over a wavelength range from 0.33 to 1.8 μm. In both investigations, the birefringence of hexagonal crystals was found to be small, about 0.006, and was fairly constant throughout the wavelength region investigated. They stated that within experimental error the dispersion equation proposed by DeVore [9] or by Czyzak et al. [10] was valid for both cubic and hexagonal crystals.

For ease of comparison, the deviations of above mentioned data sets from the recommended values in the fundamental transparent region at room temperature are plotted in figure 3. It is obvious that the disagreement among the data sets reported by different investigators is greater than the accuracy claimed by each of them. Although internal consistency was observed in each investigation, unaccounted sources of errors are responsible for these discrepancies.

In the present work, eq (9) is used to represent the room-temperature refractive index of ZnS. The main task is the selection of the appropriate parameters ε_∞, ε_0, and λ_I, and the determination of the coefficients A, B, and the parameter λ_u. But the most important of all is the selection of reliable data sets used for input to fit eq (9). The selected data sets are limited to the works of Feldman et al. [17], Moll [8], and Hattori et al. [19]. The data of Feldman et al. cover a wide spectral region and it is believed to be measured with the highest accuracy for CVD ZnS which is likely to be exclusively used for quality optics in the future. The data of Moll cover more short wavelengths and wider temperature region than those of Feldman et al.

Moreover, the room temperature data in the overlapped region are consistent to within third decimal place with those of Feldman et al. The data set reported by Hattori [19] is used to substantiate the correctness of the static dielectric constant for the infrared term.

Literature values of ε_∞, ε_0, and λ_I are very discrepant as shown in table 2 where the room-temperature ε_∞ values vary from 4.7 to 5.7. For refractive index calculation accurate to the third or fourth decimal place, the variation of available ε_∞ is far less adequate than required. However, far better values of ε_∞ can be obtained from available dispersion equations covering visible region proposed by various investigators. From table 1, the ε_∞ values are: 5.1219 by Mell, 5.164 by DeVore, 5.131 and 5.0475 by Czyzak et al., and 5.0996 by Feldman et al. Clear enough, a value in the neighborhood of 5.1 must be the correct value of ε_∞.

The values of ε_0 from table 2 vary from 8.34 to 8.9 for cubic ZnS, not acceptable for refractive index calculation. Neither the available dispersion equations indicate an adequate value for ε_0 due to lack of data beyond 10.6 μm to provide adequate dispersion to substantiate the physical meaning of the parameters of the infrared term. However, it is fortunate that we have data in the 100 to 600 μm region reported by Hattori et al. [19]. Although the dispersion equation defined by this data set predicts a low value of ε_∞ for lack of dispersion in the data set, the value of ε_0 is in concordance with the square of refractive index at long wavelength end which in definition is close to the static dielectric constant. Since the refractive index values in this data set vary from 2.95 at 100 μm to 2.89 in the wavelength range from 300 to 600 μm, there is no question that the correct value of ε_0 must be about 2.89^2 or 8.35.

Among the values of λ_I in table 2, the values reported by Manabe et al. are chosen to be the appropriate parameter for eq (9) for the reason that one of the values was observed from transmission measurement for evaporated thin film which is a direct and positive means of determining λ_I. Additional supporting evidence is that the similar result was observed by Mathieu and Mathieu [22] from Raman measurement. A correct value of λ_I must be within the range from 35.46 to 36.76 μm.

Table 2. Available data on ε_∞, ε_0, and λ_I of ZnS

Temp., K	ε_∞	ε_0	λ_I, μm	Ref.	Remarks
300	5.7	8.9	35.46,36.76	[16]	cubic
300	5.7	9.6	36.50	[16]	hexagonal
300		8.37		[24]	
300	5.13			[25]	
300			36.90	[26]	
300	4.7	8.34	38.46	[19]	
300			32.26	[27]	cubic
300			33.33	[27]	hexagonal
300		8.7		[28]	
80	4.8	8.10	38.17	[19]	
80		8.14		[24]	
2	4.9	8.04	38.02	[19]	

Cardona and Harbeke [23] investigated band structure of cubic and hexagonal ZnS crystals in the spectral region below 0.41 μm. It was observed that a striking similarity in the spectra of optical constants of cubic and hexagonal ZnS crystals, indicating a small difference in the arrangement of the atoms in the two modifications. Although only small differences are observed in refractive and absorption indices for the crystals, there are some differences in the fine structure in the absorption spectra. In all cases a weak absorption peak is located at about 0.33 μm and a strong absorption peak at about 0.23 μm followed by a number of strong peaks at lower wavelengths. This finding renders a support to the dispersion equations found earlier by others where the effective absorption band is about 0.27 μm; and the values of λ_u in eq (9) should be approximately in the range from 0.23 to 0.27 μm but closer to 0.23 μm to account for the effect from infrared term. This latter statement is supported by the findings of Hall [34] and Cox et al. [36] from their investigations of vacuum deposited film in which they found that refractive index curve has its maximum at about 0.23 μm.

With all the essential parameters, discussed above, at hand the selected data are fitted to eq (9) for the determination of the constants A and B by letting the parameters vary within their corresponding estimated limits. The dispersion equation for ZnS at room temperature thus obtained is

$$n^2 = 8.34096 + \frac{0.14540}{\lambda^2 - (0.23979)^2} + \frac{3.23924}{\lambda^2/36.525^2 - 1}, \qquad (19)$$

where λ is in units of μm. Equation (19) is valid in the wavelength range from 0.5 to 14 μm. In figure 3, deviations of available room temperature data from those calculated from eq (19) are plotted for visual comparison. It is clearly shown that most of the data in the short wavelength region are scattered over a wide range as expected with the exception of the data of Mell [8] and of Bond [15] which show consistent deviation of less than 0.0016 and have the same dispersion as that of eq (19). In the long wavelength region, the data of Irtran 2 from Kodak publication U-72 [21] indicate a constant deviation of about −0.0015 throughout the wavelength range from 1 to 13 μm but the data for the same material reported by Wolfe and Korniski [18] show a constant deviation of about +0.0025 in the region below 10 μm and a high dispersion in the region between 10 and 14 μm. While the deviation of data of Mell and of Bond can be attributed to the experimental error and impurity contents of the samples, the

opposite deviations of data for Irtran 2 samples cannot be accounted for from experimental origin. As Wolfe and Korniski pointed out that it is likely caused by the differences in the material from different batch.

The constant deviation of the data sets mentioned above renders a support to the validity of eq (19) as far as the dispersion of ZnS is concerned. Regarding the values of refractive index at room temperature, eq (19) can be used for CVD ZnS from 0.6 to 11 μm with uncertainty about ± 0.0003 or less; outside this region larger uncertainties of the order ± 0.0005 are expected from 0.5 to 0.6 μm and ± 0.001 between 11 and 14 μm. Equation (19) can also be used for cubic single crystal of ZnS in the visible region up to 1 μm with uncertainties ± 0.002 based on the fact that data measured by Mell and by Bond are consistent with the calculated values within the cited uncertainty. Refractive indices of Irtran 2 can be very different for different samples as discussed above. As a consequence, eq (19) does not give the exact values of refractive indices but with a constant shift of the order of two units in the third decimal place in the region below 10 μm.

No attempt was made to analyze the available data for thin films since their refractive property is affected by many factors which do not permit adequate characterization. As a result, statements made by different investigators are often conflicting and inconsistent. The pressure and type of residue gas during deposition, the temperature the substrate maintained during deposition, the rate of deposition, the thickness of the film, the heat treatment after deposition, and aging are equally important contributors. In general, the refractive index data of a film deposited in a good vacuum tend to be lower than that of the bulk because the observed data are actually the effective index for the combination of ZnS plus possible voids which can easily be observed under an electron microscope. On the other hand, high refractive index is obtained for the films which are oxidized during deposition or aging by the undesirable residual gas or physical environment. However, it has been observed that the refractive index of thin film tends to agree with the bulk if the films are deposited under high vacuum on substrates maintained at elevated temperatures during deposition and followed by appropriate annealing. Figure 4 shows the deviations of experimental film data from the bulk data calculated from eq (19). Although there is a disagreement in the refractive index values, most of the available film data generally follow a normal dispersion curve. It

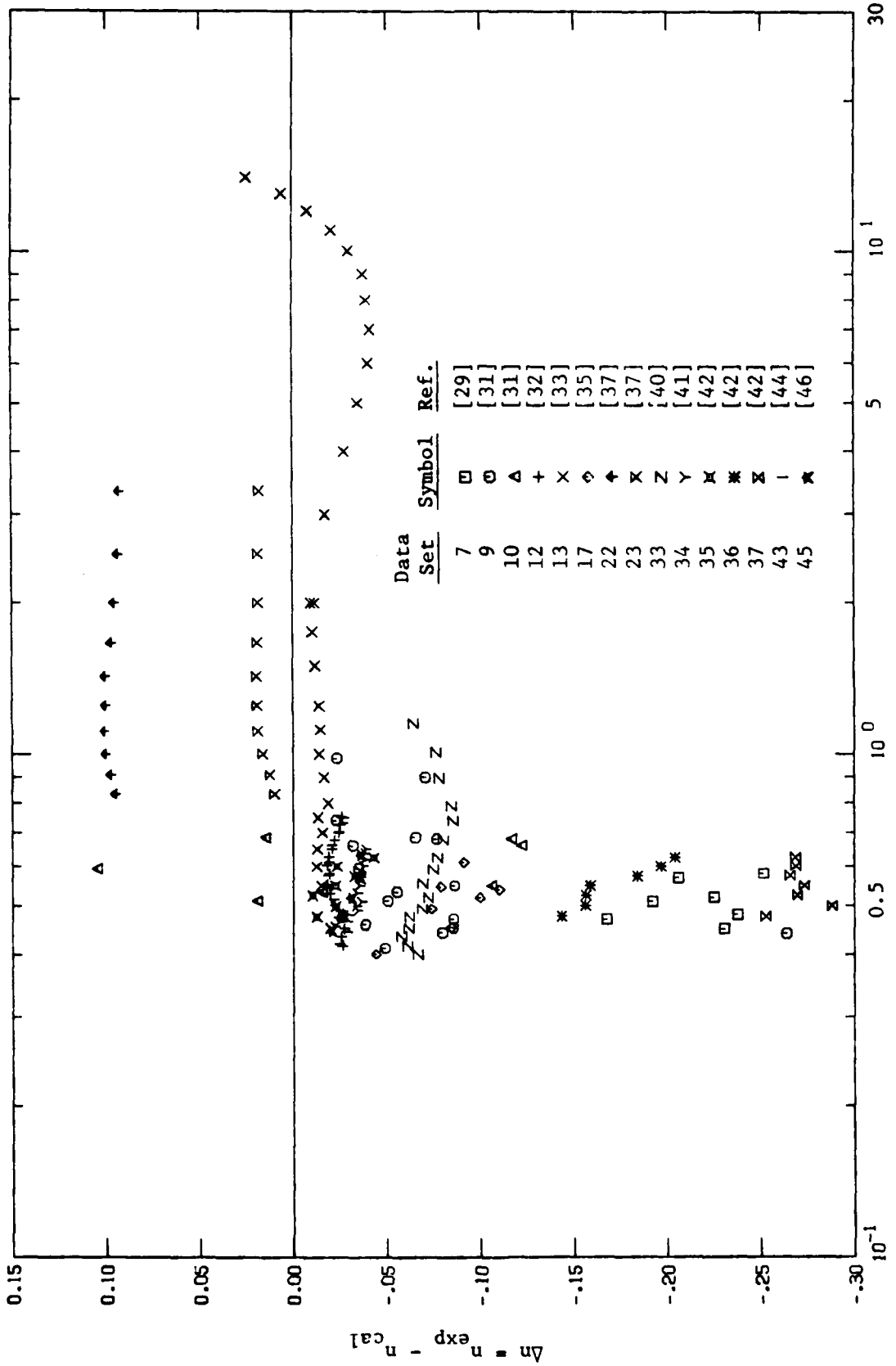

Figure 4. Comparison of experimental refractive indices of ZnS films and calculated values for bulk ZnS from eq (19). The calculated values are represented by the line $\Delta n = 0$. Refer to table A-1 for the corresponding data sets.

can be safely said that a properly prepared film sample should have the same dispersion as that of a bulk sample though different in refractive index values. In other words, the deviation should be nearly a constant as evidently indicated in figure 4.

Equation (19) is also valid in the wavelength region 133-585 μm. The averaged differences between the experimental data and the calculated values are of the order of ± 0.006. The dispersion in this region is rather small as the difference of two extreme refractive indices is only 0.055 but the uncertainty in the data is rather large (of the order ± 0.005) as the data were digitized from a graph of low resolution. Under such condition, the reliability of the digitized values is compatible with the calculated ones. Therefore, no recommended values in this region are given and the readers are referred to the corresponding digitized data in table A-1 for their application.

Literature data on the temperature-dependent refractive index is very scanty. Data reported in table A-2 and plotted in figure 2 are those of Mell [8] and Wolfe and Korniski [18]. Additional data sets plotted in figure 2 were derived from the dn/dT data reported by Feldman et al. [17] (see tables A-3 and A-4 and figures 5 and 6). Although the data sets by Mell cover a wide temperature range from 135 up to 979 K, they cover only the visible wavelengths. These data in the short wavelength region below 0.5 μm are not reliable for pure single crystal as it contains impurities evidenced by the greenish color of the sample. At high temperatures, the uncertainties are expected to be increased as the effects of impurities are increased.

The data reported by Wolfe and Korniski cover a temperature range from 84.9 to 295.9 K and a wavelength range from 1 to 14 μm in an effort to determine the dn/dT values. Since the claimed precision of their measurement is about $\pm 3 \times 10^{-4}$ in the refractive index while the dn/dT value is in the order of $\pm 5 \times 10^{-5} K^{-1}$, each dn/dT value thus determined at temperature intervals of 10 degrees has a large error of about $\pm 4 \times 10^{-5} K^{-1}$ associated with it. As a result, the large error masked the detail variation of dn/dT with temperature and wavelength; only average values could be obtained. For the wavelengths 1.0, 2.5, 7.0, and 10.5 μm, the average dn/dT values vary linearly with temperature from $3.5 \times 10^{-5} K^{-1}$ at 100 K to $7.6 \times 10^{-5} K^{-1}$ at 280 K. Lacking in wavelength variation, these data are not suitable for data analysis but provide a rough comparison.

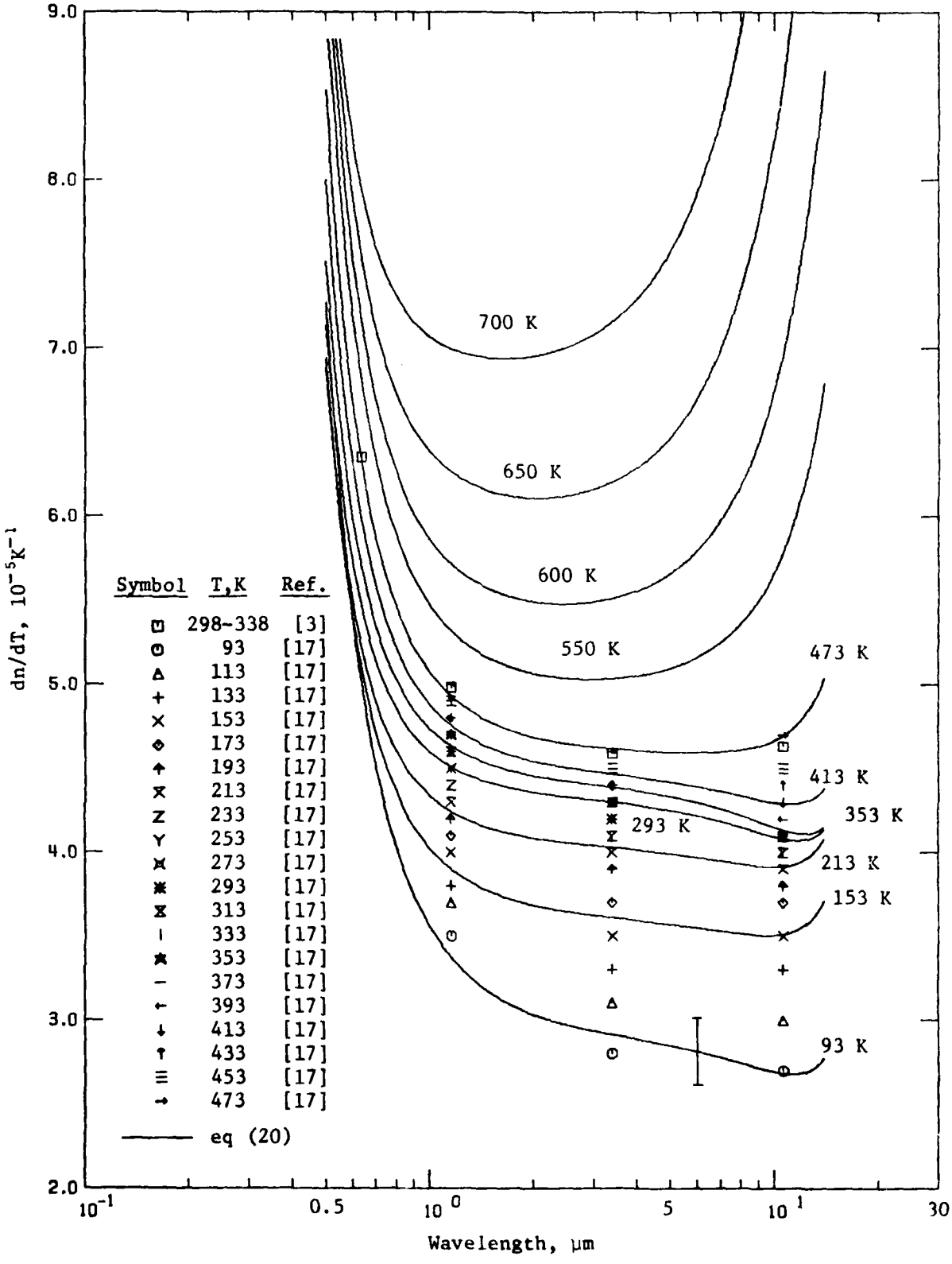

Figure 5. Experimental and calculated dn/dT of ZnS (wavelength dependence). Refer to table A-3 for the corresponding data sets.

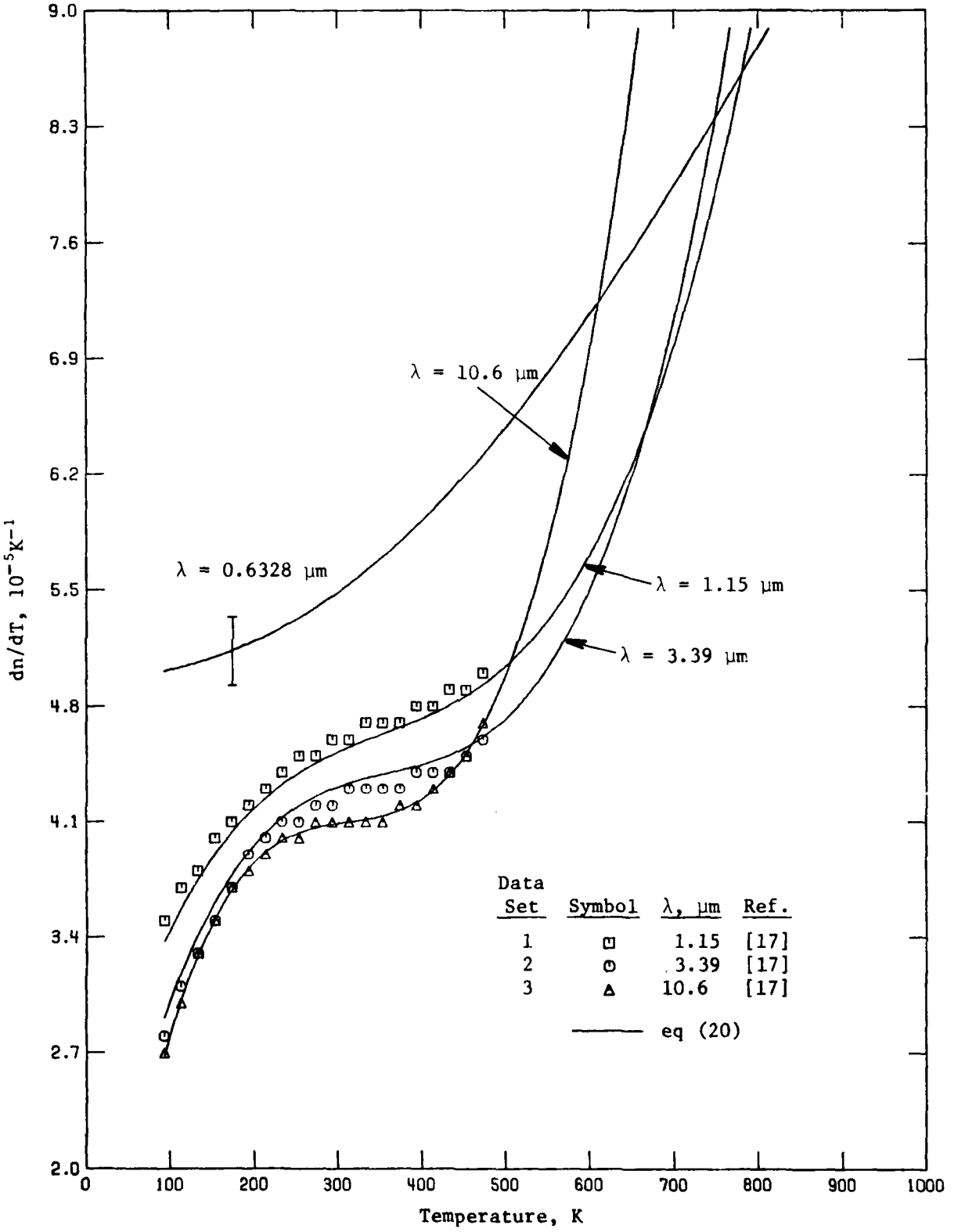

Figure 6. Experimental and calculated dn/dT of ZnS (temperature dependence). Refer to table A-4 for the corresponding data sets.

Although Feldman et al. reported only room temperature refractive index, their dn/dT data are quite adequate to calculate the refractive index values at other temperatures from 93 to 473 K. The dn/dT data were measured by an interferometric technique at three discrete laser wavelengths: 1.15, 3.39, and 10.6 μm. The shift of Fizeau interference fringes as a function of temperature, starting from room temperature, was observed and the corresponding dn/dT value was determined with appropriate corrections for thermal expansion of the sample and for the temperature variation of refractive index of the ambient air. This method is by far the most accurate means in the determination of dn/dT, and hence used as the basis of our data analysis. It appears that eq (18) should be used in the determination of the constants. However, there are problems which have to be clarified and solved before a least square fit of data can be performed.

The first problem is the temperature variation of the parameters λ_u and λ_I in eqs (13) or (18). In the study of fundamental optical absorption edge of synthetic crystal of hexagonal zinc sulfide, Piper [1] found that the decreasing shift of band gap is approximately linearly proportional to temperature over a wide temperature range. In terms of wavelength shift, the corresponding proportional constant is 0.4841×10^{-4} μm K^{-1}. This value is adopted for the parameter β_u in eq (13) in view of that λ_u, though it does not exactly correspond to band gap, is the effective absorption band and that the quoted shift is small enough not to introduce sensitive effect on the refractive index as a whole. We have, therefore, $\lambda_u = \lambda_{u0} + \beta_u t = 0.23979 + 0.484 \times 10^{-4} t$, where λ_{u0} is determined at room temperature as indicated in eq (19). Experimental value on the temperature shift of λ_I does not appear to be available for ZnS but that for ZnSe and ZnTe were measured by LaCombe and Irwin [82]. Based on the fact that such shift for the compounds of the same family does not vary appreciably among the member compounds [5], the experimental value of ZnSe, $1/\lambda_I \, d\lambda_I/dT = 1.3 \times 10^{-4} K^{-1}$, is adopted for ZnS. From that, the corresponding value of β_I, i.e., $d\lambda_I/dT$, for ZnS is 0.00475 μm K^{-1} using $\lambda_{I0} = 36.525$ determined at room temperature and the parameter λ_I is, therefore, expressed as $\lambda_I = 36.525 + 0.00475\ t$.

The second problem is that the data of Feldman et al. is available only up to 473 K and only at three wavelengths all in the infrared. The constants determined based on these data may not be valid in the visible region and/or at

higher temperatures. To check the validity of the results, data reported by Mell must be in agreement with the predicted ones. As pointed out earlier, the former are expected to have larger uncertainties at short wavelengths, <0.50 μm, and at high temperatures, >400 K.

The third problem is the variation of dn/dT data with temperature. A careful review of figure 6, one notices that of all the three available data sets, the dn/dT values increase monotonically with temperature in the temperature region 93-300 K and remain essentially as a constant thereafter up to 400 K. After that the dn/dT appears to increase with increasing temperature but there is no experimental data at higher temperatures to ensure such behavior at higher temperatures. The evidence that supports the continuous increase of dn/dT versus temperature for ZnS at high temperatures is that in the case of ZnSe Feldman et al. observed the exact behavior and Mangir and Hellwarth [64] observed that within the experimental uncertainty, $\pm 0.2 \times 10^{-5} K^{-1}$, there is no variation of $\Delta n/\Delta T$ values in the temperature range from 293 to 473 K but at higher temperatures up to 600 K a small constant increase at a rate of 0.5×10^{-5} per 100 K was observed at all wavelengths. Additional evidence was found in the n versus T data by Mell; at wavelengths 0.578 and 0.619 μm the $\Delta n/\Delta T$ values are found to be increasing with temperature at a rate of about $0.4\text{-}0.6 \times 10^{-5}$ per 100 K in the temperature range from 477 to 979 K. All of the evidence suggest that the dn/dT of ZnS is continuously increasing with temperature in the temperature range above 475 K.

With all these considerations, a least-squares fit of dn/dT data to eq (18) yielded the following expression for the refractive index of ZnS as a function of both wavelength and temperature:

$$n^2(\lambda,t) = E(t) + \frac{A(t)}{\lambda^2-\lambda_u^2} + \frac{B(t)}{\lambda^2/\lambda_I^2-1}, \qquad (20)$$

where λ is in units of μm,

t = T-293 in units of °K,

λ_u = 0.23979 + 0.00004841 t in units of μm,

λ_I = 36.525 + 0.00475 t in units of μm,

$E(t) = 8.34096 + 1.29107 \times 10^{-3} t + 4.68388 \times 10^{-7} t^2 - 1.31683 \times 10^{-9} t^3 - 6.64356 \times 10^{-12} t^4$,

$A(t) = 0.14540 + 1.13319 \times 10^{-5} t + 1.05932 \times 10^{-8} t^2 + 1.06004 \times 10^{-10} t^3 - 2.27671 \times 10^{-13} t^4$,

$$B(t) = 3.23924 + 1.09600 \times 10^{-3}t + 4.20092 \times 10^{-7}t^2 - 1.11350 \times 10^{-9}t^3 - 7.29592 \times 10^{-12}t^4.$$

Equation (20) was used to generate the recommended values of the refractive index of CVD ZnS and single crystal ZnS with the results given in tables 3 and 4 and plotted in figures 7 and 8. To provide visual comparison of calculated values with the experimental data, calculated values at a few specified temperatures and wavelengths are plotted in figures 2 and 7 where excellent agreement is observed. Table 5 gives the calculated dn/dT values for CVD ZnS based on the first derivative of eq (20) with respect to T with the corresponding curves shown in figure 9. The calculated room temperature $dn/d\lambda$ values for CVD ZnS based on the first derivative of eq (20) with respect to λ at 293 K are given in table 6 and shown in figure 10.

For CVD ZnS, eq (20) is valid over a wavelength range from 0.5 to 14 μm and a temperature range from 93 up to 618 K based entirely on the available data and supporting evidence discussed earlier and an appropriate extrapolation from 600 to 618 K. Extrapolation beyond 618 K is not recommended as the temperature dependent terms are determined by empirical fit of limited available data without real physical meaning. Although outstanding agreement between Mell's data and the prediction values at high temperatures is observed (figures 2 and 7) encouraging extrapolation, it is the predicted high rate of increase of dn/dT at high temperatures for infrared wavelengths (see figure 6) that discourages the extrapolation as it may lead to erroneous results unless there is sufficient supporting evidence in the high temperature region to ensure such extrapolation. For single crystal ZnS, eq (20) is valid over a wavelength region between 0.5 to 1 μm but over a wider temperature range from 93 to 1000 K. The valid wavelengths are limited in that narrow region because of the fact that refractive index of single crystal is mostly available only in the visible region and is obtained for the natural crystal from which data at wavelengths <0.5 μm are not reliable.

Uncertainties of the recommended refractive index are estimated based on the standard deviations of data fit calculations when reliable data are available and/or by comparing the available data with predicted values when experimental data in that region are either scanty or having large errors. For CVD ZnS in the recommended temperature region, the estimated uncertainties are $\pm$0.0003 for wavelength region between 0.6 and 11 μm, $\pm$0.0005 between 0.5 to 0.6

Table 3. Recommended values on the refractive index of CVD ZnS

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
0.50	2.4061	2.4096	2.4131	2.4165	2.4200	2.4236	2.4275	2.4315	2.4357	2.4402	2.4449	2.4473
0.55	2.3742	2.3773	2.3802	2.3832	2.3863	2.3895	2.3928	2.3963	2.3999	2.4038	2.4078	2.4099
0.60	2.3516	2.3543	2.3570	2.3597	2.3625	2.3654	2.3684	2.3716	2.3749	2.3784	2.3820	2.3839
0.65	2.3348	2.3373	2.3398	2.3424	2.3450	2.3477	2.3506	2.3535	2.3566	2.3598	2.3632	2.3650
0.70	2.3220	2.3243	2.3267	2.3292	2.3317	2.3343	2.3370	2.3398	2.3427	2.3457	2.3490	2.3507
0.75	2.3120	2.3142	2.3165	2.3188	2.3213	2.3238	2.3264	2.3291	2.3319	2.3348	2.3379	2.3395
0.80	2.3040	2.3061	2.3083	2.3106	2.3130	2.3154	2.3180	2.3206	2.3233	2.3261	2.3291	2.3307
0.85	2.2974	2.2994	2.3016	2.3039	2.3062	2.3086	2.3111	2.3137	2.3163	2.3191	2.3220	2.3236
0.90	2.2920	2.2940	2.2961	2.2983	2.3006	2.3030	2.3055	2.3080	2.3106	2.3133	2.3162	2.3177
0.95	2.2875	2.2894	2.2915	2.2937	2.2960	2.2983	2.3008	2.3032	2.3058	2.3085	2.3113	2.3128
1.0	2.2837	2.2856	2.2876	2.2898	2.2921	2.2944	2.2968	2.2992	2.3018	2.3044	2.3072	2.3087
1.5	2.2642	2.2659	2.2679	2.2700	2.2721	2.2744	2.2766	2.2789	2.2813	2.2838	2.2865	2.2879
2.0	2.2569	2.2586	2.2605	2.2626	2.2647	2.2669	2.2691	2.2714	2.2738	2.2762	2.2788	2.2802
2.5	2.2528	2.2545	2.2563	2.2584	2.2605	2.2627	2.2649	2.2672	2.2695	2.2719	2.2745	2.2759
3.0	2.2498	2.2514	2.2533	2.2553	2.2574	2.2596	2.2618	2.2641	2.2664	2.2688	2.2714	2.2728
3.5	2.2471	2.2487	2.2505	2.2526	2.2547	2.2569	2.2591	2.2613	2.2636	2.2660	2.2686	2.2700
4.0	2.2444	2.2460	2.2479	2.2499	2.2520	2.2542	2.2564	2.2586	2.2609	2.2633	2.2659	2.2673
4.5	2.2417	2.2433	2.2451	2.2471	2.2492	2.2514	2.2536	2.2558	2.2581	2.2605	2.2631	2.2645
5.0	2.2387	2.2403	2.2422	2.2442	2.2463	2.2484	2.2506	2.2528	2.2551	2.2575	2.2602	2.2616
5.5	2.2356	2.2371	2.2390	2.2410	2.2431	2.2452	2.2474	2.2496	2.2519	2.2543	2.2570	2.2584
6.0	2.2321	2.2337	2.2355	2.2375	2.2396	2.2418	2.2439	2.2461	2.2484	2.2508	2.2535	2.2550
6.5	2.2284	2.2300	2.2318	2.2338	2.2359	2.2380	2.2402	2.2424	2.2446	2.2471	2.2498	2.2513
7.0	2.2244	2.2260	2.2278	2.2298	2.2319	2.2340	2.2361	2.2383	2.2406	2.2431	2.2458	2.2473
7.5	2.2201	2.2216	2.2235	2.2254	2.2275	2.2296	2.2317	2.2339	2.2362	2.2387	2.2415	2.2430
8.0	2.2154	2.2169	2.2188	2.2207	2.2228	2.2249	2.2270	2.2292	2.2315	2.2340	2.2368	2.2384
8.5	2.2103	2.2119	2.2137	2.2157	2.2177	2.2198	2.2219	2.2241	2.2264	2.2289	2.2318	2.2334
9.0	2.2049	2.2064	2.2083	2.2102	2.2123	2.2143	2.2164	2.2186	2.2209	2.2235	2.2264	2.2280
9.5	2.1991	2.2006	2.2024	2.2044	2.2064	2.2085	2.2106	2.2127	2.2151	2.2176	2.2206	2.2223
10.0	2.1928	2.1944	2.1962	2.1981	2.2002	2.2022	2.2043	2.2065	2.2088	2.2114	2.2144	2.2161
10.5	2.1861	2.1876	2.1895	2.1914	2.1935	2.1955	2.1976	2.1997	2.2021	2.2047	2.2078	2.2095
11.0	2.1789	2.1805	2.1823	2.1843	2.1863	2.1883	2.1904	2.1926	2.1949	2.1976	2.2007	2.2025
11.5	2.1713	2.1728	2.1746	2.1766	2.1786	2.1807	2.1827	2.1849	2.1872	2.1899	2.1932	2.1950

Table 3. Recommended values on the refractive index of CVD ZnS--Continued

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
12.0	2.1630	2.1646	2.1664	2.1684	2.1704	2.1725	2.1745	2.1767	2.1791	2.1818	2.1851	2.1871
12.5	2.1543	2.1558	2.1577	2.1597	2.1617	2.1637	2.1658	2.1680	2.1704	2.1732	2.1766	2.1786
13.0	2.1449	2.1465	2.1483	2.1503	2.1524	2.1544	2.1565	2.1587	2.1611	2.1639	2.1674	2.1695
13.5	2.1349	2.1365	2.1383	2.1404	2.1424	2.1445	2.1466	2.1488	2.1512	2.1541	2.1577	2.1599
14.0	2.1242	2.1258	2.1277	2.1297	2.1318	2.1339	2.1360	2.1382	2.1407	2.1436	2.1474	2.1496

Table 4. Recommended values on the refractive index of single crystal ZnS

λ, μm	Temperature, K									
	93	193	293	393	493	593	693	793	893	993
0.50	2.406	2.413	2.420	2.427	2.436	2.445	2.455	2.464	2.473	2.480
0.52	2.392	2.398	2.405	2.412	2.420	2.428	2.437	2.447	2.456	2.463
0.54	2.380	2.386	2.392	2.399	2.406	2.414	2.423	2.432	2.441	2.449
0.56	2.369	2.375	2.381	2.387	2.394	2.402	2.410	2.419	2.428	2.436
0.58	2.360	2.365	2.371	2.377	2.384	2.391	2.399	2.408	2.417	2.426
0.60	2.352	2.357	2.363	2.368	2.375	2.382	2.390	2.398	2.407	2.417
0.62	2.344	2.350	2.355	2.361	2.367	2.374	2.381	2.390	2.399	2.409
0.64	2.338	2.343	2.348	2.354	2.360	2.367	2.374	2.382	2.391	2.402
0.66	2.332	2.337	2.342	2.348	2.353	2.360	2.367	2.376	2.385	2.395
0.68	2.327	2.332	2.337	2.342	2.348	2.354	2.361	2.370	2.379	2.390
0.70	2.322	2.327	2.332	2.337	2.343	2.349	2.356	2.364	2.374	2.385
0.72	2.318	2.322	2.327	2.332	2.338	2.344	2.351	2.359	2.369	2.380
0.74	2.314	2.318	2.323	2.328	2.334	2.340	2.347	2.355	2.364	2.376
0.76	2.310	2.315	2.319	2.325	2.330	2.336	2.343	2.351	2.360	2.372
0.78	2.307	2.311	2.316	2.321	2.327	2.332	2.339	2.347	2.357	2.369
0.80	2.304	2.308	2.313	2.318	2.323	2.329	2.336	2.344	2.353	2.366
0.82	2.301	2.305	2.310	2.315	2.320	2.326	2.333	2.341	2.350	2.363
0.84	2.299	2.303	2.307	2.312	2.318	2.323	2.330	2.338	2.348	2.360
0.86	2.296	2.300	2.305	2.310	2.315	2.321	2.327	2.335	2.345	2.358
0.88	2.294	2.298	2.303	2.308	2.313	2.318	2.325	2.333	2.343	2.355
0.90	2.292	2.296	2.301	2.305	2.311	2.316	2.323	2.331	2.340	2.353
0.92	2.290	2.294	2.299	2.303	2.309	2.314	2.321	2.328	2.338	2.351
0.94	2.288	2.292	2.297	2.302	2.307	2.312	2.319	2.326	2.337	2.350
0.96	2.287	2.291	2.295	2.300	2.305	2.310	2.317	2.325	2.335	2.348
0.98	2.285	2.289	2.294	2.298	2.303	2.309	2.315	2.323	2.333	2.346
1.00	2.284	2.288	2.292	2.297	2.302	2.307	2.314	2.321	2.332	2.345

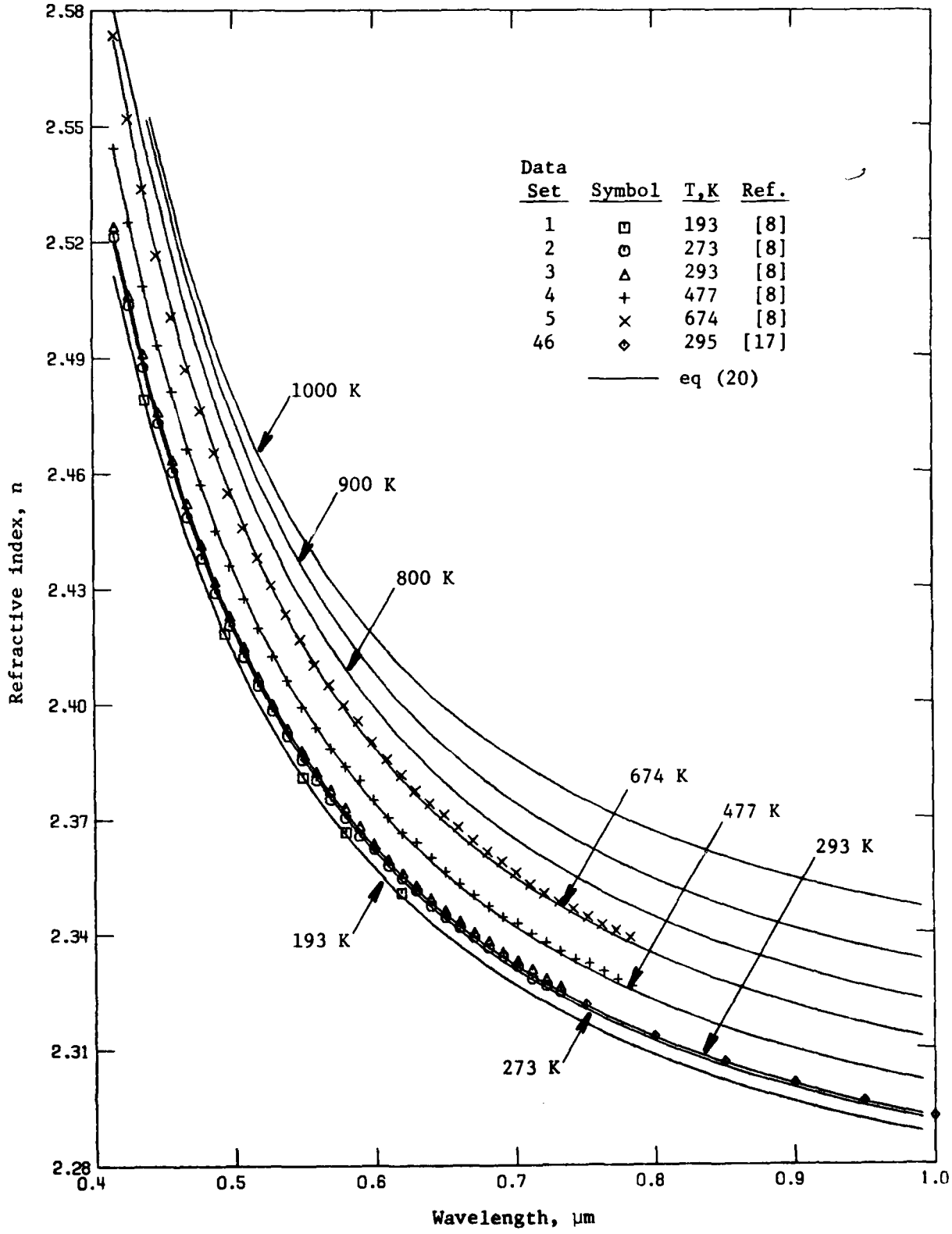

Figure 7. Comparison of experimental and calculated refractive indices of ZnS at various temperatures. Refer to table A-1 for the corresponding data sets.

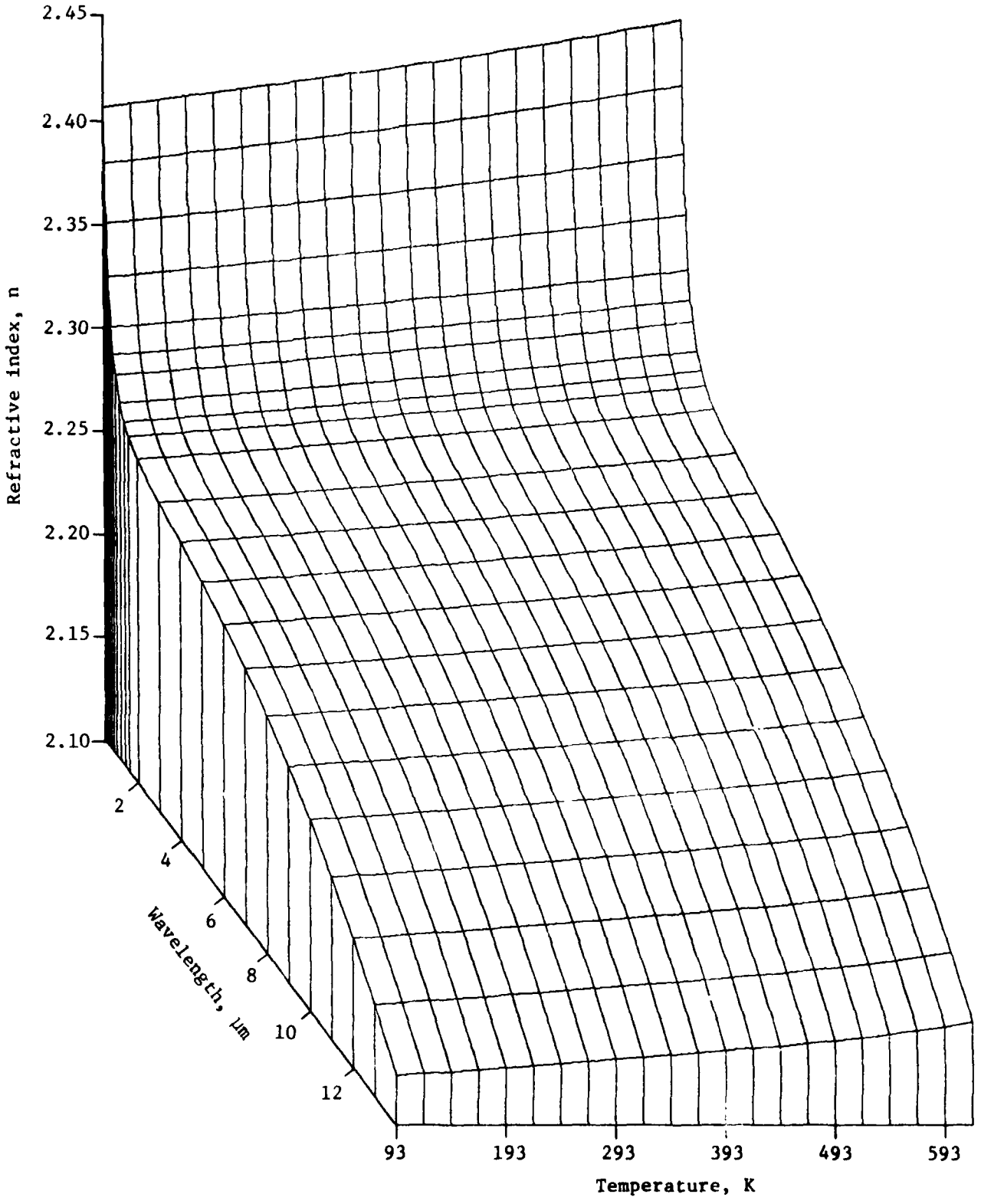

Figure 8. Recommended n-λ-T diagram of ZnS.

Table 5. Recommended values (in units of $10^{-5}K^{-1}$) on the temperature derivative of refractive index of CVD ZnS

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
0.50	7.3	7.0	6.9	6.9	7.1	7.4	7.8	8.3	8.7	9.1	9.5	9.7
0.55	6.1	6.0	6.0	6.1	6.2	6.5	6.8	7.1	7.5	7.9	8.2	8.4
0.60	5.4	5.4	5.4	5.5	5.7	5.9	6.2	6.5	6.8	7.1	7.5	7.6
0.65	4.9	5.0	5.1	5.2	5.4	5.5	5.8	6.0	6.3	6.6	7.0	7.2
0.70	4.5	4.7	4.8	5.0	5.1	5.3	5.5	5.7	6.0	6.3	6.6	6.8
0.75	4.2	4.5	4.7	4.8	5.0	5.1	5.3	5.5	5.7	6.0	6.4	6.6
0.80	4.0	4.3	4.5	4.7	4.8	5.0	5.1	5.3	5.6	5.8	6.2	6.4
0.85	3.9	4.2	4.4	4.6	4.8	4.9	5.0	5.2	5.4	5.7	6.1	6.3
0.90	3.7	4.1	4.4	4.5	4.7	4.8	4.9	5.1	5.3	5.6	6.0	6.2
0.95	3.6	4.0	4.3	4.5	4.6	4.8	4.9	5.0	5.2	5.5	5.9	6.1
1.0	3.6	4.0	4.2	4.5	4.6	4.7	4.8	5.0	5.2	5.4	5.8	6.0
1.5	3.2	3.7	4.0	4.3	4.4	4.5	4.6	4.7	4.8	5.1	5.5	5.8
2.0	3.0	3.6	4.0	4.2	4.4	4.4	4.5	4.6	4.8	5.0	5.4	5.7
2.5	3.0	3.6	3.9	4.2	4.3	4.4	4.5	4.6	4.7	5.0	5.4	5.7
3.0	2.9	3.5	3.9	4.2	4.3	4.4	4.5	4.5	4.7	5.0	5.4	5.7
3.5	2.9	3.5	3.9	4.2	4.3	4.4	4.4	4.5	4.7	5.0	5.4	5.7
4.0	2.9	3.5	3.9	4.1	4.3	4.4	4.4	4.5	4.7	5.0	5.5	5.8
4.5	2.9	3.5	3.9	4.1	4.3	4.3	4.4	4.5	4.7	5.0	5.5	5.9
5.0	2.8	3.5	3.9	4.1	4.3	4.3	4.4	4.5	4.7	5.0	5.6	5.9
5.5	2.8	3.5	3.9	4.1	4.2	4.3	4.4	4.5	4.7	5.1	5.6	6.0
6.0	2.8	3.5	3.9	4.1	4.2	4.3	4.4	4.5	4.7	5.1	5.7	6.1
6.5	2.8	3.4	3.8	4.1	4.2	4.3	4.3	4.5	4.7	5.1	5.8	6.2
7.0	2.8	3.4	3.8	4.1	4.2	4.2	4.3	4.5	4.7	5.2	5.9	6.3
7.5	2.8	3.4	3.8	4.1	4.2	4.2	4.3	4.5	4.7	5.2	5.9	6.4
8.0	2.7	3.4	3.8	4.0	4.2	4.2	4.3	4.4	4.8	5.3	6.1	6.6
8.5	2.7	3.4	3.8	4.0	4.1	4.2	4.3	4.4	4.8	5.3	6.2	6.7
9.0	2.7	3.4	3.8	4.0	4.1	4.2	4.3	4.4	4.8	5.4	6.3	6.9
9.5	2.7	3.4	3.8	4.0	4.1	4.2	4.2	4.4	4.8	5.5	6.4	7.0
10.0	2.7	3.4	3.8	4.0	4.1	4.1	4.2	4.4	4.9	5.5	6.6	7.2
10.5	2.7	3.4	3.8	4.0	4.1	4.1	4.2	4.5	4.9	5.6	6.7	7.4
11.0	2.7	3.4	3.8	4.0	4.1	4.1	4.2	4.5	4.9	5.7	6.9	7.7

Table 5. Recommended values (in units of $10^{-5}K^{-1}$) on the temperature derivative of refractive index of CVD ZnS--Continued

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
11.5	2.7	3.4	3.8	4.0	4.1	4.1	4.2	4.5	5.0	5.8	7.1	7.9
12.0	2.7	3.4	3.9	4.0	4.1	4.1	4.2	4.5	5.0	6.0	7.3	8.2
12.5	2.7	3.5	3.9	4.0	4.1	4.1	4.2	4.5	5.1	6.1	7.5	8.5
13.0	2.7	3.5	3.9	4.1	4.1	4.1	4.2	4.6	5.2	6.2	7.8	8.8
13.5	2.7	3.5	4.0	4.1	4.1	4.1	4.2	4.6	5.3	6.4	8.1	9.1
14.0	2.8	3.6	4.0	4.1	4.1	4.1	4.3	4.6	5.4	6.6	8.4	9.5

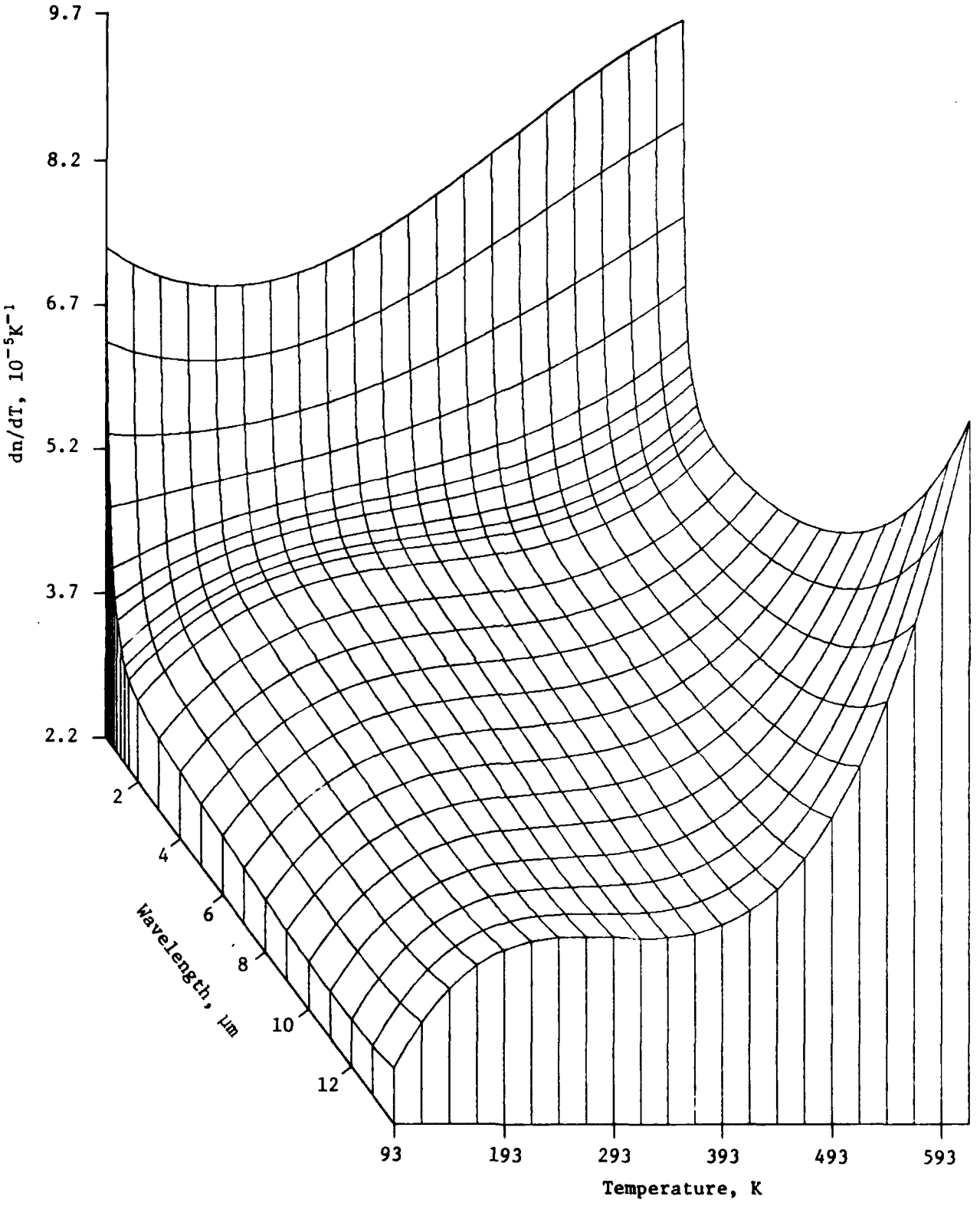

Figure 9. Recommended dn/dT-λ-T diagram of ZnS.

Table 6. Recommended values on the wavelength derivative of refractive index of CVD ZnS

λ, μm	$-\frac{dn}{d\lambda}$, $10^{-3}\mu m^{-1}$
0.50	811.2
0.55	558.9
0.60	404.2
0.65	303.2
0.70	234.1
0.75	185.0
0.80	149.1
0.85	122.1
0.90	101.4
0.95	85.3
1.0	72.5
1.5	21.6
2.0	10.4
2.5	6.9
3.0	5.7
3.5	5.4
3.6[a]	5.35[a]
4.0	5.4
4.5	5.7
5.0	6.1
5.5	6.6
6.0	7.2
6.5	7.8
7.0	8.4
7.5	9.1
8.0	9.8
8.5	10.5
9.0	11.3
9.5	12.1
10.0	13.0
10.5	13.9
11.0	14.8
11.5	15.8
12.0	16.9
12.5	18.0
13.0	19.3
13.5	20.6
14.0	21.9

[a]Minimum point on the curve.

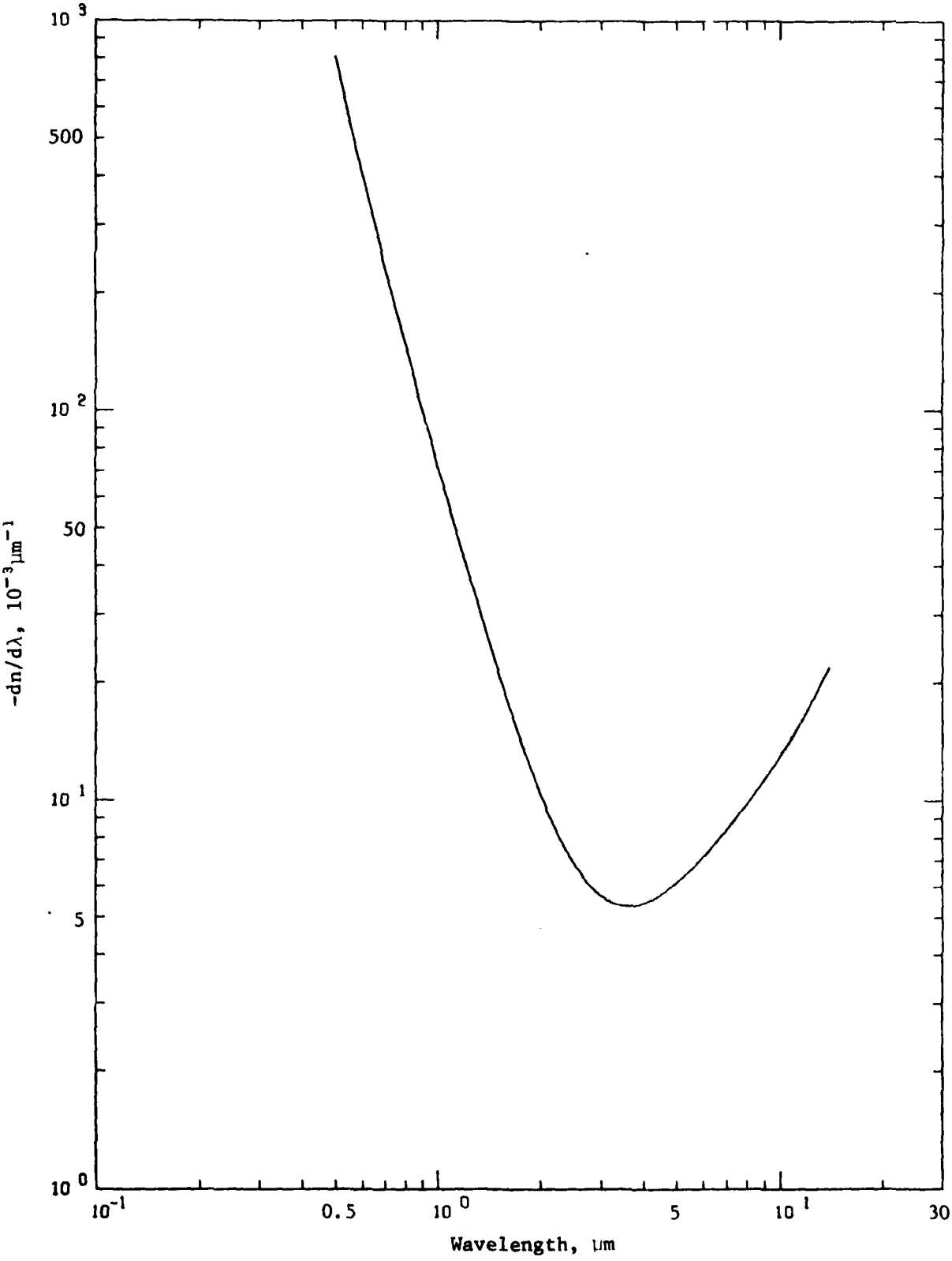

Figure 10. Recommended dn/dλ curve of ZnS at 293 K.

μm, and ±0.001 between 11 to 14 μm. For the single crystal ZnS, the uncertainty of ±0.002 is applied.

Estimation of uncertainties in the recommended dn/dT values are based on the results of Feldman et al. which are used to determine the constants of eq (20). Their reported experimental uncertainties are $\pm 0.2 \times 10^{-5} K^{-1}$ for all the three wavelengths investigated. Our least-squares calculations yielded basically the same uncertainties. Error bars corresponding to this value are indicated in figures 5 and 6 where calculations are compared with the experimental data.

Uncertainties of the recommended dn/dλ values are estimated in the following manner. Taking the first derivative of eq (19) with respect to λ, we have $-(n/\lambda)(dn/d\lambda) = A_0 R_u^2 + B_0 R_I^2/\lambda_I^2$ which leads to

$$\delta\left(\frac{dn}{d\lambda}\right) = \frac{\lambda \delta n}{n^2}\left(A_0 R_u^2 + \frac{B_0 R_I^2}{\lambda_I^2} + 4n^2 R_u + \frac{4n^2 |R_I|}{\lambda_I^2}\right) . \qquad (21)$$

Based on the quoted uncertainties for refractive index of CVD ZnS, it is appropriate to adopted δn = ±0.0005 for the evaluation of δ(dn/dλ) for the entire wavelength range from 0.5 to 14 μm. The uncertainties of dn/dλ thus calculated are $\pm 5 \times 10^{-3}$ μm^{-1} at 0.5 μm, $\pm 4 \times 10^{-3}$ μm^{-1} at 0.6 μm, $\pm 2 \times 10^{-3}$ μm^{-1} at 1 μm, $\pm 0.4 \times 10^{-3}$ μm^{-1} at 5 μm, $\pm 0.2 \times 10^{-3}$ μm^{-1} at 10 μm, and $\pm 0.2 \times 10^{-3}$ μm^{-1} at 14 μm.

3.2. Zinc Selenide, ZnSe

There are 36 sets of experimental data available for the refractive index (wavelength dependence and temperature dependence) of zinc selenide as tabulated in tables A-5 and A-6 and plotted in figures 11 and 12 where some of the data sets are made for thin films or multiple layers and are included here for the purpose of comparison and completeness. After a careful review and evaluation of the available data and associated information, it was found that the data sets reported by Marple [48,49], Rambauske [50,51], Hilton and Jones [52], Wunderlich and DeShazer [53], Feldman et al. [17], and Thompson et al. [54] are representative of the available refractive index for zinc selenide in the fundamental transparent region between 0.4 and 18.2 μm; while data sets reported by Hattori et al. [19] are the only available data in the wavelength

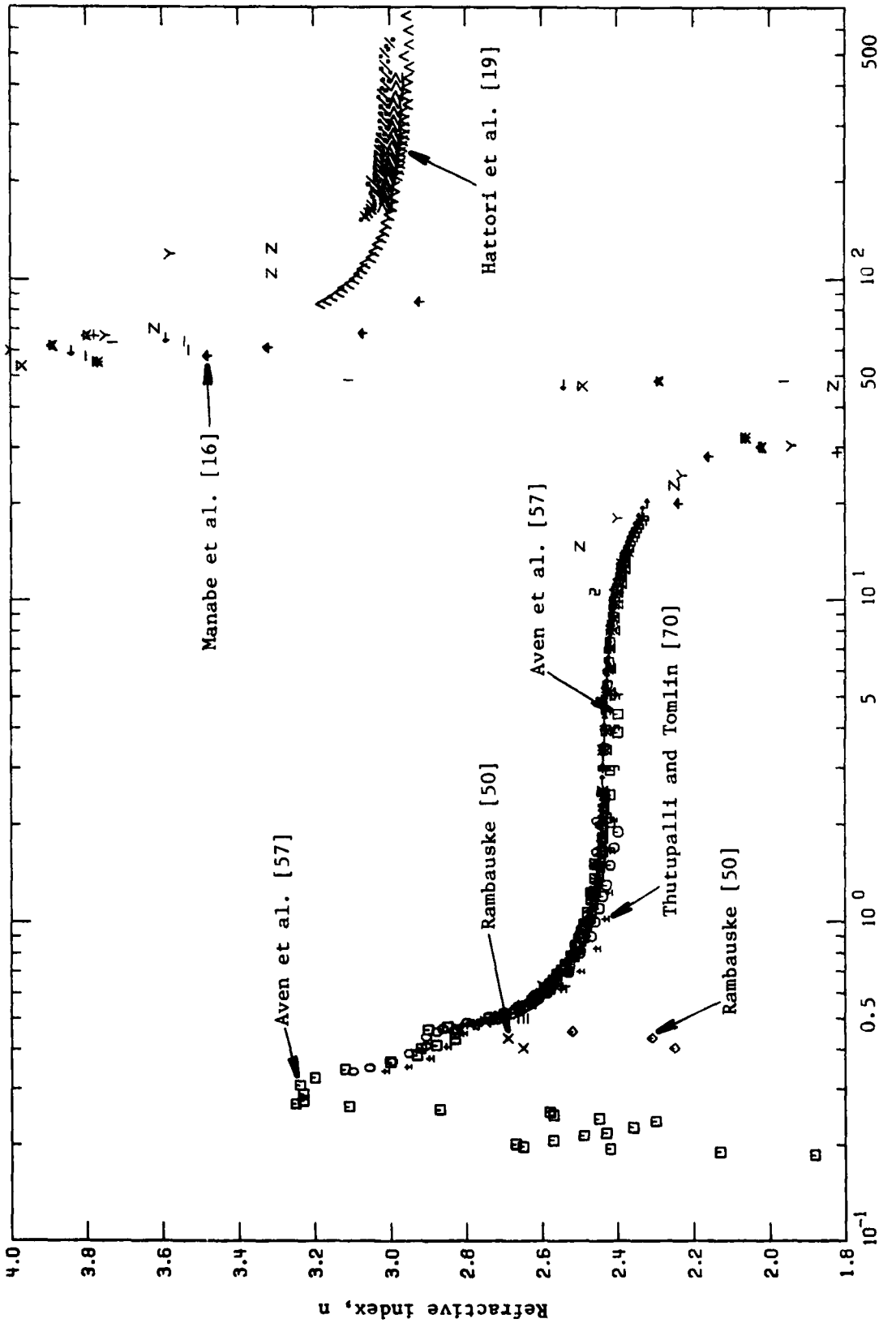

Figure 11. Available experimental refractive index of ZnSe (wavelength dependence).

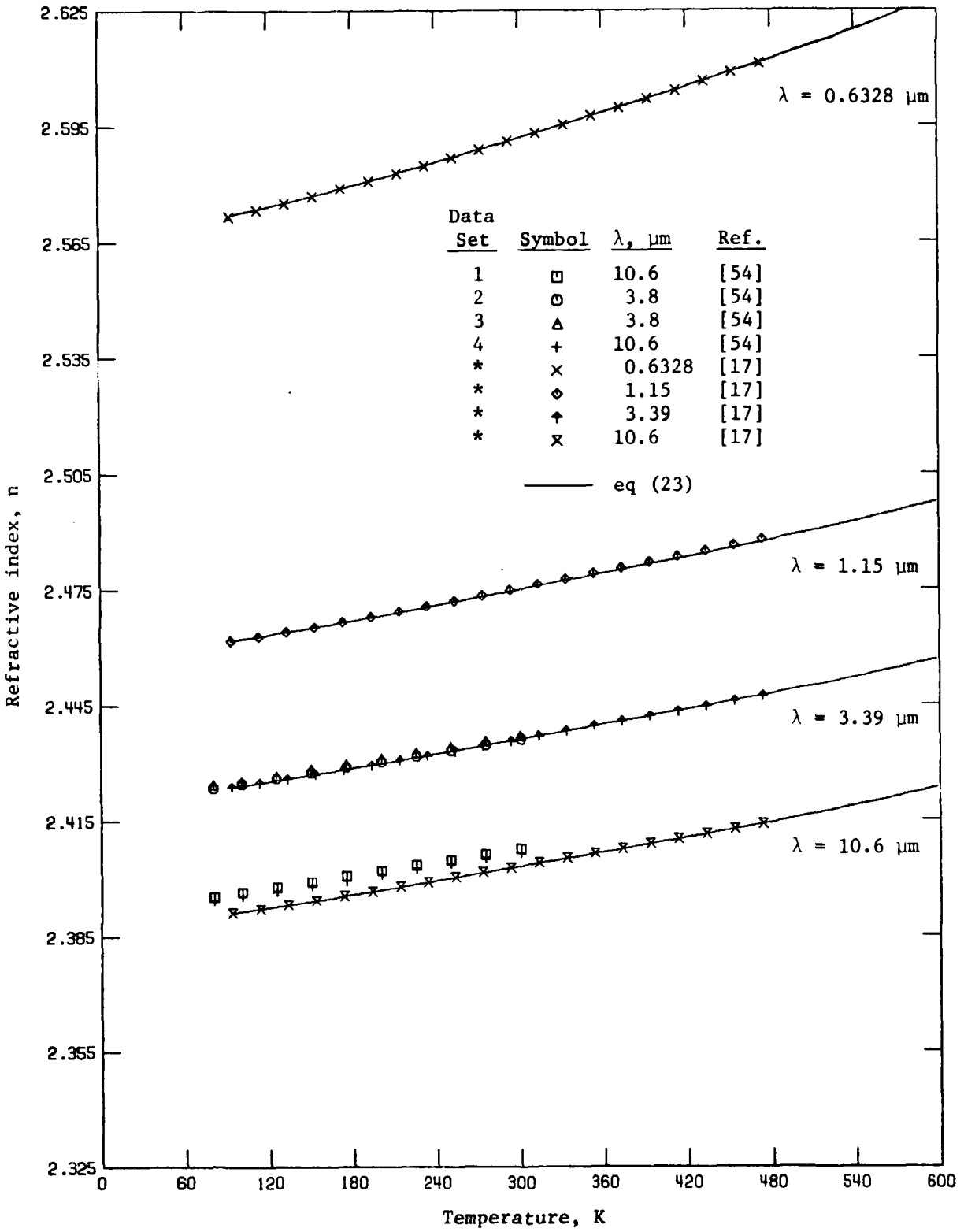

Figure 12. Experimental and calculated refractive index of ZnSe (temperature dependence). Refer to table A-6 for the corresponding data sets. Data sets "*" are derived from dn/dT data given in table A-8.

range from 83 to 1163 μm. The data reported by Manabe et al. [16] and by Hadni et al. [55,56] are concerning the characteristics of the reststrahlen region; and the data of Aven et al. [57] are for both the reststrahlen and electronic absorption regions.

For the purpose of obtaining consistent refractive index of ZnSe over a wavelength range from the short-wave transmission limit set by the band gap to 2.5 μm, Marple [48,49] carefully measured the refractive index of ZnSe prisms with impurities less than 10-20 ppm. Experimental error of the data is ± 0.002 or less, however, the results for two ZnSe prisms differ by up to 0.005 in the wavelength region between 0.496 and 0.83 μm. The cause of this difference is unknown as it cannot be accounted for by the error in the prism angle measurements alone. The possible cause of such discrepancy is due to a difference in impurity contents or stoichiometric balance between the two prisms as one showed a slightly brownish tint when compared with the lemon-yellow color of the purer ZnSe crystal. As shown in table 7, the equation $n^2 = A + B\lambda^2/(\lambda^2-C^2)$ was used to fit experimental data for each prism with A, B, and C being adjustable parameters. Because of the limited spectral range, A, B, and C were not fit the data with a more realistic theory of the dielectric constants. However, the best-fit values of A, B, and C for each of the two prisms indicate a value of 5.90 for the optical dielectric constant of ZnSe.

Rambauske [50,51] reported refractive index data over a spectral band from 0.400 to 0.644 μm for two ZnSe specimens obtained from two suppliers. The orange-yellow specimen from Aerospace Research Laboratory is of high purity and the results of which are more representative of pure ZnSe; the yellow specimen from Harshaw Chemical Co. contains considerable impurities and the results of which are quite discrepant from those of the former. Although the size of discrepancy in the transparent region is less than one unit in the second decimal place, it is significantly larger in the absorption region. For example, the refractive index of Harshaw specimen is 2.25 at 0.4044 μm but 2.65 for other specimens. Additional data in the visible region between 0.50 and 0.633 μm were reported by Wunderlich and DeShazer [53]. Minimum deviation method was used and experimental error in n was reported to be ± 0.002. The data were fitted to a single term Sellmeier formula as given in table 7.

Table 7. Comparison of dispersion equations proposed for ZnSe

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Marple, D.T.F., 1964 [48]	0.48-2.50 μm 298 K	for one sample: $n^2 = 4.00 + \frac{1.90\,\lambda^2}{\lambda^2 - 0.113}$ for second sample: $n^2 = 3.71 + \frac{2.19\,\lambda^2}{\lambda^2 - 0.105}$
Manabe, A., Mitsuishi, A., and Yoshinaga, H., 1967 [16]	20-85 μm 300 K 100 K	$n^2-k^2 = \varepsilon_\infty + \frac{N\,(1-\Omega^2)}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ $2nk = \frac{N\delta\Omega}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ at 300 K: $\varepsilon_\infty = 5.4$, $\lambda_I = 48.31$, $\delta = 0.018$, and $N = 2.2$; at 100 K: $\varepsilon_\infty = 5.4$, $\lambda_I = 47.39$, $\delta = 0.010$, and $N = 2.2$.
Handi, A., Henry, P., Lambert, J.P., Morlot, G., Strimer, P., and Chanal, D., 1967 [55]	15-125 μm 290 K 90 K	$n^2-k^2 = \varepsilon_\infty + \frac{(\varepsilon_0-\varepsilon_\infty)\,(1-\Omega^2)}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ $2nk = \frac{(\varepsilon_0-\varepsilon_\infty)\,\delta\Omega}{(1-\Omega^2)^2 + \delta^2\Omega^2}$

Table 7. Comparison of dispersion equations proposed for ZnSe--Continued

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Handi, A., et al., 1967 [55], cont.		at 290 K: $\varepsilon_\infty = 6.3$, $\varepsilon_0 = 9.6$, $\lambda_I = 49.0$, and $\delta = 0.022$; at 90 K: $\varepsilon_\infty = 6.3$, $\varepsilon_0 = 9.53$, $\lambda_I = 47.44$, and $\delta = 0.010$.
Kodak publication U-72, 1971 [21]	1.0–20 μm 300 K	$n = 2.4350823 + \frac{5.1567472 \times 10^{-2}}{\lambda^2 - 0.028} + \frac{2.4901923 \times 10^{-3}}{(\lambda^2 - 0.028)^2} - 2.7245212 \times 10^{-8}\lambda^2 - 9.8541275 \times 10^{-8}\lambda^4$
Hattori, T., Homma, Y., Mitsuishi, A., and Tacke, M., 1973 [19]	156–541 μm at 300 K 166–422 μm at 80 K 83–1163 μm at 2 K	$n^2 = \frac{\varepsilon_0 - \varepsilon_\infty \Omega^2}{1 - \Omega^2}$ at 300 K: $\varepsilon_0 = 8.99$, $\varepsilon_\infty = 5.3$, and $\lambda_I = 49.261$ μm; at 80 K: $\varepsilon_0 = 8.76$, $\varepsilon_\infty = 5.5$, and $\lambda_I = 48.309$ μm; at 2 K: $\varepsilon_0 = 8.68$, $\varepsilon_\infty = 5.6$, and $\lambda_I = 47.619$ μm.
Wunderlich, J.A. and DeShazer, L.G., 1977 [53]	0.5017–0.6328 μm 300 K	$n^2 = 1 + \frac{4.7032\ \lambda^2}{\lambda^2 - (0.26522)^2}$

Table 7. Comparison of dispersion equations proposed for ZnSe--Continued

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]	0.54-18.2 μm 293 K	$n^2 = 1 + \sum_{i=1}^{3} \frac{A_i\lambda^2}{\lambda^2 - \lambda_i^2}$ for one sample at 293.3 K: $A_1 = 4.2980149$ $A_2 = 0.62776557$ $A_3 = 2.8955633$ $\lambda_1 = 0.19206300$ $\lambda_2 = 0.37878260$ $\lambda_3 = 46.994595$ for second sample at 293.8 K: $A_1 = 4.4639521$ $A_2 = 0.46132463$ $A_3 = 2.8828867$ $\lambda_1 = 0.20107634$ $\lambda_2 = 0.39210520$ $\lambda_3 = 47.047590$
Present work, 1982	0.55-18 μm 93-618 K	$n^2(\lambda,t) = E(t) + \frac{A(t)}{\lambda^2 - \lambda_u^2} + \frac{B(t)}{\lambda^2/\lambda_I^2 - 1}$ $t = T - 293$ See eq (23) in text for the expressions of λ_u, λ_I, E(t), A(t), and B(t).

In an effort to measure refractive index of polycrystalline ZnSe with high precision, Hilton and Jones [52] reported data for an Irtran 4 specimen over a wavelength range from 2.5 to 14 μm at two temperatures, 295 and 198 K, using minimum deviation method. Although the claimed experimental error is about ±0.0003 in refractive index, the corresponding values tabulated in table A-5 should have larger uncertainties as they were extracted from a graph. Based on the data obtained at two temperatures, the average temperature coefficient of refractive index at 5 μm was evaluated to be $4.8 \times 10^{-5} K^{-1}$ comparable with those reported in other studies.

Refractive index of CVD ZnSe were measured by Feldman et al. [17] as part of the effort in the characterization of high-power laser window materials. Two CVD ZnSe samples were measured with high precision minimum deviation method over a wide wavelength range from 0.54 to 18.2 μm of laser interest. The reported room-temperature data were given to the fifth decimal place and were fitted to a three-term Sellmeier type dispersion equation (shown in table 7). Since the parameters in their dispersion equation were not intended to have physical significance but a mathematical fit to the observed data, the parameter values determined for these two samples are considerably different though the difference in refractive indices at any wavelength is less than four units in the fourth decimal place. In view of the reported average absolute residuals of n from the best fit equation of each data set, 6.2×10^{-5} and 4.1×10^{-5}, respectively, the difference of four units in the fourth decimal place cannot be accounted for by experimental errors. The discrepancies in these two data sets must be of impurity or crystal defect origin. It is likely that an uncertainty of magnitude ±0.0004 will be a reasonable estimate for reference data values. Under such circumstances, either data set of Feldman et al. can be considered as representative of the refractive index of ZnSe.

The indices of refraction of ZnSe in the far infrared spectral range from 83 to 1163 μm were measured by Hattori et al. [19] at temperatures 2, 80, and 300 K. The results were described by a simple dispersion equation, shown in table 7, for an undamped harmonic oscillator from which the static dielectric constant, optical dielectric constant, and wavelength of TO mode phonon were determined with least-squares fit. The static dielectric constant serves as a check for the values obtained from various optical methods. Since the data were measured by interference method and the value of ε_0 was obtained in long

wavelength region, it is believed to be reliable and should be adopted as a known parameter in the dispersion equation of ZnSe.

Manabe et al. [16] studied optical constants in the reststrahlen region by means of infrared lattice reflection spectra in the spectral region between 20 and 85 μm and the spectra were analyzed using Drude dispersion relation. The oscillator strength, N, optical dielectric constant, ε_∞, damping factor, δ, and wavelength of transverse optical phonon, λ_I, in the Drude equations (shown in table 7) were determined by fit of reflectivity data. The wavelength of transverse optical phonon was also determined directly from transmission spectrum of an evaporated thin film and was found to agree with that obtained from the reflection spectra analysis. The static dielectric constant, ε_0, was determined by letting $\lambda = \infty$ in the resulting Drude equation assuming zero absorption, i.e., $\varepsilon_0 = n^2 = \varepsilon_\infty + N\lambda_I^2$. Optical constants in the reststrahlen region were also studied by Hadni et al. [55,56] for an Irtran 4 sample at temperatures 80 and 290 K. The various parameters, ε_0, ε_∞, and λ_I, were determined from analyzing the reflection and transmission spectra with the Kramers-Kronig relations and with the Lorentz one-oscillator model. Aven et al. [57] performed a similar study on a single crystal ZnSe for determining the wavelength of optical phonon and optical dielectric constants. The static dielectric constant was determined from capacitance measurements on a single-crystal wafer. In addition, the absorption bands in the ultraviolet region were also observed. The wavelengths of the observed absorption bands were determined at 0.459, 0.394, 0.261, and 0.243 μm with the first one corresponding the energy gap.

For the purpose of ease of comparison, the above mentioned data sets for the fundamental transparent region are plotted in figure 13. It is obvious that the disagreement among the data sets reported by different investigators is greater than the accuracy claimed by each of them. Although internal consistency was observed in each investigation, unaccounted sources of errors are responsible for these discrepancies.

In the present work, eq (9) is used to represent the room-temperature refractive index of ZnSe. The main problems are to select the appropriate parameters, ε_∞, ε_0, and λ_I, and to determine the coefficients A, B, and the parameters λ_u. Literature values of ε_∞, ε_0, and λ_I are very discrepant as shown in table 8. The available room-temperature ε_∞ values vary considerably

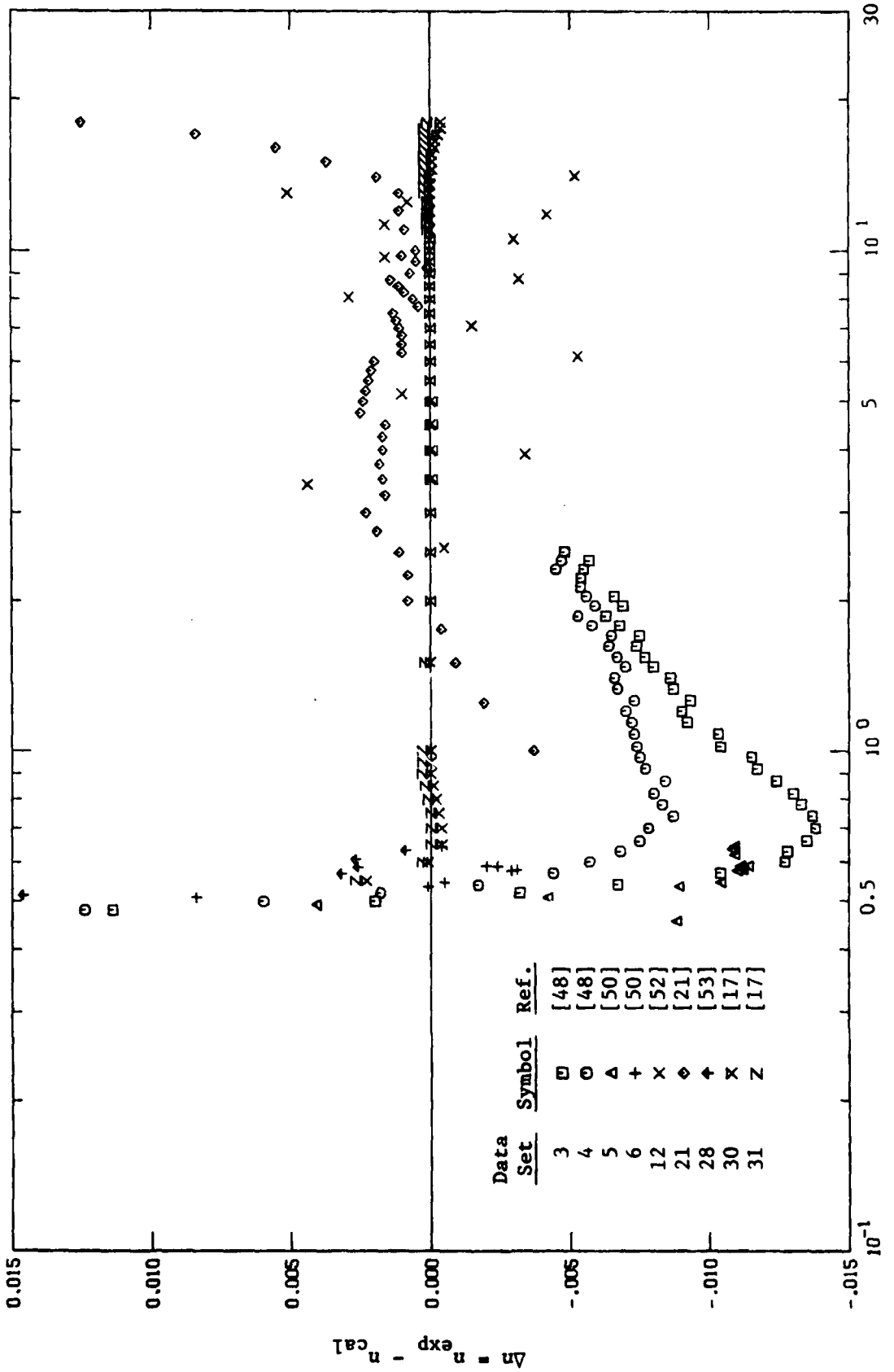

Figure 13. Comparison of experimental and calculated refractive index values of ZnSe at room temperature. The calculated values from eq (22) are represented by the line $\Delta n = 0$. Refer to table A-5 for the corresponding data sets.

Table 8. Available data on ε_∞, ε_0, and λ_I of ZnSe

Temp., K	ε_∞	ε_0	λ_I, μm	Ref.
300	5.4	7.6	48.31,49.02	[16]
300		9.12		[24]
300	5.90			[48]
300			49.26	[58]
300	5.3	8.99	49.26	[19]
300	5.75 ± 0.1	8.1 ± 0.3	47.69	[57]
300	6.3	9.6	49.02,48.97	[56]
300	5.4	7.6	48.31	[59]
300	6.10	9.2	47.85	[60]
300			46.51	[27]
300			49.02	[61]
300	5.86			[21]
300	6.3			[50]
80	5.5	8.76	48.31	[19]
80	6.3	9.53	47.44	[56]
80	5.4	7.6	47.39	[59]
80	5.4	7.6	47.39	[16]
2	5.6	8.68	47.62	[19]

from 5.3 to 6.3, which is too much for refractive index calculation of desirable accuracy; one has to resort to available dispersion equations which were proposed for visible region by various investigators. From table 7, the ε_∞ values are: 5.90 by Marple, 5.7032 by Wunderlich and DeShazer, and 5.925 by Feldman et al. It appears that the second value given above is somewhat too low in comparison with the others. However, recalling the narrow wavelength region coverage in the work of Wunderlich and DeShazer, one may reasonably understand that data over that wavelength region do not have enough dispersion to define the coefficients of a dispersion equation with certainty. Should they investigate a wider spectral region extended toward short wavelengths, the corresponding ε_∞ from the dispersion equation would agree with the others. Based on this consideration, a value in the neighborhood of 5.91 should be correct for eq (9).

The values of ε_0 from table 6 vary from 7.6 to 9.6, far too large for refractive index calculation. None of the available dispersion equations indicates adequate value except that reported by Hattori et al. [19] whose room-temperature measurements covered the spectral region between 165 to 540 μm. By definition, the value of ε_0 equals the square of the refractive index measured at long wavelengths; in fact, the values of refractive index read from the graph are 3.063 at 156 μm and 2.999 at 540 μm. An appropriate value of ε_0 is, therefore, approximately 9.0.

Among the values of λ_I from table 8, the values reported by Manabe et al. [16] are chosen to be the approximate parameter for eq (9) for the reasons that one of the values was determined by transmission measurement on evaporated thin film which is a direct means for determining material properties of this kind. Therefore, the value of λ_I must be within the range from 48.31 to 49.02 μm.

The value of λ_u is very uncertain in that values based on available dispersion equations are: 0.325 and 0.336 μm by Marple [48], 0.26522 μm by Wunderlich and DeShazer [53], and 0.192 and 0.379 μm or 0.201 and 0.392 μm by Feldman et al. [17], while absorption peaks based on reflectivity observation [57] are at 0.243, 0.261, 0.394, and 0.459 μm. It appears, however, that a proper value of λ_u should be around 0.3 μm.

With all the essential parameters as discussed above at hand the data of Feldman et al. are fitted to eq (9) for the determination of the constants A

and B by allowing the parameters varying within their corresponding estimated limits. The dispersion equation of ZnSe at room temperature thus obtained is

$$n^2 = 9.01536 + \frac{0.24482}{\lambda^2 - (0.29934)^2} + \frac{3.08889}{\lambda^2/48.38^2 - 1} \qquad (22)$$

where λ is in units of μm. Equation (22) is valid in the wavelength range from 0.55 to 18 μm. In figure 13, deviations of the available room temperature data from those calculated from eq (22) are plotted for visual comparison. It is clear that the data from various measurements are quite different from the values calculated from eq (22). While most of the data of Rambauske [50] are considerably lower than calculated values, those of Wunderlich and DeShazer [53] are considerably higher in the corresponding spectral region. Such wide discrepancies are of material origins, and it appears that refractive index of ZnSe is very sensitive to impurity content of the sample, particularly in the short wavelength region. To show such disagreement, a figure reported by Rambauske is reproduced in figure 14 where the two curves obtained for two samples of different impurities disagree with each other not only in absolute values of the property but also in the shapes of the curves particularly in the wavelength region below 0.5 μm where the effects of impurity prevail as the wavelength corresponding to the energy gap of ZnSe is about 0.48 μm. By investigating the sample in the wavelength region near the energy gap or absorption edge, the presence of impurities can be revealed. From figure 14, it appears that sample with less impurity should have sharper dispersion curve. Based on this consideration, the sample measured by Wunderlich and DeShazer must be purer than those used by Rambauske. In fact, the data of the former are in agreement with the values calculated from eq (22) in the region >0.55 μm below which absorption becomes significant as it approaches the absorption edge and eq (22) becomes invalid.

Large discrepancies are observed between the calculated values from eq (22) and data of Marple [48]. As discussed earlier, not only the samples measured by Marple have noticeable concentration of a large variety of impurities but also the results for these samples differ by 0.005 in most of the wavelength region covered, it is not surprising to see the large departures of his data from eq (22). Comparing with other measurements it is revealed that the samples studied by Marple are probably of similar nature as those measured by Rambauske as the data behave similarly in the overlapped region.

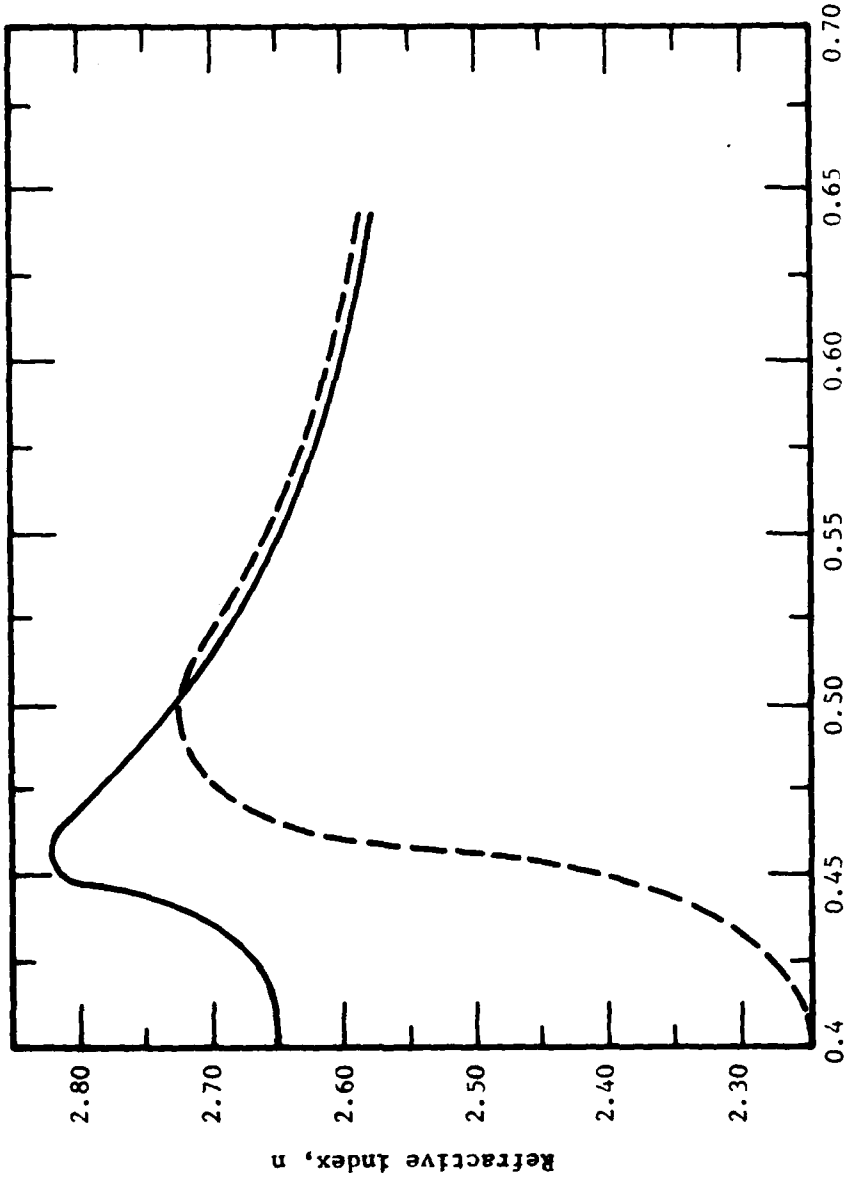

Figure 14. Dispersion curves for two different ZnSe samples reported in ref. [50].

Although Irtran 4 is considered a polycrystalline of ZnSe, its refractive index is different from that of CVD ZnSe which is also a polycrystalline in nature. As shown in figure 13, data from Eastman Kodak Publication U-72 [21] is discrepant from eq (22) by an amount up to 0.0025 over the spectral range from 1 to 16 μm, beyond which higher discrepancies are observed. Irtran 4 data reported by Hilton and Jones [52] seem to be scattered evenly around the calculated curve but this may not be true as this data set was digitized from a graph. As discussed earlier in subsection 3.1 for the case of ZnS that refractive index of Irtran 2 is quite sample dependent and the same observation is expected for Irtran 4.

Based on the considerations discussed above, it is concluded that eq (22) is valid for CVD ZnSe with uncertainty ± 0.0004 estimated from the average residual of least-square data fitting and the highest disagreement between the two data sets of Feldman et al.

In figure 15 are plotted the deviations of film ZnSe data from the calculated bulk data based on eq (22). Unlike in the case of ZnS where a definite trend of the deviation clearly exists, such behavior does not seem to appear in figure 15. A possible reason for this situation is that we have only limited data sets for statistical comparisons; no definite trend can be established at this time for lack of available data.

Equation (22) is also valid in the wavelength region 155-540 μm. The averaged differences between the experimental data and the calculated values are of the order of ± 0.003. The dispersion in this region is rather small as the difference of two extreme refractive indices is only 0.064 but the uncertainty in the data is rather large (of the order ± 0.005) as the data were digitized from a graph of low resolution. Under such condition, the reliability of the digitized values is compatible with the calculated ones. Therefore, no recommended values in this region are given and the readers are referred to the corresponding digitized data in table A-5 for their application.

Literature data on the temperature dependent refractive index of ZnSe is extremely scarce. Data given in table A-6 and plotted in figure 12 are measured by Thompson et al. [54]. Additional data sets plotted in the same figure were derived from the dn/dT data reported by Feldman et al (see tables A-7 and A-8 and figures 16 and 17).

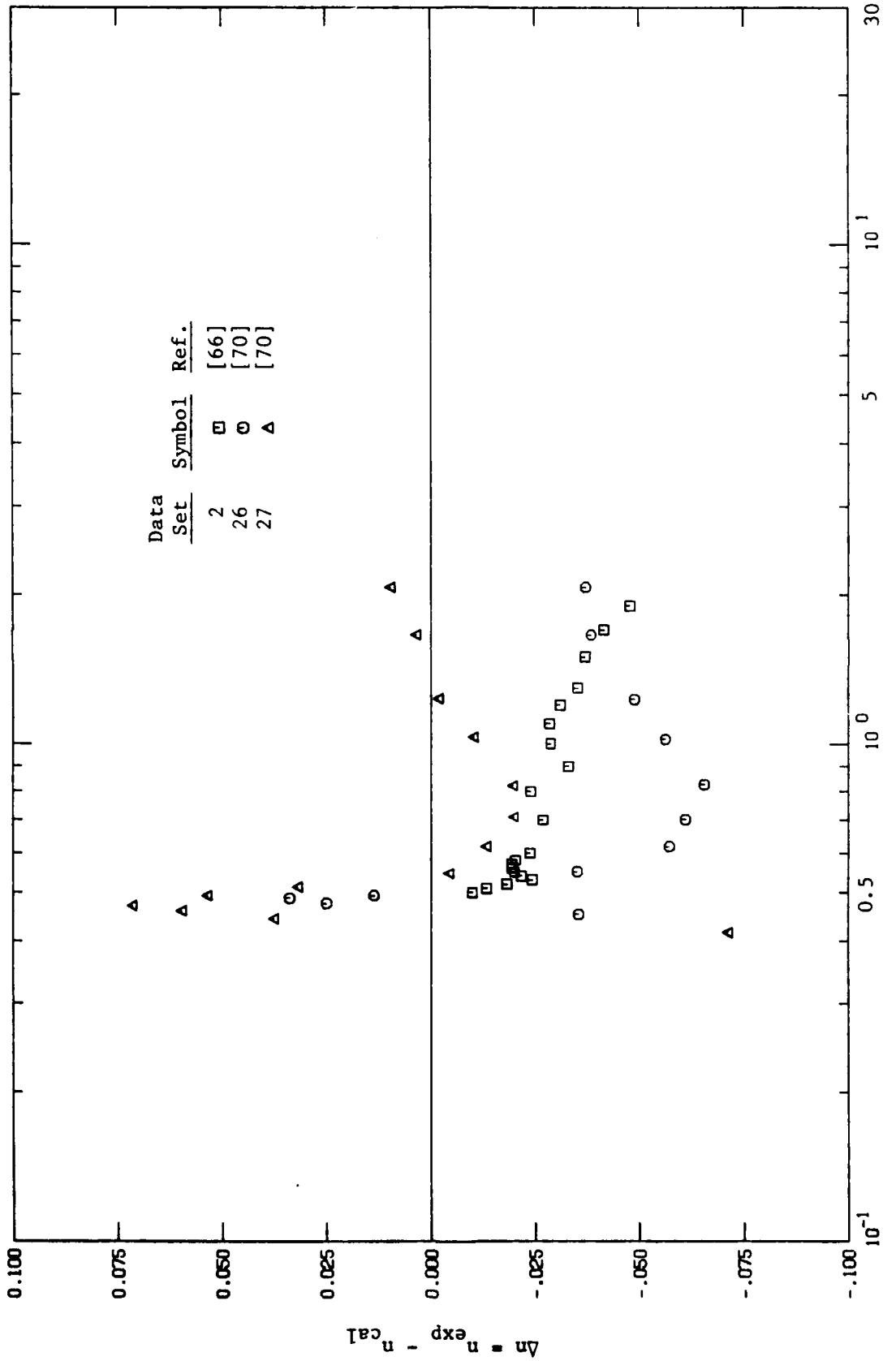

Figure 15. Comparison of experimental refractive indices of ZnSe films and calculated values for bulk ZnSe from eq (22). The calculated values are represented by the line $\Delta n = 0$. Refer to table A-5 for the corresponding data sets.

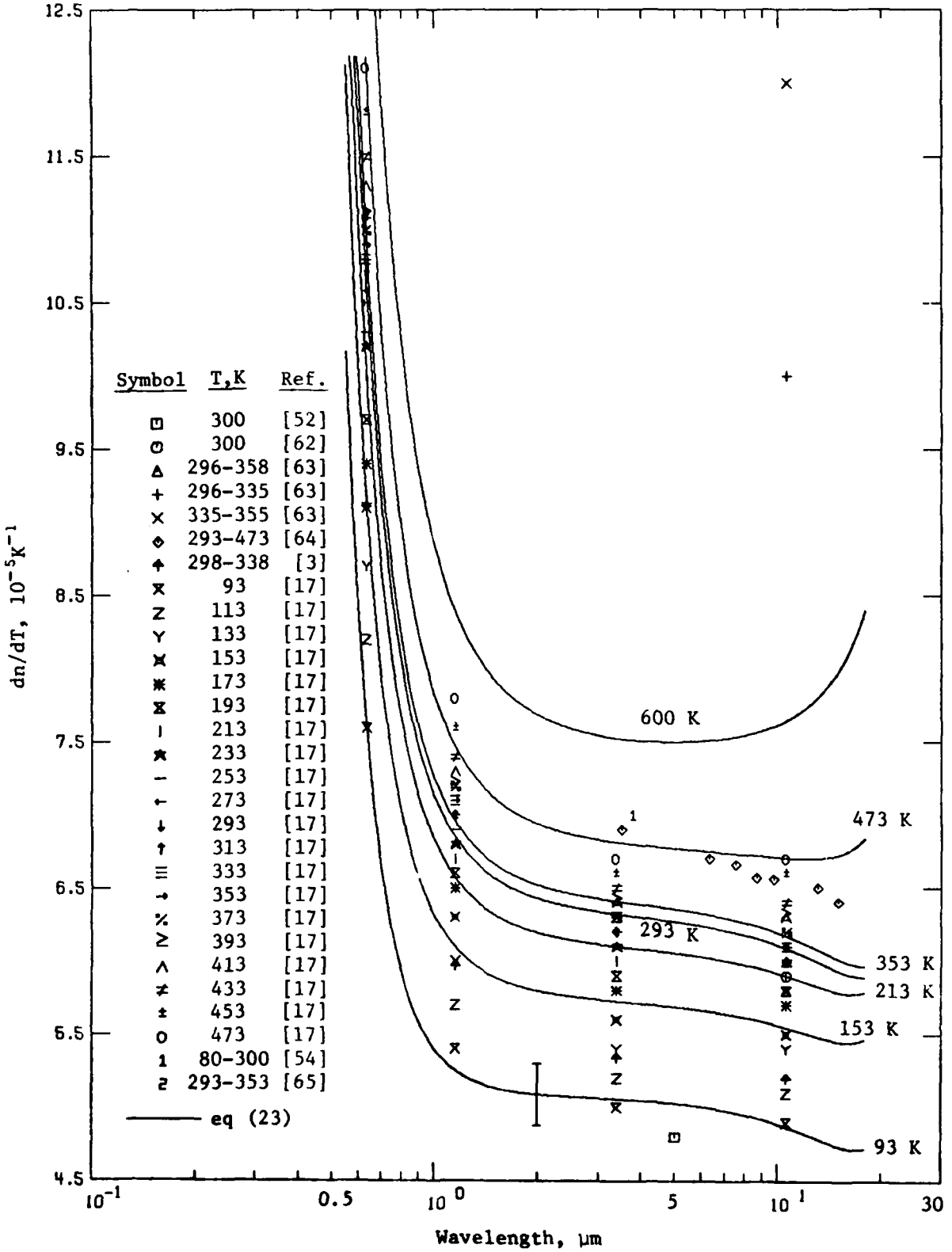

Figure 16. Experimental and calculated dn/dT of ZnSe (wavelength dependence). Refer to table A-7 for the corresponding data sets.

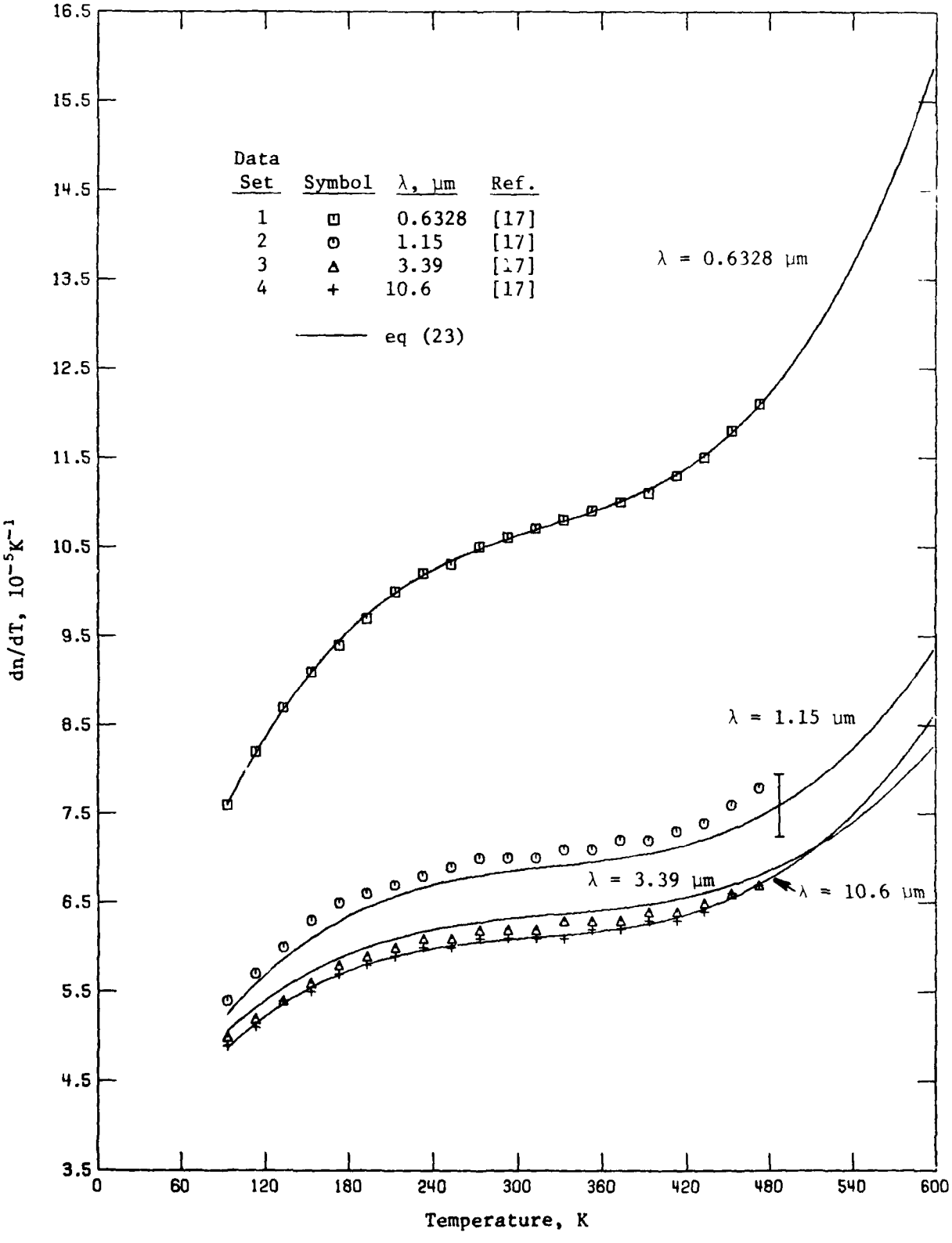

Figure 17. Experimental and calculated dn/dT of ZnSe (temperature dependence). Refer to table A-8 for the corresponding data sets.

Thompson et al. [54] reported refractive indices of two CVD ZnSe specimens at 3.8 and 10.6 μm over the temperature range 80 to 300 K. Values for the two specimens from different batch supplied by RCA Inc. were found to differ by a constant value of about 0.001 over the entire temperature range. This difference cannot be accounted for by the experimental error of ±0.0002 and the possible cause may be attributed to difference in impurity contents and crystal defects. Although the refractive index data of the two specimens differ by more than the experimental error, the temperature coefficients of refractive index in both cases are equal to within the experimental error. Furthermore, the dn/dT values, $7 \times 10^{-5} K^{-1}$ at 3.8 μm and $6 \times 10^{-5} K^{-1}$ at 10.6 μm, show no evidence of temperature dependence in that temperature region. From figure 12 it is noticed that the data of Thompson et al. from 80 to 300 K differ uniformly from those of Feldman et al. by about 0.005 at 10.6 μm and by about 0.002 at 3.8 μm. These discrepancies are partly due to difference in material and partly due to errors in digitizing the graph given by Thompson et al. As a result, their data are not chosen in data analysis for their large uncertainties and for lacking in dispersion of dn/dT values.

Although Feldman et al. reported only room temperature refractive index, their dn/dT data are adequate to calculate the refractive index values at other temperatures from 93 to 473 K. The dn/dT data were measured by an interferometric technique at four discrete laser wavelengths: 0.6328, 1.15, 3.39, and 10.6 μm. It appears that eq (18) is to be used for the determination of the constants E's, A's, and B's. However, before a least-square fit of data can be carried out, the following considerations have to be made.

The temperature variation of λ_u and λ_I in eqs (13) or (18) can be defined using available literature data on temperature shift of energy gap and the TO mode optical phonon. In the study of the theory of temperature derivative of refractive index in transparent crystals, Tsay et al. [5] calculated $d\omega_g/dT$ based on a pseudopotential method. In terms of wavelength shift, their result for ZnSe is $d\lambda_g/dT = 1.004 \times 10^{-4}$ μm K^{-1}. Based on the fact that the $d\lambda_g/dT$ of ZnS remains a constant over a wide temperature range [1], the same is assumed to be true for ZnSe. This value is adopted for the parameter λ_u in eq (13) in view of that λ_u, though it is not exactly corresponding to energy gap, is the effective absorption band and that the quoted shift is small enough not to introduce significant effect on the refractive index as a whole. We have,

therefore, $\lambda_u = \lambda_{u0} + \beta_u t = 0.29934 + 1.004 \times 10^{-4} t$, where λ_{u0} is determined at room temperature as indicated in eq (22). Experimental value on the temperature shift of λ_I of ZnSe was found to be $1/\lambda_I \, d\lambda_I/dT = 1.3 \times 10^{-4} K^{-1}$ by LaCombe and Irwing [82]. Using $\lambda_{I0} = 48.38$, the corresponding value of β_I is 0.00629 $\mu m \, K^{-1}$ and the parameter λ_I is $\lambda_I = 48.38 + 0.00629 \, t$.

A careful review of figure 16, one can discover large discrepancies occurring at wavelength 10.6 μm at which quite a number of measurements due to CO_2 laser interest are found. The large disagreement is best demonstrated by the work of Skolnik and Clark [63] who measured dn/dT for two types of samples, the Irtran 4 and the Raytheon CVD ZnSe. They found the dn/dT value of the latter sample is twice as much as that of the former though both samples have essentially the same density. Since the dn/dT of Irtran 4 is in agreement with that of other investigators who reported data for CVD ZnSe, the Raytheon sample must be of very much different nature from the other CVD ZnSe samples. Unfortunately, however, the origin of such large discrepancy is not understood at present.

A careful review of figure 17, one can see clearly that for all the four curves of dn/dT versus T, the dn/dT values increase with T in the temperature region between 93 K and room temperature and remain practically a constant thereafter up to 400 K. Above 400 K the dn/dT appears to increase with increasing temperature. The increase of dn/dT with temperature is real as it was also observed by Mangir and Hellwart [64] that within the experimental uncertainty, $0.2 \times 10^{-5} K^{-1}$, there is no variation of $\Delta n/\Delta T$ values over the temperature range from 293 to 473 K, but at higher temperatures up to 600 K, a small constant increase at a rate of 0.5×10^{-5} per 100 K was observed at all wavelengths. Their observation stopped at 600 K and there is no experimental data at higher temperatures to support the extrapolation of such increase above 600 K. However, the discussion for the case of ZnS (subsection 3.1) may be also valid for ZnSe assuming that the refractive properties of members of the same family behave similarly.

With all these considerations, a least-squares fit of dn/dT data to eq (18) yielded the following expression for the refractive index of ZnSe as a function of both wavelength and temperature:

$$n^2(\lambda,t) = E(t) + \frac{A(t)}{\lambda^2-\lambda_u^2} + \frac{B(t)}{\lambda^2/\lambda_I^2-1}, \qquad (23)$$

where λ is in units of μm,

t = T−293 in units of K,

λ_u = 0.29934 + 0.0001004 t in units of μm,

λ_I = 48.38 + 0.00629 t in units of μm,

$E(t) = 9.01536 + 1.44190 \times 10^{-3}t + 3.32973 \times 10^{-7}t^2 - 1.08158 \times 10^{-9}t^3 - 3.88394 \times 10^{-12}t^4$,

$A(t) = 0.24482 + 2.77806 \times 10^{-5}t + 1.01703 \times 10^{-8}t^2 - 4.51746 \times 10^{-11}t^3 + 4.18509 \times 10^{-13}t^4$,

$B(t) = 3.08889 + 1.13495 \times 10^{-3}t + 2.89063 \times 10^{-7}t^2 - 9.55657 \times 10^{-10}t^3 - 4.76123 \times 10^{-12}t^4$.

Equation (23) was used to calculate the recommended values of the refractive index of ZnSe with the results given in table 9 and plotted in figure 18. To provide visual comparison of calculated values with the experimental data, calculated values of a few specified wavelengths are plotted in figure 12 where excellent agreement is observed. Tables 10 and 11, respectively, give the calculated dn/dT and dn/dλ values based on the first derivatives of eq (23) with respect to T and λ. The corresponding plots are shown in figures 19 and 20.

Equation (23) is valid over the wavelength range from 0.55 to 18 μm and the temperature range from 93 to 618 K based on the available data and supporting evidence discussed earlier. Extrapolation beyond 618 K is not recommended as the temperature dependent terms are determined solely by data fitting calculations without any theoretical justification. The uncertainties of recommended values are estimated to be ±0.0004 over the entire wavelength and temperature ranges based on the standard deviation of data fitting had the possible discrepancies due to sample preparation under similar controlled conditions.

Uncertainties in the recommended dn/dT values are estimated based on the results of data fitting calculation and that reported by Feldman et al. which are the primary source of the data for eq (23). Their reported uncertainties are $\pm 0.1 \times 10^{-5} K^{-1}$ at all the four wavelengths investigated. Our calculation, however, indicated a higher value of $\pm 0.2 \times 10^{-5} K^{-1}$. Error bars corresponding to the latter are indicated in figures 16 and 17 where calculations are compared with experimental data.

Table 9. Recommended values on the refractive index of CVD ZnSe

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
0.55	2.6346	2.6401	2.6463	2.6530	2.6601	2.6674	2.6749	2.6828	2.6911	2.7003	2.7105	2.7162
0.60	2.5927	2.5973	2.6024	2.6079	2.6137	2.6196	2.6257	2.6320	2.6387	2.6460	2.6542	2.6587
0.65	2.5627	2.5667	2.5712	2.5760	2.5810	2.5861	2.5913	2.5968	2.6025	2.6087	2.6157	2.6196
0.70	2.5402	2.5439	2.5479	2.5523	2.5568	2.5614	2.5662	2.5710	2.5762	2.5817	2.5879	2.5914
0.75	2.5230	2.5263	2.5301	2.5342	2.5384	2.5427	2.5470	2.5515	2.5563	2.5614	2.5671	2.5702
0.80	2.5093	2.5125	2.5162	2.5200	2.5240	2.5280	2.5322	2.5364	2.5408	2.5456	2.5510	2.5539
0.85	2.4984	2.5015	2.5049	2.5086	2.5124	2.5163	2.5203	2.5243	2.5286	2.5332	2.5382	2.5410
0.90	2.4894	2.4924	2.4958	2.4994	2.5030	2.5068	2.5106	2.5145	2.5186	2.5231	2.5279	2.5306
0.95	2.4819	2.4849	2.4882	2.4917	2.4953	2.4990	2.5027	2.5065	2.5105	2.5147	2.5195	2.5221
1.0	2.4757	2.4786	2.4818	2.4853	2.4888	2.4924	2.4960	2.4998	2.5037	2.5078	2.5124	2.5150
1.5	2.4448	2.4476	2.4506	2.4537	2.4570	2.4603	2.4636	2.4671	2.4706	2.4744	2.4785	2.4807
2.0	2.4342	2.4369	2.4399	2.4430	2.4462	2.4494	2.4527	2.4560	2.4595	2.4631	2.4671	2.4693
2.5	2.4290	2.4317	2.4347	2.4377	2.4409	2.4441	2.4473	2.4506	2.4541	2.4577	2.4616	2.4637
3.0	2.4258	2.4285	2.4314	2.4345	2.4376	2.4408	2.4440	2.4473	2.4507	2.4543	2.4582	2.4603
3.5	2.4234	2.4261	2.4290	2.4321	2.4352	2.4384	2.4416	2.4449	2.4483	2.4519	2.4558	2.4579
4.0	2.4215	2.4241	2.4271	2.4301	2.4332	2.4364	2.4396	2.4429	2.4463	2.4498	2.4537	2.4558
4.5	2.4197	2.4223	2.4252	2.4283	2.4314	2.4346	2.4377	2.4410	2.4444	2.4480	2.4518	2.4539
5.0	2.4179	2.4206	2.4235	2.4265	2.4296	2.4328	2.4359	2.4392	2.4426	2.4461	2.4500	2.4521
5.5	2.4161	2.4188	2.4217	2.4247	2.4278	2.4309	2.4341	2.4374	2.4407	2.4443	2.4482	2.4503
6.0	2.4142	2.4169	2.4198	2.4228	2.4259	2.4290	2.4322	2.4355	2.4388	2.4424	2.4463	2.4484
6.5	2.4123	2.4150	2.4178	2.4209	2.4239	2.4271	2.4302	2.4335	2.4368	2.4404	2.4443	2.4464
7.0	2.4103	2.4129	2.4158	2.4188	2.4219	2.4250	2.4282	2.4314	2.4347	2.4383	2.4422	2.4443
7.5	2.4081	2.4107	2.4136	2.4166	2.4197	2.4228	2.4259	2.4292	2.4325	2.4361	2.4400	2.4421
8.0	2.4058	2.4084	2.4113	2.4143	2.4173	2.4204	2.4236	2.4268	2.4302	2.4337	2.4376	2.4398
8.5	2.4033	2.4059	2.4088	2.4118	2.4148	2.4179	2.4211	2.4243	2.4276	2.4312	2.4352	2.4373
9.0	2.4007	2.4033	2.4062	2.4092	2.4122	2.4153	2.4184	2.4216	2.4250	2.4286	2.4325	2.4347
9.5	2.3980	2.4006	2.4034	2.4064	2.4094	2.4125	2.4156	2.4188	2.4222	2.4257	2.4297	2.4319
10.0	2.3950	2.3976	2.4005	2.4034	2.4065	2.4095	2.4127	2.4158	2.4192	2.4228	2.4267	2.4289
10.5	2.3919	2.3945	2.3974	2.4003	2.4033	2.4064	2.4095	2.4127	2.4160	2.4196	2.4236	2.4258
11.0	2.3887	2.3912	2.3941	2.3970	2.4000	2.4031	2.4062	2.4094	2.4127	2.4163	2.4203	2.4225
11.5	2.3852	2.3878	2.3906	2.3935	2.3965	2.3996	2.4027	2.4058	2.4092	2.4128	2.4168	2.4190
12.0	2.3815	2.3841	2.3869	2.3898	2.3928	2.3959	2.3990	2.4021	2.4055	2.4091	2.4131	2.4153

Table 9. Recommended values on the refractive index of CVD ZnSe--Continued

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
12.5	2.3777	2.3802	2.3830	2.3860	2.3890	2.3920	2.3951	2.3982	2.4015	2.4052	2.4092	2.4115
13.0	2.3736	2.3762	2.3790	2.3819	2.3849	2.3879	2.3909	2.3941	2.3974	2.4011	2.4051	2.4074
13.5	2.3693	2.3719	2.3747	2.3776	2.3806	2.3836	2.3866	2.3898	2.3931	2.3967	2.4008	2.4031
14.0	2.3648	2.3674	2.3701	2.3731	2.3760	2.3790	2.3821	2.3852	2.3885	2.3922	2.3963	2.3986
14.5	2.3601	2.3626	2.3654	2.3683	2.3713	2.3742	2.3773	2.3804	2.3837	2.3874	2.3916	2.3939
15.0	2.3551	2.3576	2.3604	2.3633	2.3662	2.3692	2.3723	2.3754	2.3787	2.3824	2.3866	2.3890
15.5	2.3498	2.3524	2.3551	2.3580	2.3610	2.3640	2.3670	2.3701	2.3735	2.3772	2.3814	2.3838
16.0	2.3443	2.3468	2.3496	2.3525	2.3555	2.3584	2.3614	2.3646	2.3679	2.3716	2.3759	2.3783
16.5	2.3385	2.3411	2.3438	2.3467	2.3497	2.3526	2.3556	2.3588	2.3621	2.3659	2.3702	2.3726
17.0	2.3324	2.3350	2.3377	2.3406	2.3436	2.3465	2.3495	2.3527	2.3560	2.3598	2.3642	2.3666
17.5	2.3260	2.3286	2.3313	2.3342	2.3372	2.3401	2.3431	2.3463	2.3496	2.3534	2.3578	2.3604
18.0	2.3193	2.3218	2.3246	2.3275	2.3305	2.3334	2.3364	2.3396	2.3429	2.3468	2.3512	2.3538

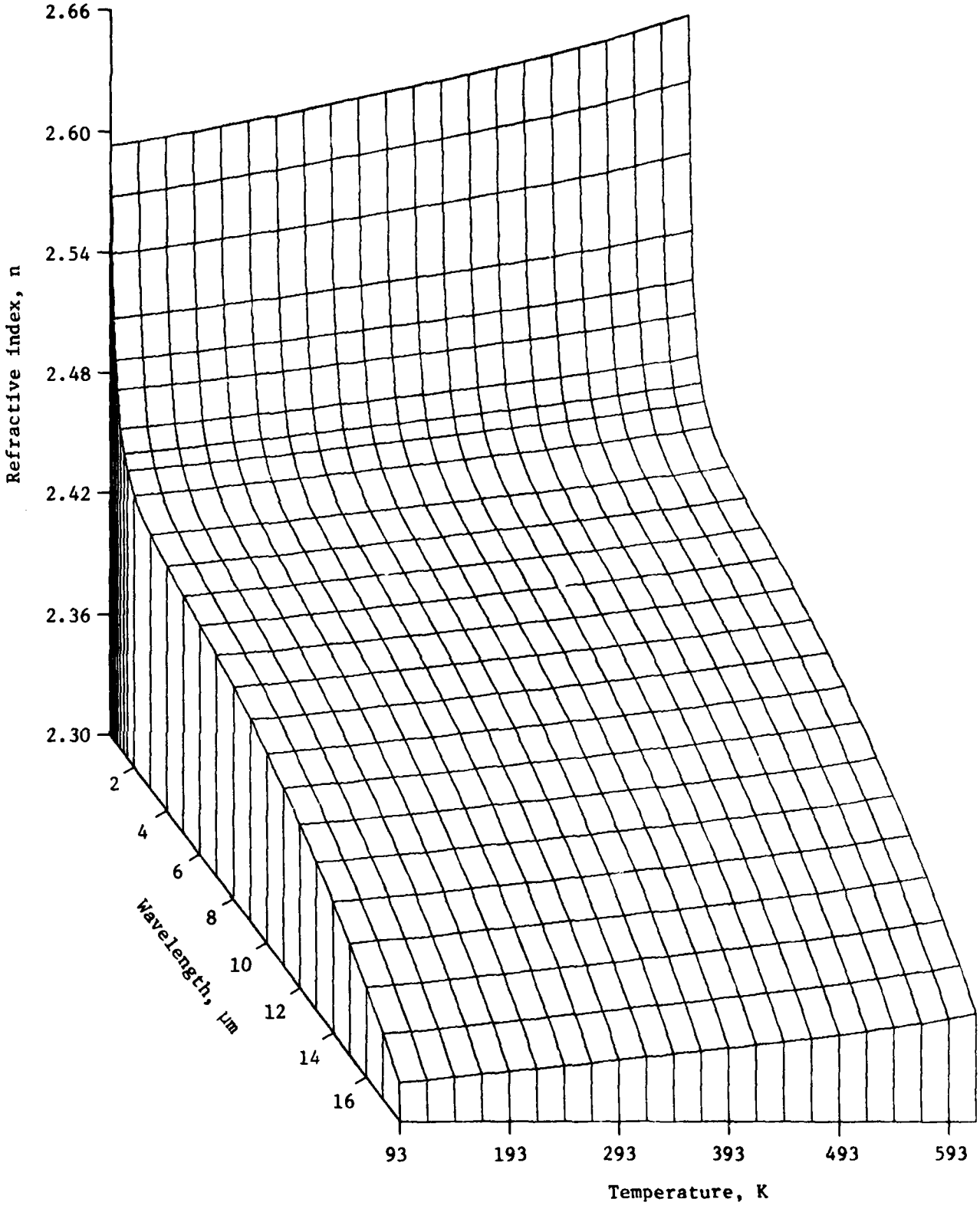

Figure 18. Recommended n-λ-T diagram of ZnSe.

Table 10. Recommended values (in units of $10^{-5}K^{-1}$) on the temperature derivative of refractive index of CVD ZnSe

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
0.55	10.2	11.9	13.0	13.8	14.3	14.8	15.3	16.2	17.4	19.3	21.9	23.6
0.60	8.4	9.8	10.7	11.3	11.7	12.0	12.4	13.0	13.9	15.4	17.5	18.8
0.65	7.3	8.5	9.3	9.8	10.1	10.4	10.6	11.1	11.9	13.1	14.9	16.0
0.70	6.6	7.8	8.5	8.9	9.2	9.3	9.6	10.0	10.6	11.7	13.3	14.3
0.75	6.2	7.2	7.9	8.3	8.5	8.7	8.8	9.2	9.8	10.7	12.1	13.1
0.80	5.9	6.9	7.5	7.8	8.0	8.2	8.3	8.7	9.2	10.1	11.4	12.2
0.85	5.7	6.6	7.2	7.5	7.7	7.8	8.0	8.3	8.8	9.6	10.8	11.6
0.90	5.6	6.4	7.0	7.3	7.5	7.6	7.7	8.0	8.5	9.2	10.4	11.1
0.95	5.5	6.3	6.8	7.1	7.3	7.4	7.5	7.8	8.2	8.9	10.0	10.7
1.0	5.4	6.2	6.7	7.0	7.1	7.2	7.4	7.6	8.0	8.7	9.8	10.4
1.5	5.1	5.8	6.2	6.4	6.6	6.6	6.7	6.9	7.3	7.8	8.7	9.2
2.0	5.1	5.7	6.1	6.3	6.4	6.5	6.6	6.8	7.1	7.6	8.4	8.9
2.5	5.1	5.7	6.0	6.3	6.4	6.4	6.5	6.7	7.0	7.5	8.2	8.7
3.0	5.1	5.6	6.0	6.2	6.3	6.4	6.5	6.7	7.0	7.5	8.2	8.7
3.5	5.1	5.6	6.0	6.2	6.3	6.4	6.5	6.6	6.9	7.4	8.2	8.6
4.0	5.0	5.6	6.0	6.2	6.3	6.4	6.5	6.6	6.9	7.4	8.2	8.6
4.5	5.0	5.6	6.0	6.2	6.3	6.4	6.4	6.6	6.9	7.4	8.2	8.6
5.0	5.0	5.6	6.0	6.2	6.3	6.3	6.4	6.6	6.9	7.4	8.2	8.6
5.5	5.0	5.6	5.9	6.1	6.3	6.3	6.4	6.6	6.9	7.4	8.2	8.7
6.0	5.0	5.6	5.9	6.1	6.2	6.3	6.4	6.6	6.9	7.4	8.2	8.7
6.5	5.0	5.6	5.9	6.1	6.2	6.3	6.4	6.6	6.9	7.4	8.2	8.7
7.0	5.0	5.6	5.9	6.1	6.2	6.3	6.4	6.6	6.9	7.4	8.2	8.7
7.5	5.0	5.5	5.9	6.1	6.2	6.3	6.4	6.6	6.9	7.4	8.3	8.8
8.0	5.0	5.5	5.9	6.1	6.2	6.2	6.3	6.5	6.9	7.5	8.3	8.8
8.5	4.9	5.5	5.9	6.1	6.2	6.2	6.3	6.5	6.9	7.5	8.3	8.9
9.0	4.9	5.5	5.9	6.0	6.1	6.2	6.3	6.5	6.9	7.5	8.3	8.9
9.5	4.9	5.5	5.8	6.0	6.1	6.2	6.3	6.5	6.9	7.5	8.4	9.0
10.0	4.9	5.5	5.8	6.0	6.1	6.2	6.3	6.5	6.9	7.5	8.4	9.0
10.5	4.9	5.5	5.8	6.0	6.1	6.2	6.3	6.5	6.9	7.5	8.5	9.1
11.0	4.9	5.4	5.8	6.0	6.1	6.1	6.3	6.5	6.9	7.6	8.5	9.1
11.5	4.8	5.4	5.8	6.0	6.1	6.1	6.2	6.5	6.9	7.6	8.6	9.2

Table 10. Recommended values (in units of $10^{-5}K^{-1}$) on the temperature derivative of refractive index of CVD ZnSe--Continued

λ, μm	Temperature, K											
	93	143	193	243	293	343	393	443	493	543	593	618
12.0	4.8	5.4	5.8	6.0	6.0	6.1	6.2	6.5	6.9	7.6	8.6	9.3
12.5	4.8	5.4	5.8	5.9	6.0	6.1	6.2	6.5	6.9	7.6	8.7	9.4
13.0	4.8	5.4	5.7	5.9	6.0	6.1	6.2	6.4	6.9	7.7	8.8	9.5
13.5	4.8	5.4	5.7	5.9	6.0	6.0	6.2	6.4	6.9	7.7	8.8	9.5
14.0	4.8	5.4	5.7	5.9	6.0	6.0	6.2	6.4	6.9	7.7	8.9	9.6
14.5	4.8	5.4	5.7	5.9	5.9	6.0	6.1	6.4	7.0	7.8	9.0	9.7
15.0	4.7	5.4	5.7	5.9	5.9	6.0	6.1	6.4	7.0	7.8	9.1	9.9
15.5	4.7	5.4	5.7	5.9	5.9	6.0	6.1	6.4	7.0	7.9	9.2	10.0
16.0	4.7	5.4	5.7	5.9	5.9	6.0	6.1	6.4	7.0	7.9	9.3	10.1
16.5	4.7	5.4	5.7	5.8	5.9	6.0	6.1	6.4	7.0	8.0	9.4	10.3
17.0	4.7	5.4	5.7	5.8	5.9	5.9	6.1	6.4	7.1	8.1	9.5	10.4
17.5	4.7	5.4	5.7	5.8	5.9	5.9	6.1	6.5	7.1	8.1	9.6	10.6
18.0	4.7	5.4	5.7	5.8	5.9	5.9	6.1	6.5	7.1	8.2	9.8	10.7

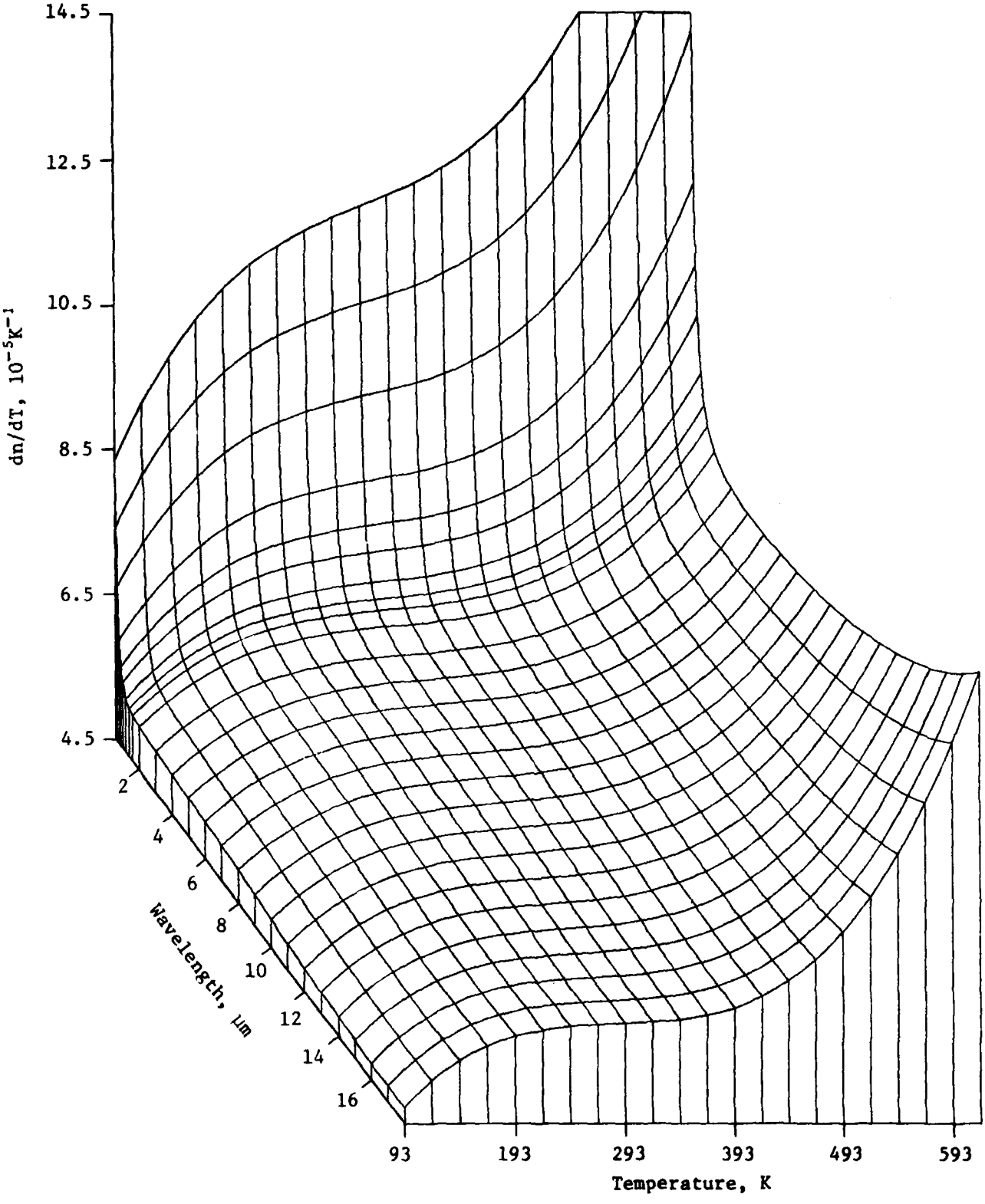

Figure 19. Recommended dn/dT-λ-T diagram of ZnSe.

Table 11. Recommended values on the wavelength derivative of refractive index of CVD ZnSe

λ, μm	$-\frac{dn}{d\lambda}$, $10^{-3}\mu m^{-1}$	λ, μm	$-\frac{dn}{d\lambda}$, $10^{-3}\mu m^{-1}$
0.55	1117.1	7.5	4.5
0.60	769.0	8.0	4.8
0.65	556.7	8.5	5.1
0.70	418.5	9.0	5.4
0.75	323.9	9.5	5.7
0.80	256.6	10.0	6.1
0.85	207.2	10.5	6.4
0.90	170.1	11.0	6.8
0.95	141.6	11.5	7.2
1.0	119.2	12.0	7.6
1.5	32.8	12.5	8.0
2.0	14.2	13.0	8.4
2.5	8.0	13.5	8.8
3.0	5.4	14.0	9.3
3.5	4.3	14.5	9.8
4.0	3.8	15.0	10.3
4.5	3.6	15.5	10.8
4.8[a]	3.58[a]	16.0	11.3
5.0	3.6	16.5	11.9
5.5	3.7	17.0	12.5
6.0	3.8	17.5	13.1
6.5	4.0	18.0	13.7
7.0	4.3		

[a]Minimum point on the curve.

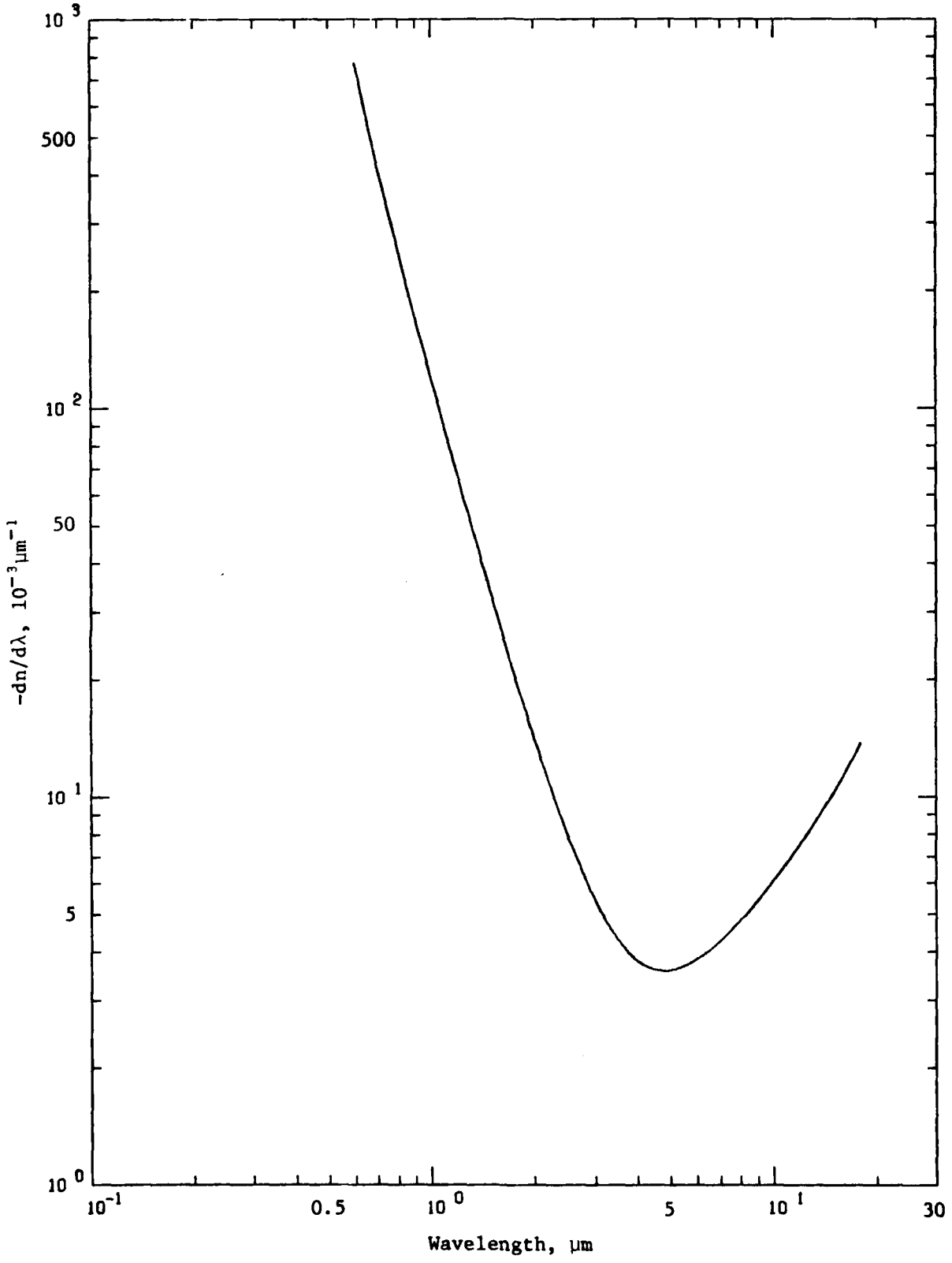

Figure 20. Recommended dn/dλ curve of ZnSe at 293 K.

Uncertainties of the recommended $dn/d\lambda$ values are estimated based on eq (21). Using $\delta n = \pm 0.0004$, the $\delta(dn/d\lambda)$ values are $\pm 4 \times 10^{-3} K^{-1}$ at 0.6 μm, $\pm 2 \times 10^{-3} K^{-1}$ at 1 μm, $\pm 0.3 \times 10^{-3} K^{-1}$ at 5 μm, $\pm 0.2 \times 10^{-3} K^{-1}$ at 10 μm, $\pm 0.1 \times 10^{-3} K^{-1}$ at 15 μm, and $\pm 0.1 \times 10^{-3} K^{-1}$ at 18 μm.

3.3. Zinc Telluride, ZnTe

There are 22 sets of experimental data available for the refractive index of zinc telluride as tabulated in table A-9 and plotted in figure 21 where some of the data sets are for thin films included for the purpose of comparison. It should be noted that all of these available data are at room temperature except those of Hattori et al. [19]. Presently, refractive index data in the fundamental transparent region at other temperatures are not yet available. As a result, our data analysis is limited to room temperature. Refractive index of bulk ZnTe in the transparent region are reported by Aten et al. [72], Shiozawa et al. [73-75,78,79], Marple [48], and Horikoshi [80]. Data sets reported by Hattori et al. [19] are the only available data in the far infrared wavelength range from about 102 to 583 μm. The data reported by Manabe et al. [16] and by Hadni et al. [55,56] concerns with the characteristics of the reststrahlen region; and the data of Cardona [77] are in the electronic absorption region.

In an effort to study the direct and phonon-assisted optical transitions in zinc telluride, Aten et al. [72] measured refractive index over a wavelength range from 0.56 to 2.34 μm to determine the necessary parameter to correlate the energies of longitudinal and transverse phonons. Although the refractive index data were obtained with the minimum deviation method for a sample of very low impurity concentration, this data set listed in table A-9 are expected to have uncertainties in the second decimal place for they were digitized from a graph.

Shiozawa et al. [73-75,78,79] reported two sets of data for synthetic crystals of ZnTe measured with minimum deviation method. The first data set was observed over the visible region for a small sample of apparent impurities. The results were considered as preliminary and were plotted in the form of $1/(n^2-1)$ vs $1/\lambda^2$ in order to test the form of the dispersion. The measured values did fall on a straight line in the plot, but the predicted value of 8.24 for optical dielectric constant is much higher than that for purer samples.

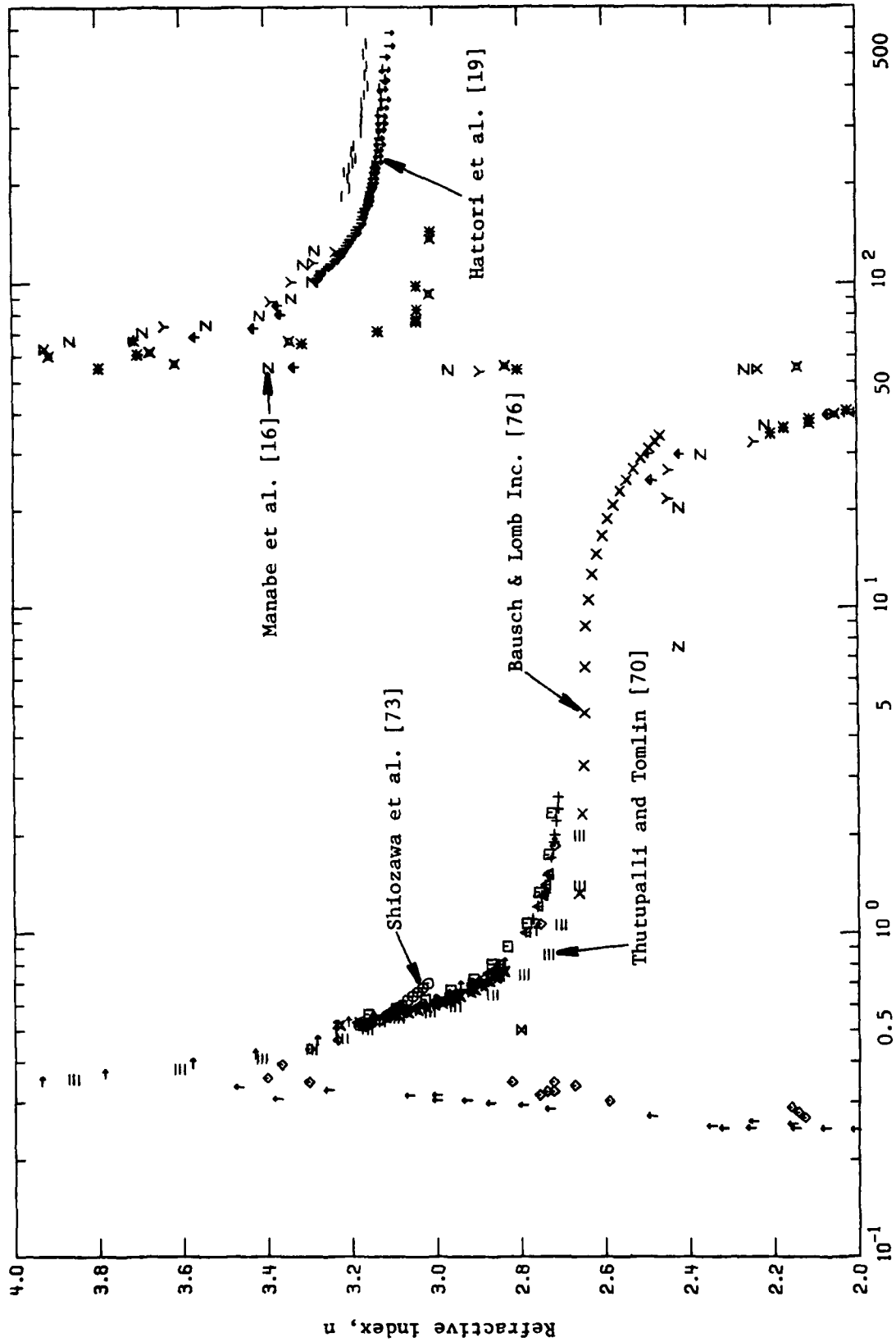

Figure 21. Available experimental refractive index of ZnTe (wavelength dependence).

The second set was obtained over an extended wavelength range from 0.569 to 1.515 μm for a purer crystal, containing some twinning, cut from a boule grown by sublimation method. The reported uncertainty of the refractive index measurements is ±0.002. The optical dielectric constant predicted by this data set is 7.26 ± 0.03, in good agreement with other literature values.

For the purpose of obtaining consistent refractive indices of ZnTe over a wavelength range from the short-wave transmission limit set by the band gap to 2.06 μm, Marple [48,49] measured the refractive index of two ZnTe samples with a variety of impurities, of the order 10-20 ppm, grown by sublimation in argon atmosphere. Experimental error of the data is ±0.003 or less; the results for two prisms differ by up to 0.003 in the entire wavelength region consistently within the possible combined experimental error for the two sets of data. As shown in table 12, the equation $n^2 = A + B\lambda^2/(\lambda^2-C^2)$ was used to fit experimental data for each prism with A, B, and C being adjustable parameters. Because of the limited spectral range, A, B, and C were not fitted to the data with a more realistic theory of the dielectric constants. However, the best-fit values of A, B, and C for each of the two prisms indicate an average value of 7.28 for the optical dielectric constant of ZnTe.

Similar to Marple's work, Horikoshi et al. [80] measured refractive index of ZnTe samples containing detectable impurities of the order of 100 ppm. The crystals were grown by a vapor phase technique in a vacuum or an argon atmosphere or were grown from a melt. The average values of refractive index by minimum deviation method were fitted to an equation of the form of $n^2 = A + B/(\lambda^2-C^2)$ as given in table 12. Although the experimental error is not reported with the data, it is likely to be of the order ±0.01 estimated from their graphical presentation. When compared with the data reported by other investigators it is revealed that their samples correspond closely to one of the samples measured by Marple as evidenced by close agreement of the constants A, B, and C in the dispersion equations (see table 12). For the purpose of ease of comparison, the differences between the above mentioned data sets and the recommended values for the transparent region are plotted in figure 22.

The indices of refraction of ZnTe in the far infrared spectral range from 102 to 584 μm were measured by Hattori, et al. [19] at temperatures 2, 80, and 300 K. The results were described by a simple dispersion equation, shown in table 12, for an undamped harmonic oscillator from which the static dielectric

Table 12. Comparison of dispersion equations proposed for ZnTe

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Marple, D.T.F., 1964 [48]	0.57-2.6 μm 298 K	for one sample: $n^2 = 3.96 + \frac{3.29\ \lambda^2}{\lambda^2 - (0.366)^2}$ for less pure sample: $n^2 = 4.58 + \frac{2.72\ \lambda^2}{\lambda^2 - (0.3875)^2}$
Manabe, A., Mitsuishi, A., Yoshinaga, H., 1967 [16]	24-85 μm at 300 K 42-67 μm at 100 K	$n^2-k^2 = \varepsilon_\infty + \frac{N\ (1-\Omega^2)}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ $2nk = \frac{N\delta\Omega}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ at 300 K: $\varepsilon_\infty = 6.7$, $\lambda_I = 56.50$ μm, $\delta = 0.017$, and $N = 2.4$; at 100 K: $\varepsilon_\infty = 6.7$, $\lambda_I = 55.56$ μm, $\delta = 0.013$, and $N = 2.4$.
Handi, A., Henry, P., Lambert, J.P., Morlot, G., Strimer, P., and Chanal, D., 1967 [55]	36-136 μm at 290 K 34-144 μm at 80 K	$n^2-k^2 = \varepsilon_\infty + \frac{(\varepsilon_0-\varepsilon_\infty)\ (1-\Omega^2)}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ $2nk = \frac{(\varepsilon_0-\varepsilon_\infty)\ \delta\Omega}{(1-\Omega^2)^2 + \delta^2\Omega^2}$ at 290 K: $\varepsilon_\infty = 6.2$, $\varepsilon_0 = 8.3$, $\lambda_I = 56.5$ μm, and $\delta = 0.075$;

Table 12. Comparison of dispersion equations proposed for ZnTe--Continued

Source	Wavelength and temperature ranges	Dispersion equation λ in μm, $\Omega = \lambda_I/\lambda$
Handi, A., et al., 1967 [55], cont.		at 90 K: $\varepsilon_\infty = 6.1$, $\varepsilon_0 = 8.3$, $\lambda_I = 55.34$ μm, and $\delta = 0.063$.
Hattori, T., Homma, Y., Mitsuishi, A., and Tacke, M., 1973 [19]	184-542 μm at 300 K 161-452 μm at 80 K 102-584 μm at 2 K	$n^2 = \frac{\varepsilon_0 - \varepsilon_\infty \Omega^2}{1 - \Omega^2}$ at 300 K: $\varepsilon_0 = 9.92$, $\varepsilon_\infty = 6.0$, and $\lambda_I = 55.56$ μm; at 80 K: $\varepsilon_0 = 9.65$, $\varepsilon_\infty = 6.2$, and $\lambda_I = 52.63$ μm; at 2 K: $\varepsilon_0 = 9.63$, $\varepsilon_\infty = 6.3$, and $\lambda_I = 52.08$ μm.
Horikoshi, Y., Ebina, A., and Takahashi, T., 1972 [80]	0.55-0.76 μm at 300 K 97 K	at 300 K: $n^2 = 4.56 + \frac{2.7090\,\lambda^2}{\lambda^2 - (0.38637)^2}$ at 97 K: $n^2 = 4.36 + \frac{2.4615\,\lambda^2}{\lambda^2 - (0.38451)^2}$
Present work, 1982	0.55-30 μm at 293 K	$n^2 = 9.92 + \frac{0.42530}{\lambda^2 - (0.37766)^2} + \frac{2.63580}{\lambda^2/56.5^2 - 1}$

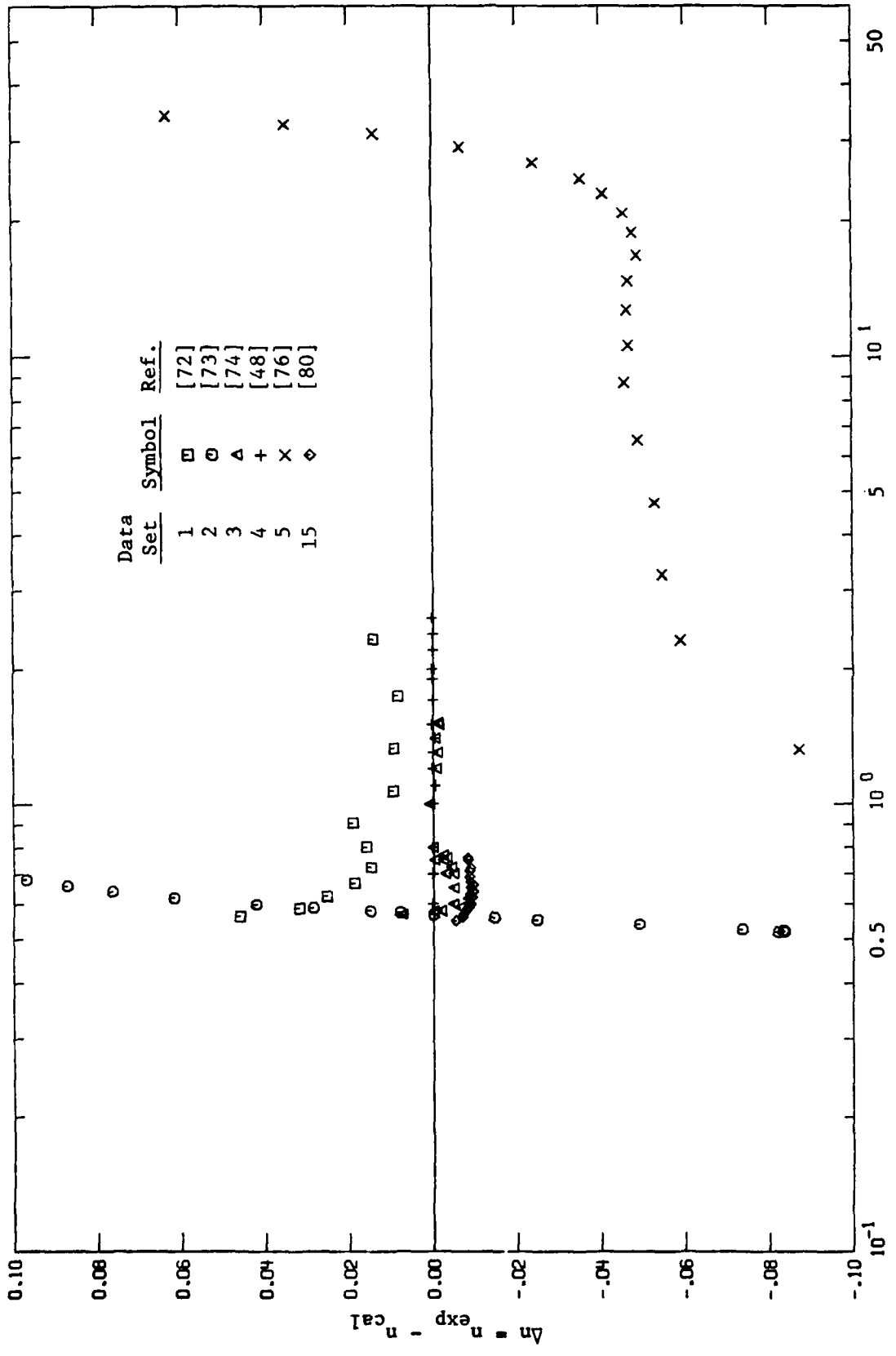

Figure 22. Comparison of experimental and calculated refractive index values of ZnTe at room temperature. The calculated values from eq (24) are represented by the line $\Delta n = 0$. Refer to table A-9 for the corresponding data sets.

constant, optical dielectric constant, and wavelength of TO mode phonon were determined with least-squares fit. The static dielectric constant serves as a check for the values obtained from other reports. Since the data were measured by interference method and the value of ε_0 was obtained in long wavelength region, it is believed to be reliable and should be adopted as a known parameter in the dispersion equation of ZnTe.

Manabe et al. [16] studied optical constants in the reststrahlen region by means of infrared lattice reflection spectra in the spectral region between 20 μm and 85 μm which were analyzed using Drude dispersion relation. The oscillator strength, N, optical dielectric constant, ε_∞, damping factor, δ, and wavelength of transverse optical phonon, λ_I, in the Drude equations (shown in tables 12 and 13) were determined by least-squares fit of reflectivity data. The wavelength of transverse optical phonon was also determined directly from transmission spectrum of an evaporated thin film and was found to agree with that obtained from the reflection spectra analysis. The static dielectric constant, ε_0, was determined by letting $\lambda = \infty$ in the resulting Drude equation assuming zero absorption, i.e., $\varepsilon_0 = n^2 = \varepsilon_\infty + N\lambda_I^2$. Optical constants in the reststrahlen region were also studied by Hadni et al. [55,56] for ZnTe pellet sample at temperatures 80 and 290 K. The various parameters, ε_0, ε_∞, and λ_I, were determined from analyzing the reflection and transmission spectra with the Kramers-Kronig relations and with the Lorentz one-oscillator model as shown in table 12. Cardona [77] investigated the optical properties in the ultraviolet region for the determination of the optical dielectric constant, using Penn's model, based on the observation of the peak positions in the ultraviolet spectra of various properties. The value of ε_∞, 7.2, determined from reflectivity peaks agree well with those from dispersion equations of other investigators.

From the brief review of the available data sets given above, it is clear that the correct values of the parameters ε_0, ε_∞, and λ_I for eq (9) are about 9.92, 7.26, and 56.5 μm, respectively. Decision remains to be made is in choosing the reliable data for the determination of the constants A, B, and λ_u. Although it is noted in the case of ZnSe that the data sets reported by Marple are not only discrepant significantly from the measurements of other investigators but also lacking in internal consistency for different samples because of difference in impurity contents. Although the ZeTe samples measured

Table 13. Available data on ε_∞, ε_0, and λ_I of ZnTe

Temp., K	ε_∞	ε_0	λ_I, μm	Ref.
300	6.7	9.1	56.50,55.87	[16]
300		10.10		[24]
300	7.28			[48]
300			56.34	[83]
300	6.0	9.92	55.56	[19]
300	6.2	8.3	56.50	[56]
300	6.7	9.1	56.50	[59]
300			52.63	[27]
300			56.50	[61]
300	7.26			[79]
300		18.6		[84]
300		10.1		[85]
80	6.2	9.65	52.63	[19]
80	6.1	8.3	55.34	[56]
80	6.7	9.1	55.56	[59]
80	6.7	9.1	55.56	[16]
2	6.3	9.63	52.08	[19]

by him have impurity levels as much as in his ZnSe samples, it is found that the refractive index of ZnTe is not so sensitive to impurity contents as in the case of ZnSe samples. The first evidence is that the two sets of data reported by Marple for different samples agree within the experimental error; the second is that the data by Shiozawa et al., though for samples having crystal defects of different nature, agree with data by Marple within the errors combined, i.e., ± 0.005. Additional evidence was observed from the data of Horikoshi et al. [80], whose sample had impurities five times higher than that used by Marple, and yet the data agree within the experimental uncertainties. Based on the consideration given above and its wide spectral coverage, the data set by Marple was taken as the basis for the data fitting calculation.

The selected data set is numerically fitted to eq (9). Since the available data is limited to the region between 0.57 and 2.6 μm while the transparent region of ZnTe extends up to over 30 μm, it is necessary to hold the parameters ε_0 and λ_I at fixed values, 9.92 and 56.5 μm. This was confidently done because in the cases of ZnS and ZnSe, the best-fit values of ε_0 and λ_I are found in close agreement with the selected literature values. It is reasonable to assume that uncertainties in these types of calculation can be held to minimum as long as the parameter values for ZnTe come from the same sources. The constants A, B, and λ_u are then determined by least-square fit. The dispersion equation for ZnTe at room temperature thus obtained is

$$n^2 = 9.92 + \frac{0.42530}{\lambda^2 - (0.37766)^2} + \frac{2.63580}{\lambda^2/56.5^2 - 1} \qquad (24)$$

where λ is in units of μm. Equation (24) is valid in the wavelength range from 0.57 to 30 μm. In figure 22, deviations of available data in the fundamental transparent region from those calculated from eq (24) are plotted for visual comparison in which a data set for film from Bausch and Lomb Inc. [76] is also included. It is interesting to note that as far as the dispersion is concerned the data set from Bausch and Lomb Inc. is consistent with eq (24) in the spectral range from 2 to 20 μm; large departure is observed at 1 μm and beyond 20 μm. A careful examination of the data from ref. [76], one can find that the reported data at wavelengths >20 μm are questionable. To make the point clear, the concerned graph from ref. [76] is reproduced in figure 23 for ease of discussion; were the largely deviated data point at the upper right of the figure not included, the curve in the wavelength region >20 μm would be

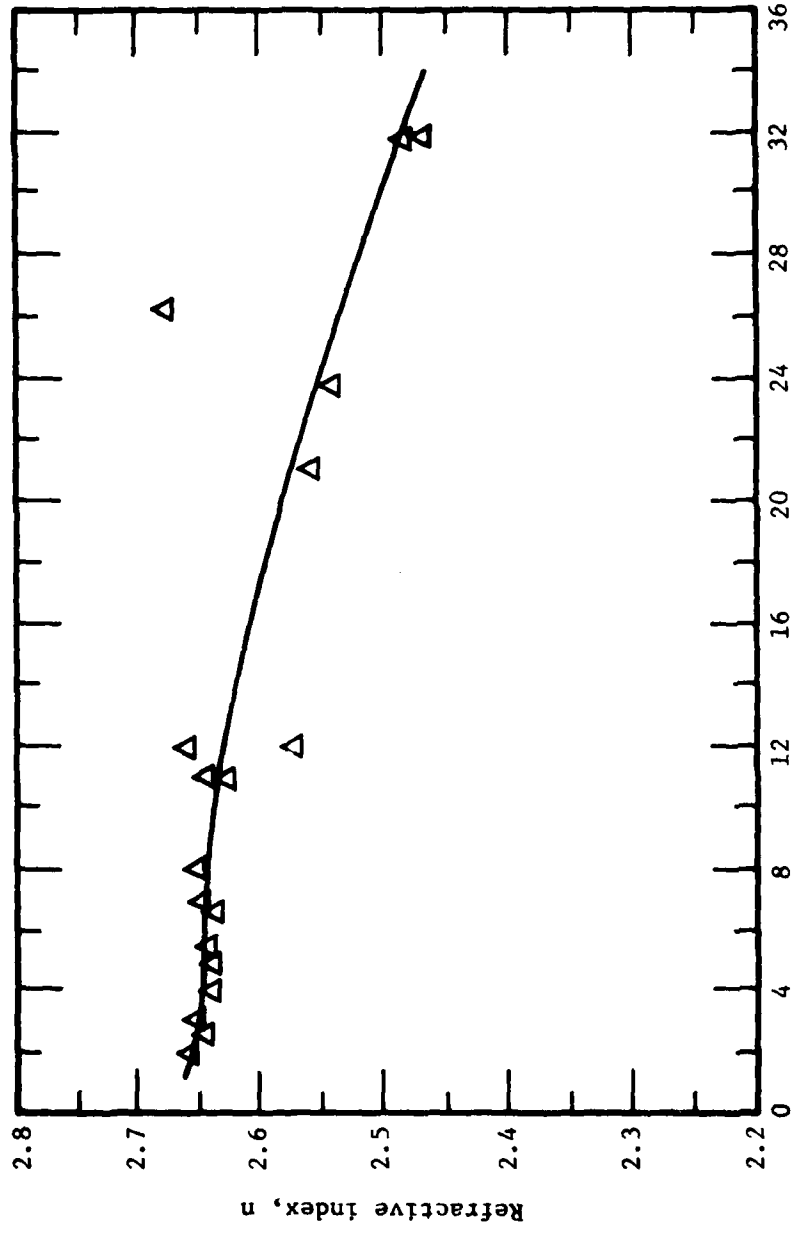

Figure 23. Measured dispersion of a ZnTe film reported in ref. [76].

considerably lowered and dispersion in that region would likely be consistent with that of eq (24). The largely deviated data point was either measured with very large uncertainty or originated from some unknown mechanisms. At any rate, the departure from consistent dispersion behavior shown in figure 23 is simply attributed to the decision made by the investigators on the shape of the curve. Other film data sets shown in figure 24 seem to support that film has normal dispersion as its corresponding bulk material.

Equation (24) was used to calculate the recommended values of the refractive index of ZnTe at room temperature. The recommended values are given in table 14 and plotted in figure 25 together with the experimental data sets discussed before. Uncertainties in the calculated values are estimated as follows. In the wavelength region between 0.57 to 2.6 μm, the estimated uncertainties are ±0.003 based on the uncertainties reported by Marple. In the region between 2.6 and 15 μm, larger uncertainties of the order ±0.005 are estimated because there is no experimental data available at wavelengths >2.6 μm. Since the dispersion in this region is low, the uncertainties should not be very much different from Marple's data. In the region between 15 and 30 μm, larger uncertainties are expected as the dispersion increases as the wavelength increased becoming closer to the reststrahlen region. The estimated upper limit of uncertainties in this region can be calculated from the expression

$$\pm\Delta n = 0.005 + \frac{B\lambda^2 \Delta\lambda_I}{2n\lambda_I^3(\lambda^2/\lambda_I^2-1)^2} \qquad (25)$$

where $\Delta\lambda_I = 0.63$ corresponds to the difference of the two possible values reported by Manabe [16] (see table 13). From this expression, the uncertainties in n are ±0.0056 at 17 μm, ±0.00059 at 20 μm, ±0.0067 at 25 μm, and ±0.0082 at 30 μm.

Equation (24) is also valid in the wavelength region 184-541 μm. The averaged differences between the experimental data and the calculated values are of the order of ±0.009. The dispersion in this region is rather small as the difference of two extreme refractive indices is only 0.059 but the uncertainty in the data is rather large (of the order ±0.005) as the data were digitized from a graph of low resolution. Under such condition, the reliability of the digitized values is compatible with the calculated ones. Therefore, no recommended values in this region are given and the readers are

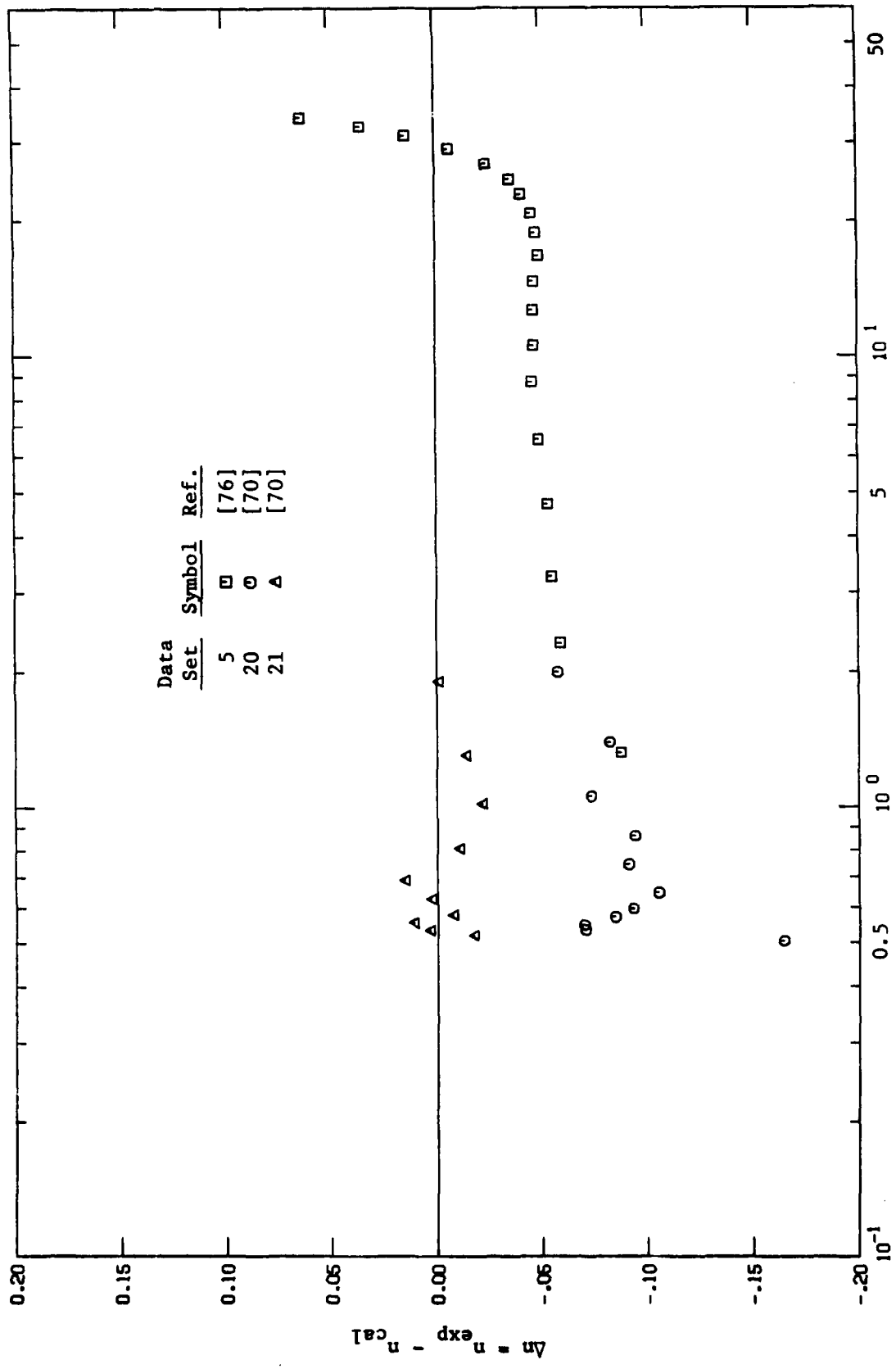

Figure 24. Comparison of experimental refractive indices of ZnTe films and calculated values for bulk ZnTe from eq (24). The calculated values are represented by the line $\Delta n = 0$. Refer to table A-9 for the corresponding data sets.

Table 14. Recommended values on the refractive index and its wavelength derivative of ZnTe at 293 K

λ, μm	n	$-\frac{dn}{d\lambda}$, $10^{-3}\mu m^{-1}$	λ, μm	n	$-\frac{dn}{d\lambda}$, $10^{-3}\mu m^{-1}$
0.55	3.153	2902.4	13.5	2.670	4.8
0.60	3.040	1776.8	14.0	2.667	5.0
0.65	2.967	1189.7	14.5	2.665	5.2
0.70	2.917	846.0	15.0	2.662	5.4
0.75	2.880	628.4	15.5	2.659	5.7
0.80	2.853	482.3	16.0	2.656	5.9
0.85	2.831	380.0	16.5	2.653	6.2
0.90	2.814	305.6	17.0	2.650	6.4
0.95	2.801	250.1	17.5	2.647	6.7
1.0	2.789	207.7	18.0	2.643	7.0
1.5	2.736	53.0	18.5	2.640	7.3
2.0	2.719	21.6	19.0	2.636	7.6
2.5	2.711	11.3	19.5	2.632	7.9
3.0	2.706	6.9	20.0	2.628	8.2
3.5	2.704	4.8	20.5	2.624	8.6
4.0	2.701	3.7	21.0	2.620	8.9
4.5	2.700	3.1	21.5	2.615	9.3
5.0	2.698	2.8	22.0	2.610	9.7
5.5	2.697	2.7	22.5	2.605	10.1
6.0	2.696	2.6	23.0	2.600	10.5
6.1[a]		2.6[a]	23.5	2.595	10.9
6.5	2.694	2.6	24.0	2.589	11.4
7.0	2.693	2.7	24.5	2.584	11.9
7.5	2.692	2.8	25.0	2.577	12.4
8.0	2.690	2.9	25.5	2.571	12.9
8.5	2.689	3.0	26.0	2.565	13.5
9.0	2.687	3.1	26.5	2.558	14.1
9.5	2.686	3.3	27.0	2.550	14.7
10.0	2.684	3.4	27.5	2.543	15.3
10.5	2.682	3.6	28.0	2.535	16.0
11.0	2.680	3.8	28.5	2.527	16.8
11.5	2.678	4.0	29.0	2.518	17.5
12.0	2.676	4.2	29.5	2.509	18.4
12.5	2.674	4.3	30.0	2.500	19.2
13.0	2.672	4.6			

[a]Minimum point on the dn/dλ curve.

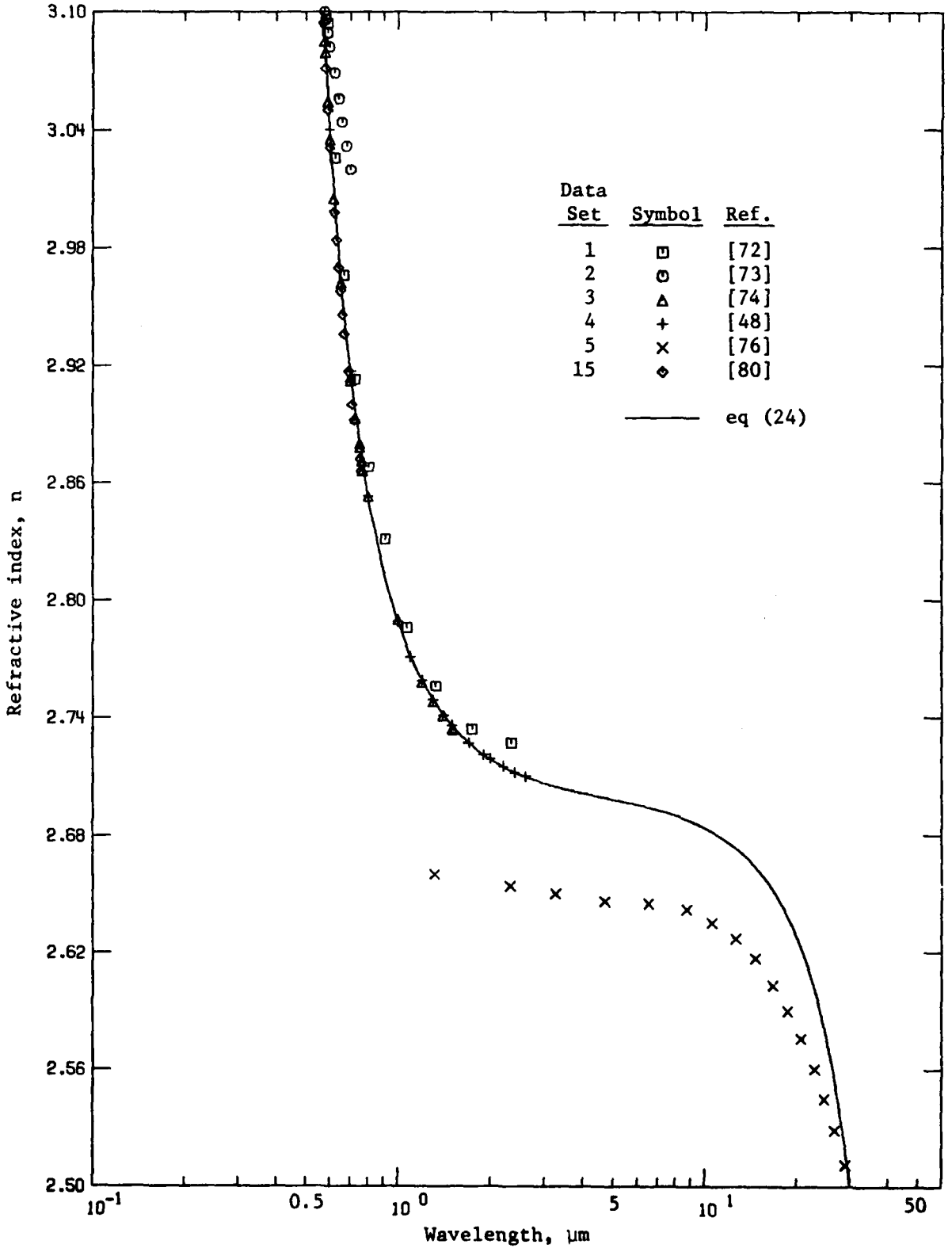

Figure 25. Recommended refractive index of ZnTe at 293 K.

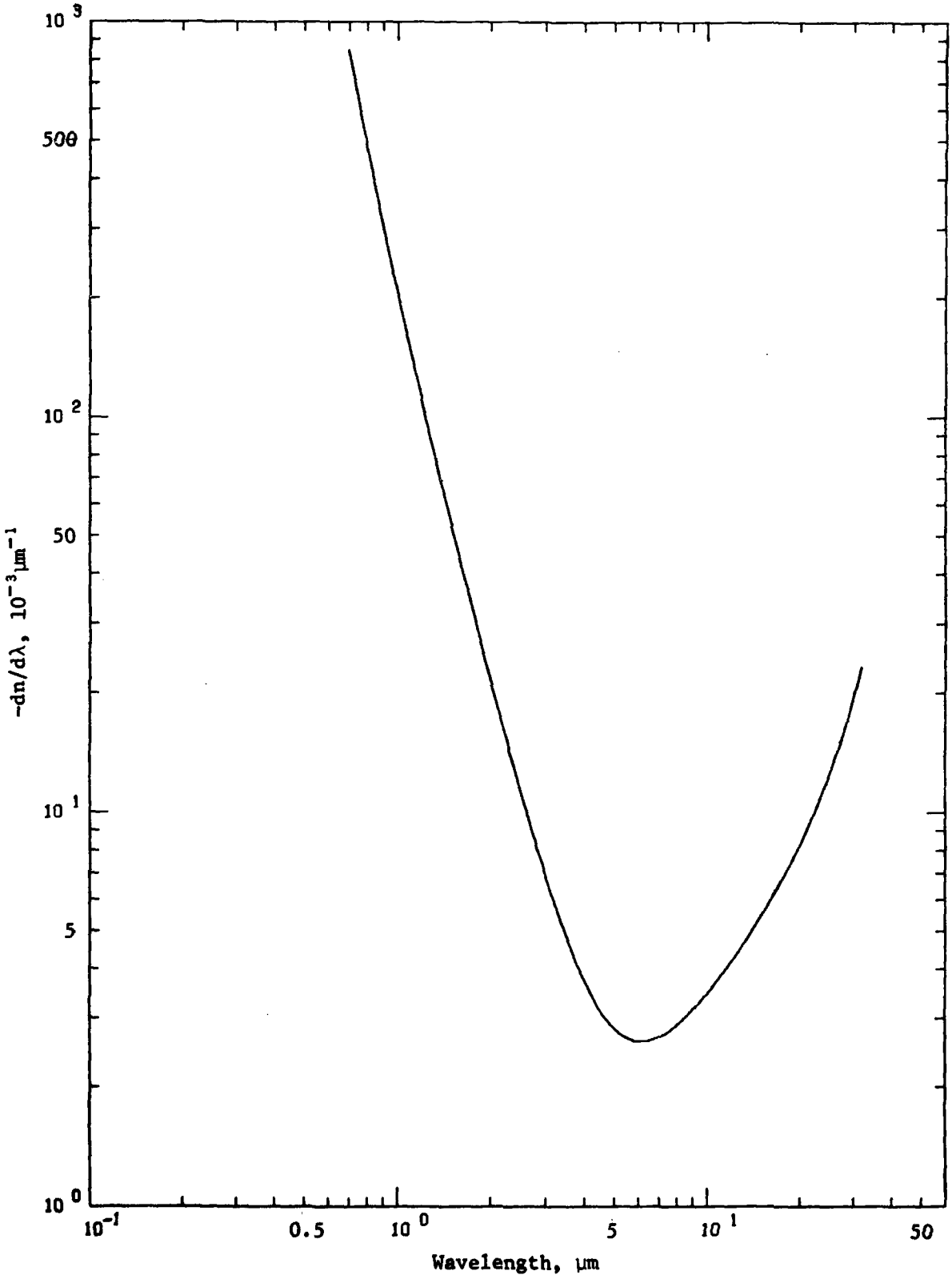

Figure 26. Recommended dn/dλ curve of ZnTe at 293 K.

referred to the corresponding digitized data in table A-9 for their application.

Uncertainties of the recommended $dn/d\lambda$ values are estimated based on eq (21). Using $\delta n = \pm 0.005$, the $\delta(dn/d\lambda)$ values are $\pm 42 \times 10^{-3}$ μm^{-1} at 0.7 μm, $\pm 24 \times 10^{-3}$ μm^{-1} at 1 μm, $\pm 4 \times 10^{-3}$ μm^{-1} at 5 μm, $\pm 2 \times 10^{-3}$ μm^{-1} at 10 μm, $\pm 1 \times 10^{-3}$ μm^{-1} in the range from 15 to 30 μm.

4. Discussions and Conclusions

Experimental data on the refractive index of zinc chalcogenides and its temperature derivative were exhaustively surveyed and reviewed and recommended values for these materials were generated based on the available data. Since the state of art of the refractive index of each of these materials has not been well defined, our recommendations should be considered at best representing the average values of selected data sets. Many factors are known to influence the accuracy of the results of refractive index determination. Two most important ones are the method used and the characteristics of the specimen. Although the minimum deviation method is known to be the most accurate way in determining the refractive index which in many cases are reported to the fifth decimal place, this reproducibility is applicable only for a given specimen on a given set of apparatus. For different specimens even from the same batch, the reproducibility of this method is at most in the fourth decimal place as the properties of the materials are influenced by many factors which are especially effective in the semiconductors. Among other things, the single most important factor is the impurity contents of the specimen. Although this is a well known source of error, unfortunately, this very piece of information is usually not reported. As a consequence, discrepancies among the available data cannot be reasonably resolved.

The empirical dispersion equations, eqs (21) and (23), used to generate recommended values of ZnS and ZnSe are both wavelength and temperature dependent. At a given temperature, the wavelength dependent equation is reduced to a Sellmeier type formula widely used to represent refractive index in the fundamental transparent region. At a given wavelength, however, the temperature dependent is simply a fourth degree polynomial function of

temperature. This is done here for the lack of reliable data of wide wavelength and temperature coverage and the lack of understanding of the real physical processes of optical properties of the materials under consideration. The majority of reported dn/dT measurements has been centered in a temperature region around the room temperature which is coincidentally a temperature range over which the dn/dT is least dispersive. As a result, all reports made a common statement that within the experimental error, the dn/dT does not vary with temperature. Such observation has been misleading theoretical studies in the interpretation of dn/dT data in which all assumed that dn/dT is relatively independent of temperature over a fairly wide temperature range, that the contributions to dn/dT (in the transparent region) from lattice are negligible, thus the variation of occupation number of phonon is not accounted for. In reality, however, the dn/dT does vary appreciably with temperature and the lattice term does have significant contribution particularly at long wavelengths, 10.6 μm for example, as discussed in the cases of ZnS and ZnSe. Referring to figures 6 and 16, the monotonic increase of dn/dT with increasing temperature in the region >400 K is real as supported by the data of other investigators. The physical mechanism of such behavior is not known; perhaps the theory of multiphonon process may throw a light to what really happened. However, such theoretical treatments do not appear to exist. Presently, the n and dn/dT data can only be best presented by the polynomial functions proposed in this work.

It should be pointed out that the dispersion equation proposed in this work takes care both the refractive index data and the dn/dT data; in other words, n and dn/dT maintain a relation of integration and differentiation. Depending on the quality and type of available data, the constants in the dispersion equation can be determined through either expressions. As a contrast comparison, the other investigators treat n and dn/dT data separately; each is described by an equation formulated from different starting point. As a result, there is no bridge between n and dn/dT expressions.

It is noted that the present work relies heavily on the data of Feldman et al. for their high accuracy. Unless we are satisfied with the situation of available data which do not cover wide enough range of temperature for providing sufficient material for theoretical studies and do not have enough

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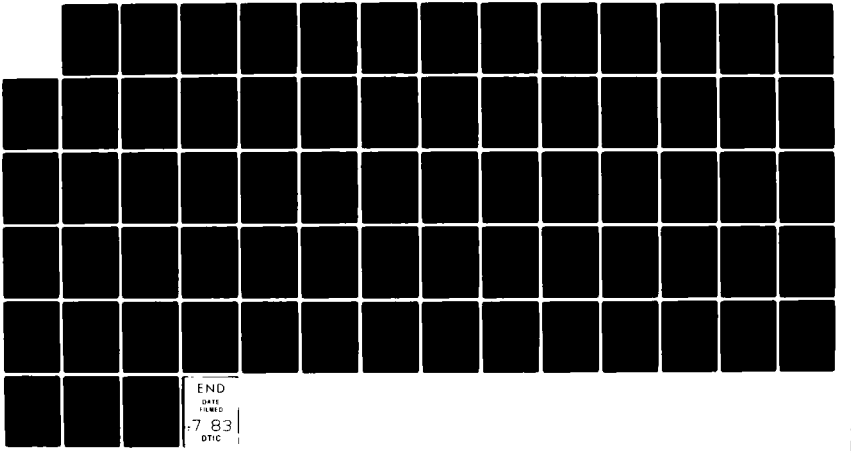

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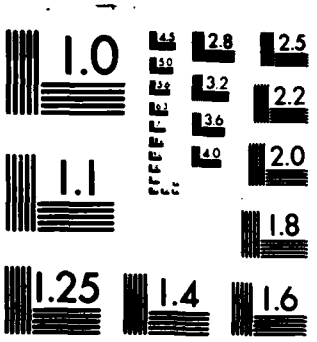

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reliable data sets for independent checking of the consistency of selected data sets, serious considerations should be taken to carry out a systematic measurement program with the following considerations:

1. Experimental method. Because minimum deviation method is not suitable for the determination of high accurate refractive index at either high or low temperatures, it is strongly felt that the counting of interference fringe shift as a function of temperature should be able to yield desirable results. In this method, the sensitivity depends on the order of interference. In order to obtain high accuracy, thick plate specimens should be used.

2. Sample characterization. As the impurity content of the sample strongly affect the refractive index, the impurities in the sample should be ascertained and reported. Merely reporting the electrical resistivity or carrier concentration of the sample is not adequate. The nature and amount of impurities should specifically be reported. In order to see the effects of impurities on the refractive index, measurement should be carried out for a group of specimens with systematically controlled impurities.

3. Environmental control. Since the temperature coefficient of refractive index of zinc chalcogenides are rather high, in the order of 5×10^{-5} to $10^{-4} K^{-1}$, the temperature of the sample must be carefully controlled to achieve the required accuracy.

In conclusion, it should be emphasized that the present work does not resolve the discrepancies among the available data sets, it simply recommends the most probable values of the refractive index that pure ZnS, ZnSe, and ZnTe may have with the quoted uncertainties. Also, it should be noted that, as in any statistical study of this type, the dispersion equations, eqs (21), (23), and (24), are valid to the reported accuracy only within the region of experimental data. In general, extrapolation of these equations for use outside of this region is invalid for quantitative results. Finally, the type of analysis presented here assumes the data to be an absolutely correct representation of the model at hand, which is not generally true since the model is an oversimplification of the true dispersion relation. However, for predictive purposes, based upon the experimental data from several authors, and within the usable region of the data, we believe that these equations are valid for calculation of the refractive index in the given wavelength and temperature regions.

5. Acknowledgments

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6. References

1. Piper, W.W., 'Some Electrical and Optical Properties of Synthetic Single Crystals of Zinc Sulfide,' Phys. Rev., 92(1), 23-7, 1953.

2. Ramachandran, G.N., 'Thermo-optic Behavior of Solids,' Indian Academy of Sciences, Proceedings, 25, 375-81, 1947.

3. Harris, R.J., Johnston, G.T., Kepple, G.A., Krok, P.C., and Mukai, H., 'Infrared Thermo-optic Coefficient Measurement of Polycrystalline ZnSe, ZnS, CdTe, CaF_2, and BaF_2, Single Crystal KCl and T1-20 Glass,' Appl. Opt., 16(2), 436-8, 1977.

4. Johnston, G.T., 'Wavelength Dependence of dn/dT in Infrared-Transmitting Semiconductor Materials,' Appl. Opt., 16(7), 1796-7, 1977.

5. Tsay, Y.F., Bendow, B., and Mitra, S.S., 'Theory of the Temperature Derivative of the Refractive Index in Transparent Crystals,' Phys. Rev. B, 8(6), 2688-96, 1973.

6. Ballard, S.S., McCarthy, K.A., and Wolfe, W.L., 'Optical Materials for Infrared Instrumentation,' Michigan Univ., Willow Run Lab. Rept. No. 2389-11-S, 115 pp., 1959. [AD 217 367]

7. Coblentz, W.W., 'Transmission and Refraction Data on Standard Lens and Prism Material with Special Reference to Infrared,' J. Opt. Soc. Am., 4, 432-47, 1920.

8. Mell, M., 'Refraction and Absorption of Light in ZnS at Temperatures Up to 700°C,' Z. Phys., 16, 244-65, 1923.

9. DeVore, J.R., 'Refractive Indices of Rutile and Sphalerite,' J. Opt. Soc. Am., 41(6), 416-9, 1951.

10. Czyzak, S.J., Baker, W.M., Crane, R.C., and Howe, J.B., 'Refractive Indexes of Single Synthetic Zinc Sulfide and Cadmium Sulfide Crystals,' J. Opt. Soc. Am., 47(3), 240-3, 1957.

11. Czyzak, S.J., Payne, H., Crane, R.C., and Baker, W.M., 'The Study of Properties of Single CdS and ZnS Crystal for Use as Detectors in Crystal Counters,' Univ. of Detroit, Tech. Rept. No. 3 on the Office of Naval Research Contract Nonr 1511 (01) NR015-218, 29 pp., 1957. [AD 143 919]

12. Czyzak, S.J., Reynolds, D.C., Allen, R.C., and Reynolds, C.C., 'On the Properties of Single Cubic Zinc Sulfide Crystals,' J. Opt. Soc. Am., 44(11), 864-7, 1954.

13. Piper, W.W., Marple, D.T.F., and Johnson, P.D., 'Optical Properties of Hexagonal ZnS Single Crystals,' Phys. Rev., 110(1), 323-6, 1958.

14. Bieniewski, T.M. and Czyzak, S.J., 'Refractive Indexes of Single Hexagonal ZnS and CdS Crystals,' J. Opt. Soc. Am., 53(4), 496-7, 1963.

15. Bond, W.L., 'Measurement of the Refractive Indices of Several Crystals,' J. Appl. Phys., 36(5), 1674-7, 1965.

16. Manabe, A., Mitsuishi, A., and Yoshinaga, H., 'Infrared Lattice Reflection Spectra of II-VI Compounds,' Jpn. J. Appl. Phys., 6(5), 593-600, 1967.

17. Feldman, A., Horowitz,D., Waxler, R.M., and Dodge, M.J., 'Optical Materials Characterization,' NBS Technical Note 993, 63 pp., 1979.

18. Wolfe, W.L. and Korniski, R., 'Refractive Index of Irtran 2 as a Function of Wavelength and Temperature,' Appl. Opt., 17(10), 1547-9, 1978.

19. Hattori, T., Homma, Y., and Mitsuishi, A., 'Indices of Refraction of ZnS, ZnSe, ZnTe, CdS, and CdTe in the Far Infrared,' Opt. Comm., 7(3), 229-32, 1973.

20. Baker, W.M., Crane, R.C., Czyzak, S.J., Farrand, B.P., Howe, J.B., LaCombe, D.J., O'Keefe, R., and Payne, H., 'The Study of Properties of Single CdS and ZnS Crystals for Use as Detectors and Crystal Counters,' Univ. of Detroit, Tech. Rept. on the office of Naval Research Contract Nonr 1511 (01) NR015-218, 21-34, 1956. [AD 111 884]

21. Kodak Publication U-72, 1971.

22. Mathieu, L. and Mathieu, J., 'Raman Scattering in Piezoelectric Crystals. IV. Blende,' C.R. Acad. Sci. Paris, 236, 371-5, 1953.

23. Cardona, M. and Harbeke, G., 'Optical Properties and Band Structure of Wurtzite-Type Crystals and Rutile,' Phys. Rev., 137(5A), 1467-76, 1965.

24. Berlincourt, D., Jaffe, H., and Shiozawa, L.R., 'Electroelastic Properties of the Sulfides, Selenides, and Tellurides of Zinc and Cadmium,' Phys. Rev., 129(3), 1009-17, 1963.

25. Reynolds, D.C., Litton, C.W., and Collin, T.C., 'Some Optical Properties of Group II-VI Semiconductors (II),' Phys. Stat. Sol., 12, 3-55, 1965.

26. Nilsen. W.G., 'Raman Spectrum of Cubic ZnS,' Phys. Rev., 182, 838-50, 1969.

27. Mitsuishi, A., Yashinaga, H., and Fujita, S., 'The Far Infrared Absorption of Sulfides, Selenides, and Tellurides of Zinc and Cadmium,' J. Phys. Soc. Jpn., 13, 1235-6, 1958.

28. Kobyakov, I.B. and Pado, G.S., 'Investigation of Electrical and Elastic Properties of Hexagonal Zinc Sulfide in the Temperature Range 1.5-300 K,' Sov. Phys. Solid State, 9(8), 1707, 1968.

29. Rood, J.L., 'Evaporated Zinc Sulfide Films,' J. Opt. Soc. Am., 41(3), 201-2, 1951.

30. Hermanson, A., 'A Method for Production on Interference Filters for Specified Wavelengths,' Nature, 167, 104-6, 1951.

31. Kuwabara, G. and Siguro, K., 'Optical Constants of ZnS Films,' J. Phys. Soc. Jpn., 7(1), 72-4, 1952.

32. Hall, J.F., Jr. and Furguson, W.F.C., 'Dispersion of Zinc Sulfide and Magnesium Fluoride Films in the Visible Spectrum,' J. Opt. Soc. Am., 45(2), 74-5, 1955.

33. Hall, J.F., Jr. and Ferguson, W.F.C., 'Optical Properties of Cadmium Sulfide and Zinc Sulfide from 0.6 Micron to 14 Microns,' J. Opt. Soc. Am., 45(9), 714-8, 1955.

34. Hall, J.F., Jr., 'Optical Properties of Zinc Sulfide and Cadmium Sulfide in the Ultraviolet,' J. Opt. Soc. Am., 46(12), 1013-5, 1956.

35. Coogan, C.K., 'The Measurement of the Optical Properties of Zinc Sulfide,' Proc. Phys. Soc., B70(9), 845-61, 1957.

36. Cox, J.T., Waylonis, J.E., and Hunter, W.R., 'Optical Properties of Zinc Sulfide in the Vacuum Ultraviolet,' J. Opt. Soc. Am., 49(8), 807-10, 1959.

37. Huldt, L. and Staflin, T., 'Optical Constants of Evaporated Films of Zinc Sulphide and Germanium in the Infra-Red,' Optica Acta, 6(1), 27-36, 1959.

38. Macskaylo, M., 'Determination of the Refractive Index of Thin Dielectric Films,' J. Opt. Soc. Am., 54(2), 198-203, 1964.

39. Heitmann, W. and Koppelmann, G., 'Refractive Index Determination for a High Reflecting Multiple Layer Dielectrics,' Z. Angew. Phys., 23(4), 221-6, 1967.

40. Burgiel, J.C., Chen, Y.S., Vratny, F., and Smolinsky, G., 'Refractive Indices of ZnO, ZnS, and Several Thin-Film Insulators,' J. Electrochem. Soc., 115(7), 729-32, 1968.

41. Shklyarevskii, I.N., El Shazli, A.F.A., and Lysova, G.V., 'Modification of the Interference Method of Measuring the Dispersion on the Refractive Index of Dielectric Layers,' Opt. Spektrosk., 30, 605-7, 1971.

42. Shklyarevskii, I.N., El-Shazli, A.F.A., and Idczak, E., 'A New Method for the Determination of the Thickness and the Refractive Index of Thin Dielectric Films Evaporated on Metal Substrates,' Solid State Comm., 9, 1737-40, 1971.

43. Kersten, R.T., Mahlein, H.F., and Rauscher, W., 'Optical Losses of Evaporation-Deposited Dielectric Waveguides,' Thin Solid Films, 28, 369-74, 1975.

44. Stipancic, M., Lugomer, S., and Luka, B., 'Dispersion Properties of ZnS Films in the Visible Spectrum,' Fizika (Zayreb), 8, 185-7, 1976.

45. Netterfield, R.P., 'Refractive Indices of ZnS and Cryolite in Multilayer Stacks,' Appl. Opt., 15(8), 1969-73, 1976.

46. Barakat, N., El-Shazly, A.F.A., and El-Shair, H.T., 'New Interferometric Method for Determining the Refractive Index of Thin Dielectric Film, Its Thickness, the Phase Shift, and the Order of Interference,' Appl. Phys., 319-23, 1977.

47. Kulakov, M.P. and Fadeev, A.V., 'Index of Refraction of Zinc Sulfide, Zinc Selenide, and Cadmium Sulfide in the IR Region,' Izv. Akad. Nauk SSSR, Neorg. Mater., 16(1), 159-60, 1980.

48. Marple, D.T.F., 'Refractive Index of ZnSe, ZnTe, and CdTe,' J. Appl. Phys., 35(3), 539-42, 1964.

49. Lorenz, M.R., Halsted, R.E., Segall, B., and Marple, D.T.F., 'Research on CdTe,' General Electric Research Lab., Schenectady, NY, Progress Rept. No. 2 on the Office of Aerospace Research, U.S. Air Force Contract AF 33(616)-8264, 1-24, 1963. [AD 412 736]

50. Rambauske, W.R., 'Optical Dispersion of Zinc Selenide,' J. Appl. Phys., 35(10), 2958-9, 1964.

51. Rambauske, W.R., 'Optical Properties of Semiconducting Crystals,' Dayton Univ. Res. Inst., Final Rept. on the Office of Aerospace Research, U.S. Air Force Contract AF 33(616)-7500, 44 pp., 1964. [AD 603 374]

52. Hilton, A.R. and Jones, C.E., 'The Thermal Change in the Nondispersive Infrared Refractive Index of Optical Materials,' Appl. Opt., 6(9), 1513-7, 1967.

53. Wunderlich, J.A. and DeShazer, L.G., 'Visible Optical Isolator Using ZnSe,' Appl. Opt., 16(6), 1584-7, 1977.

54. Thompson, C.J.C., DeBell, A.G., and Wolfe, W.L., 'Refractive Index of ZnSe at 3.8 μm and 10.6 μm, from 80 K to 300 K,' Appl. Opt., 18(13), 2085-6, 1979.

55. Hadni, A., Henry, P., Lambert, J.P., Morlot, G., Strimer, P., and Chanal, D., 'Optical Constants of Seven Ionic Crystals at Low Temperatures in the Infrared Region,' J. Phys., 1(2), C1-118-28, 1967.

56. Hadni, A., Claudel, J., and Strimer, P., 'Infrared Spectra of Absorption and Reflection of ZnSe, ZnTe, and CdSe at Low Temperature,' Phys. Stat. Sol., 26, 241-52, 1968.

57. Aven, M., Marple, D.T.F., and Segall, B., 'Some Electrical and Optical Properties on ZnSe,' J. Appl. Phys., 32(10), 2261-5, 1961.

58. Irwin, J.C. and LaCombe, J., 'Second-Order Raman Spectrum of ZnSe,' Can. J. Phys., 48, 2499-506, 1970.

59. Mitsuishi, A., Yoshinaga, H., Yata, K., and Manabe, A., 'Optical Measurement of Several Materials in the Far Infrared Region,' Jpn. J. Appl. Phys., 4(1), 581-7, 1965.

60. Mitra, S.S., 'Optically-Active Multiphonon Processes in II-VI Semiconductors,' J. Phys. Soc. Jpn. (Suppl.), 21, 61-6, 1966.

61. Krauzman, M., 'First-Order Raman Spectrum of Cubic Semiconductors,' C.R. Acad. Sci. Paris, B264(10), 1117-8, 1967.

62. Kolosovskii, O.A. and Ustimenko, L.N., 'Measurement of the Temperature Coefficient of the Refractive Index of Infrared Materials Using a CO_2 Laser,' Opt. Spektrosk., 33(4), 430-1, 1972.

63. Skolnik, L.H. and Clark, O.M., 'Temperature Change of the Refractive Index of CVD ZnSe at 10.6 μm,' Appl. Opt., 13(9), 1999-2002, 1974.

64. Mangir, M.S. and Hellwarth, R.W., 'Refractive Index Measurement and Nonlinear Moment Parameters for Polycrystalline ZnSe,' Phys. Rev., B16(2), 856-62, 1977.

65. Afanas'ev, I.I. and Nosov, V.B., 'Temperature Increments of the Refractive Indices of Certain Single Crystals,' Sov. J. Opt. Technol., 46(5), 281-3, 1979.

66. Fischer, A.G., Fonger, W., and Mason, A.S., 'Investigation of Carrier Injection Electroluminescence,' RCA Labs., Princeton, NJ, Semiannual Rept. No. 2 on the Office of Aerospace Research, U.S. Air Force Contract No. AF 19(604)-8018, 130 pp., 1962. [AD 290 231]

67. Heitmann, W., 'The Influence of Various Parameters on the Refractive Index of Evaporated Dielectric Films,' Appl. Opt., 7(8), 1541-3, 1968.

68. Kot, M.V. and Tyrziu, V.G., 'Optical properties of Thin Layers of Zinc Selenide-Cadmium Selenide and Zinc Telluride-Cadmium Telluride Systems Produced by the Wedge on Wedge Method,' (Radautsan, S.I., Ed.), Poluprov. Soedin. Ikh. Tverd. Rastvory, 31-8, 1970.

69. Franzen, D.L., 'Precision Beam Splitters for CO_2 Lasers,' Appl. Opt., 14(3), 647-52, 1975.

70. Thutupalli, G.K.M. and Tomlin, S.G., 'The Optical Properties of Thin Films of Cd and Zn Selenides and Tellurides,' J. Phys. D: Appl. Phys., 9, 1639-46, 1976.

71. Pedinoff, M.E., Braunstein, M., and Stafsudd, O.M., 'Refractive Indices of IR Materials: 10.6 μm Ellipsometer Measurements,' Appl. Opt., 16(11), 2849-57, 1977.

72. Aten, A.C., VanDoorn, C.Z., and Vink, A.T., 'Direct and Phonon-Assisted Optical Transitions in Zinc Telluride,' in Proc. Int. Conf. Phys. Semicond., Exeter, July 1962 (Stickland, A.C., Ed.), London Institute of Physics and the Physical Society, 696-702, 1962.

73. Shiozawa, L.R., Barrett, J.L., Jost, J.M., Chotkevys, G.P., and Devlin, S.S., 'Research on II-VI Compound Semiconductors,' Clevite Corp., Cleveland, OH, Final Rept. on the Office of Aerospace Research, U.S. Air Force Contract AF 33(616)-6865, 163 pp., 1962. [AD 281 718]

74. Shiozawa, L.R., Jost, J.M., Devlin, S.S., and Chotkevys, G.P., 'Research on II-VI Compound Semiconductors,' Clevite Corp., Cleveland, OH, 7th Quarterly Rept. on the Air Force Research Division, Air Research and Development Command, U.S. Air Force Contract AF 33(657)-7399, 16 pp., 1963. [AD 626 537]

75. Shiozawa, L.R., Jost, J.M., Chotkevys, G.P., Devlin, S.S., Barrett, J.L., and Sliker, T.R., 'Research on II-VI Compound Semiconductors,' Clevite Corp., Cleveland, OH, 6th Quarterly Rept. on the Air Force Research Division, Air Research and Development Command, U.S. Air Force Contract AF 33(657)-7399, 26pp., 1963. [AD 626 536]

76. Masso, J. and Turner, A.F., 'Infrared Coating Studies,' Bausch and Lomb, Inc., Research and Development Div., Final Rept. on the Department of the Army Contract DA-44-009-AMC-124(T), 21 pp., 1964. [AD 600 264]

77. Cardona, M., 'Infrared Dielectric Constant and Ultraviolet Optical Properties of Solids with Diamond, Zinc Blend, Wurtzite, and Rocksalt Structure,' J. Appl. Phys., 36(7), 2181-6, 1965.

78. Shiozawa, L.R. and Jost, J.M., 'Research on II-VI Compound Semiconductors,' Clevite Corp., Cleveland, OH, Final Rept. on the Office of Aerospace Research, U.S. Air Force Contract AF 33(657)-7399, 200 pp., 1965. [AD 620 297]

79. Sliker, T.R. and Jost, J.M., 'Linear Electro-Optic Effect and Refractive Indices of Cubic ZnTe,' J. Opt. Soc. Am., 56, 130-1, 1966.

80. Horikoshi, Y., Ebina, A., and Takahashi, T., 'Optical Absorption Due to Acceptor Levels in Undoped ZnTe,' Jpn. J. Appl. Phys., 11(7), 992-1001, 1972.

81. Crandell, M.E. and Linton, R.C., 'Optical Properties of the II-VI Compound Semiconductor ZnTe in the Vacuum Ultraviolet,' NASA Rept. NASA-CR-120336, 6-1 - 6-16, 1974.

82. LaCombe, J.L. and Irwin, J.C., 'The Temperature Dependence of the Optical Phonon Linewidths and Frequencies in ZnSe and ZnTe,' Solid State Comm., 8, 1427-31, 1970.

83. Irwin, J.C. and LaCombe, J., 'Raman Scattering in ZnTe,' J. Appl. Phys., 41(4), 1444-50, 1970.

84. Kir'yashkina, Z.I., Porov, F.M., Bilenko, D.N., and Kir'iashkin, V.I., 'An Investigation of the Dielectric Permittivity of Semiconductors,' Sov. Phys.-J. Tech. Phys., 37, 69-73, 1957.

85. Aven, M. and Segall, B., 'Carrier Mobility and Shallow Impurity States in ZnSe and ZnTe,' Phys. Rev., 130(1), 81-91, 1963.

APPENDIX

The tables included in the Appendix are available experimental data compiled during the course of the present work. The collected information covers the reported works in the last 57 years from 1923 to 1980.

The tables give for each data set the following information: the reference number, author's name (or names), year of publication, wavelength range, temperature range, the pertinent description and characterization of the specimen, and information on measurement conditions contained in the original paper.

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)

[Temperature, T, K; wavelength, λ, μm; refractive index, n]

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
1	(T=193 K)		Natural crystal; clear green sphalerite; prismatic specimens of apex angles about 22° to 25°; refractive indices were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	0.437	2.4791		
	0.4938	2.4183		
	0.5487	2.3810		
	0.5793	2.3666		
	0.6191	2.3508		
2	(T=273 K)		Natural crystal; clear green sphalerite; prismatic specimens of apex angles about 22° to 25°; refractive indices were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	0.4162	2.5214		
	0.4263	2.5037		
	0.4364	2.4876		
	0.4466	2.4731		
	0.4567	2.4605		
	0.4668	2.4486		
	0.4770	2.4379		
	0.4871	2.4290		
	0.4973	2.4204		
	0.5074	2.4123		
	0.5176	2.4048		
	0.5277	2.3982		
	0.5379	2.3918		
	0.5481	2.3855		
	0.5583	2.3802		
	0.5684	2.3751		
	0.5786	2.3705		
	0.5888	2.3657		
	0.5990	2.3622		
	0.6092	2.3579		
	0.6194	2.3547		
	0.6297	2.3513		
	0.6399	2.3474		
	0.6501	2.3445		
	0.6604	2.3417		
	0.6706	2.3391		
	0.6808	2.3364		
	0.6911	2.3341		
	0.7013	2.3315		
	0.7116	2.3283		
	0.7218	2.3265		
	0.7320	2.3248		
3	(T=293 K)		Natural crystal; clear green sphalerite; prismatic specimens of apex angles about 22° to 25°; refractive indices were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	0.4162	2.5240		
	0.4263	2.5063		
	0.4364	2.4911		
	0.4466	2.4760		
	0.4567	2.4635		
	0.4668	2.4523		
	0.4770	2.4416		
	0.4871	2.4319		
	0.4973	2.4230		
	0.5074	2.4150		
	0.5176	2.4071		
	0.5277	2.4001		
	0.5379	2.3938		
	0.5481	2.3879		
	0.5583	2.3824		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
3 cont.	0.5684	2.3777		Mell, M., 1923 [8]
	0.5786	2.3732		
	0.5888	2.3683		
	0.5990	2.3637		
	0.6092	2.3596		
	0.6194	2.3560		
	0.6297	2.3527		
	0.6399	2.3493		
	0.6501	2.3463		
	0.6604	2.3434		
	0.6706	2.3404		
	0.6808	2.3382		
	0.6911	2.3352		
	0.7013	2.3330		
	0.7116	2.3308		
	0.7218	2.3283		
	0.7320	2.3263		
4	(T=477 K)		Natural crystal; clear green sphalerite; prismatic specimens of apex angles about 22° to 25°; refractive indices were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	0.4162	2.5443		
	0.4263	2.5251		
	0.4364	2.5086		
	0.4466	2.4933		
	0.4567	2.4813		
	0.4668	2.4663		
	0.4770	2.4571		
	0.4871	2.4452		
	0.4973	2.4359		
	0.[illegible]	2.4275		
	0.5[illegible]	2.4198		
	0.5[illegible]	2.4124		
	0.5[illegible]	2.4061		
	0.54[illegible]	2.3993		
	0.5583	2.3938		
	0.5684	2.3884		
	0.5786	2.3838		
	0.5888	2.3802		
	0.5990	2.3751		
	0.6092	2.3705		
	0.6194	2.3665		
	0.6297	2.3640		
	0.6399	2.3600		
	0.6501	2.3563		
	0.6604	2.3532		
	0.6706	2.3502		
	0.6808	2.3472		
	0.6911	2.3444		
	0.7013	2.3428		
	0.7116	2.3400		
	0.7218	2.3377		
	0.7320	2.3354		
	0.7423	2.3333		
	0.7525	2.3322		
	0.7628	2.3301		
	0.7730	2.3281		
	0.7832	2.3262		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)—Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
5	(T=674 K)		Natural crystal; clear green sphalerite; prismatic specimens of apex angles about 22° to 25°; refractive indices were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	0.4155	2.5735		
	0.4256	2.5519		
	0.4357	2.5337		
	0.4459	2.5165		
	0.4560	2.5006		
	0.4661	2.4870		
	0.4763	2.4762		
	0.4864	2.4654		
	0.4965	2.4548		
	0.5067	2.4458		
	0.5168	2.4380		
	0.5270	2.4309		
	0.5371	2.4234		
	0.5473	2.4168		
	0.5574	2.4102		
	0.5676	2.4050		
	0.5778	2.3997		
	0.5880	2.3956		
	0.5981	2.3901		
	0.6083	2.3857		
	0.6185	2.3815		
	0.6287	2.3774		
	0.6390	2.3741		
	0.6492	2.3711		
	0.6594	2.3679		
	0.6697	2.3644		
	0.6799	2.3614		
	0.6901	2.3588		
	0.7004	2.3559		
	0.7106	2.3528		
	0.7208	2.3504		
	0.7311	2.3482		
	0.7413	2.3464		
	0.7516	2.3442		
	0.7619	2.3423		
	0.7721	2.3408		
	0.7824	2.3390		
6	(T=298 K)		Natural sphalerite crystal; clear, water-white; polished prism specimen of 10°19' apex angle and 1.5 cm^2 area; refractive indices were measured by the deviation method; data extracted from a table.	DeVore, J.R., 1951 [9]
	0.3650	2.679		
	0.3654	2.676		
	0.3663	2.673		
	0.3906	2.583		
	0.4047	2.549		
	0.4077	2.542		
	0.4358	2.490		
	0.4916	2.426		
	0.5461	2.390		
	0.5780	2.375		
	1.5296	2.284		
7	(T=298 K)		Thin film specimens; evaporated in vacuum of 1×10^{-3} to 2×10^{-4} mm Hg pressure at a rate of 100 Å/min. onto glass substrates; some films were exposed to air as soon as made, some were placed in a dessicator for weeks,	Rood, J.L., 1951 [29]
	0.45	2.24		
	0.47	2.28		
	0.48	2.20		
	0.51	2.22		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
7 cont.	0.52 0.57 0.58	2.18 2.17 2.12	and others were then heat treated at 623 K; refractive indices were determined from reflectivity measurements after aging; data extracted from a table.	Rood, J.L., 1951 [29]
8	(T=300 K) 0.589	2.26	Evaporated film ZnS specimen; refractive index at 0.589 μm was determined by a polarimetric method based on the changes in phase occurring by reflection of linearly polarized light from the evaporated film.	Hermansen, A., 1951 [30]
9	(T=300 K) 0.412 0.440 0.443 0.454 0.460 0.472 0.512 0.534 0.550 0.594 0.660 0.680 0.685 0.740 0.900 0.980	2.48 2.22 2.40 2.38 2.42 2.36 2.36 2.34 2.30 2.33 2.31 2.26 2.27 2.30 2.23 2.27	Thin films; evaporated onto a glass substrate; film thickness 0.142 to 0.320 μm; refractive indices were determined from measurements of transmittance, reflectance, and the phase shift of the transmitted light; data extracted from a table.	Kuwabara, G. and Isiguro, K., 1952 [31]
10	(T=300 K) 0.512 0.534 0.550 0.594 0.660 0.680 0.685	2.43 2.38 2.28 2.47 2.22 2.22 2.35	Thin films; evaporated onto a glass substrate; film thickness 0.142 to 0.320 μm; refractive indices were determined by interferometry method; the results show fairly larger fluctuation than the above data set but agree with each other within the experimental error; data extracted from a table.	Kuwabara, G. and Isiguro, K., 1952 [31]
11	(T=298 K) 0.440 0.450 0.461 0.482 0.500 0.523 0.556 0.582 0.600 0.637 0.674 0.699	2.478 2.464 2.450 2.431 2.416 2.399 2.381 2.368 2.362 2.349 2.339 2.334	Single cubic crystals; impurity content less than 0.005% including Cu, Pb, Na, and Ca; prismatic specimens of apex angle 15°; averaged data of four specimens were extracted from a curve.	Czyzak, S.J., Reynolds, D.C., Allen, R.C., and Reynolds, C.C., 1954 [12]
12	(T=298 K) 0.4162 0.4344 0.4510 0.4751	2.495 2.466 2.442 2.418	Thin film ZnS of thickness in the range 0.12 to 0.6 μm evaporated on a black glass substrate in a vacuum of 0.1 μm pressure; substrate held at room temperature at beginning of evaporation and at less than 373 K at	Hall, J.F., Jr. and Ferguson, W.F.C., 1955 [32]

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
12 cont.	0.5023	2.396	the conclusion; refractive indices were determined from reflectance data; uncertainty in n about ±0.002; data extracted from a figure.	Hall, J.F., Jr. and Ferguson, W.F.C., 1955 [32]
	0.5295	2.379		
	0.5521	2.367		
	0.5793	2.352		
	0.6034	2.343		
	0.6275	2.333		
	0.6501	2.324		
	0.6773	2.315		
	0.7014	2.307		
	0.7256	2.301		
	0.7512	2.295		
13	(T=298 K)		Thin film specimens; evaporated in vacuum onto glass substrates for the wavelength region between 0.6 μm to 2 μm and onto rock salt substrate for the region between 0.6 μm to 14 μm; the substrates were ground and polished with an angle of 3° between the front and rear surfaces to eliminate unwanted radiation reflected from the rear surface; substrates were held at room temperature at the beginning of evaporation and not higher than 100°C at the conclusion; refractive index data were determined from reflectance and transmittance measurements; it was found that n is independent on the rate of film deposition; X-ray diffraction pattern of the films showed a mixture of cubic and hexagonal crystalline structure; data extracted from a figure.	Hall, J.F., Jr. and Ferguson, W.F.C., 1955 [33]
	0.50	2.397		
	0.55	2.371		
	0.60	2.350		
	0.65	2.332		
	0.70	2.316		
	0.75	2.308		
	0.80	2.294		
	0.90	2.284		
	1.00	2.278		
	1.12	2.270		
	1.25	2.265		
	1.50	2.260		
	1.75	2.257		
	2.00	2.255		
	2.00	2.253		
	3.00	2.240		
	4.00	2.224		
	5.00	2.211		
	6.00	2.199		
	7.00	2.190		
	8.00	2.183		
	9.00	2.174		
	10.00	2.170		
	11.00	2.165		
	12.00	2.162		
	13.00	2.158		
	14.00	2.156		
14	(T=298 K)		Amorphous thin film specimens; deposited on quartz substrates by evaporation in a vacuum; refractive index data were determined from normal incident reflectance and transmittance measurements; estimated uncertainty in n about ±2%; data extracted from a figure.	Hall, J.F., Jr., 1956 [34]
	0.2118	3.341		
	0.2172	3.537		
	0.2190	3.577		
	0.2235	3.598		
	0.2276	3.579		
	0.2414	3.315		
	0.2500	3.172		
	0.2625	3.047		
	0.2750	2.953		
	0.2875	2.877		
	0.3000	2.820		
	0.3125	2.766		
	0.3250	2.724		
	0.3375	2.683		
	0.3500	2.653		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
14 cont.	0.3625	2.620		Hall, J.F., Jr., 1956 [34]
	0.3750	2.587		
	0.3875	2.563		
	0.4000	2.546		
15	(T=300 K)		Single crystal; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table.	Czyzak, S.J., Payne, H., Crane, R.C., and Baker, W.M., 1957 [11]
	0.365	2.677		
	0.404	2.516		
	0.45	2.468		
	0.50	2.417		
	0.55	2.385		
	0.6	2.362		
	0.7	2.332		
	1.0	2.293		
	1.5	2.275		
	2.0	2.263		
	2.5	2.256		
	3.0	2.253		
	3.5	2.251		
	4.0	2.251		
16	(T=298 K)		Synthetic single crystal; cubic crystal structure with lattice constant a_o=5.406 Å was verified by X-ray diffraction pattern; prism specimen was ground and polished with the principal axis (c-axis) perpendicular to the base of the prism; apex angle 10° to 15°; flatness was checked by the Newton's Rings method; refractive indices over the wavelength range from 0.44 μm to 1.4 μm were determined by deviation method; it was found the data are approximately fitted by the equation $n^2 = 5.131 + 1.275 \times 10^7/(\lambda^2 - 0.732 \times 10^7)$; data extracted from a table.	Czyzak, S.J., et al., 1957 [10]
	0.44	2.488		
	0.46	2.458		
	0.48	2.435		
	0.50	2.414		
	0.52	2.395		
	0.55	2.384		
	0.57	2.375		
	0.60	2.359		
	0.65	2.346		
	0.7	2.334		
	0.9	2.306		
	1.05	2.293		
	1.2	2.282		
	1.4	2.280		
17	(T=297 K)		Thin film specimens of 0.157, 0.213, and 0.474 μm thick; vacuum evaporated onto a fused silica substrate; evaporation rates of the order 100-500 Å/min. were used in a vacuum of 5×10^{-5} mm Hg; refractive indices were determined from transmittance, reflectance, and thickness measurements; data extracted from a figure.	Coogan, C.K., 1957 [35]
	0.241	2.619		
	0.260	2.503		
	0.300	2.500		
	0.342	2.590		
	0.361	2.625		
	0.378	2.579		
	0.378	2.596		
	0.396	2.502		
	0.401	2.507		
	0.454	2.381		
	0.494	2.351		
	0.520	2.305		
	0.538	2.283		
	0.547	2.309		
	0.611	2.267		
18	(T=87 K)		Thin film specimens of 0.157, 0.213, and 0.474 μm thick; vacuum evaporated onto a fused silica substrate; evaporation rates of	Coogan, C.K., 1957 [35]
	0.239	2.452		
	0.279	2.403		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
18 cont.	0.320	2.456	the order 100-500 Å/min. were used in a vacuum of 5×10^{-5} mm Hg; refractive indices were determined from transmittance, reflectance, and thickness measurements; data extracted from a figure.	Coogan, C.K., 1957 [35]
	0.340	2.632		
	0.373	2.606		
	0.377	2.578		
	0.396	2.503		
	0.422	2.430		
	0.453	2.378		
	0.493	2.348		
	0.546	2.314		
	0.610	2.277		
19	(T=298 K)		Single crystal; hexagonal; grown from vapor phase; refractive indices were determined by transmission interference method; data for ordinary ray extracted from a figure.	Piper, W.W., Marple, D.T.F., and Johnson, P.D., 1958 [13]
	0.3377	2.832		
	0.3390	2.785		
	0.3415	2.778		
	0.3468	2.738		
	0.3480	2.707		
	0.3508	2.694		
	0.3591	2.650		
	0.3649	2.623		
	0.3739	2.589		
	0.3834	2.562		
	0.3917	2.535		
	0.3934	2.535		
	0.4111	2.494		
	0.4168	2.487		
	0.4328	2.467		
	0.4369	2.457		
	0.4499	2.447		
	0.4662	2.420		
	0.4861	2.413		
	0.5022	2.393		
	0.5080	2.393		
	0.5317	2.379		
	0.5477	2.366		
	0.5613	2.366		
	0.5905	2.359		
	0.5985	2.352		
	0.6064	2.345		
	0.6317	2.342		
	0.6739	2.329		
	0.7168	2.315		
	0.7584	2.301		
	0.7779	2.308		
	0.8430	2.298		
	0.8757	2.298		
	0.9295	2.298		
	1.036	2.291		
	1.060	2.285		
	1.169	2.285		
	1.342	2.286		
	1.522	2.271		
	1.830	2.268		
20	(T=298 K)		Single crystal; hexagonal; grown from vapor phase; refractive indices were determined by transmission interference method; data for	Piper, W.W., et al., 1958 [13]
	0.3316	2.883		
	0.3364	2.832		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength depencence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
20 cont.	0.3615	2.792	extraordinary-ray extracted from a figure.	Piper, W.W., et al., 1958 [13]
	0.3428	2.788		
	0.3468	2.748		
	0.3494	2.721		
	0.3535	2.711		
	0.3591	2.673		
	0.3619	2.660		
	0.3678	2.640		
	0.3770	2.609		
	0.3754	2.602		
	0.3850	2.579		
	0.3950	2.555		
	0.3968	2.558		
	0.4094	2.535		
	0.4150	2.514		
	0.4208	2.508		
	0.4348	2.487		
	0.4391	2.481		
	0.4499	2.471		
	0.4686	2.451		
	0.4888	2.433		
	0.5080	2.420		
	0.5137	2.420		
	0.5380	2.400		
	0.5546	2.386		
	0.5683	2.389		
	0.5905	2.379		
	0.5985	2.369		
	0.6105	2.369		
	0.6405	2.362		
	0.6739	2.349		
	0.7281	2.339		
	0.7779	2.329		
	0.8511	2.312		
	0.9295	2.305		
	1.036	2.305		
	1.073	2.295		
	1.155	2.298		
	1.342	2.301		
	1.548	2.285		
	1.830	2.278		
21	(T=298 K)		Thin film specimen of 0.12 μm thick; vacuum deposited at a rate of 30 Å/sec onto a glass substrate at room temperature; refractive indices were determined from reflectance data measured at various incident angles; data extracted from a figure.	Cox, J.T., Waylonis, J.E., and Hunter, W.R., 1959 [36]
	0.06	0.71		
	0.07	0.64		
	0.08	0.63		
	0.09	0.69		
	0.10	0.79		
	0.11	0.73		
	0.12	0.80		
	0.125	0.91		
	0.130	1.08		
	0.135	1.22		
	0.140	1.32		
	0.150	1.40		
	0.160	1.42		
	0.170	1.49		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
21 cont.	0.180	1.62		Cox, J.T., et al., 1959 [36]
	0.190	1.81		
	0.200	2.09		
	0.210	2.59		
	0.220	3.11		
22	(T=298 K)		Thin films of 2.22 to 2.50 μm thick; evaporated in a vacuum of 4 x 10^{-5} mm Hg onto glass substrates of 50 x 60 x 1 mm plate; residual gas in the evaporation chamber was air; deposition rate was 30-60 Å/sec and the substrate was rotated during deposition; refractive indices were determined from thickness measurements and interference method and also by the Brewster angle measurement; it was found that the refractive indices of the film specimens deposited in air residual are higher than for the corresponding bulk material; averaged results from three films were extracted from a figure.	Huldt, L. and Staflin, T., 1959 [37]
	0.833	2.403		
	0.909	2.397		
	1.000	2.392		
	1.111	2.386		
	1.250	2.379		
	1.429	2.374		
	1.667	2.366		
	2.000	2.360		
	2.500	2.354		
	3.333	2.348		
23	(T=298 K)		Thin films of 2.22 to 2.50 μm thick; evaporated in a vacuum of 4 x 10^{-5} mm Hg onto glass substrates of 50 x 60 x 1 mm plate; residual gas in the evaporation chamber was nitrogen; deposition rate was 30-60 Å/sec and the substrate was rotated during deposition; refractive indices were determined from thickness measurements and interference method and also by the Brewster angle measurement; it was found that the refractive indices of the film specimens deposited in nitrogen residual are closer to those of bulk crystal; averaged results from three films were extracted from a figure.	Huldt, L. and Staflin, T., 1959 [37]
	0.833	2.318		
	0.909	2.312		
	1.000	2.308		
	1.111	2.304		
	1.250	2.298		
	1.429	2.293		
	1.667	2.288		
	2.000	2.283		
	2.500	2.279		
	3.333	2.273		
24	(T=298 K)		Synthetic single crystal; hexagonal structure; prism specimen; spectroscopic analysis revealed the presence of impurities: Mg, Si, Fe, each less than 10^{-4}%; crystal structure confirmed by X-ray and lattice constants were found to be a_o=3.820 Å and c_o=6.260 Å; Rochon prism was used to separate the ordinary and extraordinary rays; refractive index data were determined by deviation method; data for the ordinary ray were extracted from a table.	Bieniewski, T.M. and Czyzak, S.J., 1963 [14]
	0.360	2.705		
	0.375	2.637		
	0.400	2.560		
	0.410	2.539		
	0.420	2.522		
	0.425	2.511		
	0.430	2.502		
	0.440	2.486		
	0.450	2.473		
	0.460	2.459		
	0.470	2.448		
	0.475	2.445		
	0.480	2.438		
	0.490	2.428		
	0.500	2.421		
	0.525	2.402		
	0.550	2.386		
	0.575	2.375		
	0.600	2.363		
	0.625	2.354		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
24 cont.	0.650	2.346		Bieniewski, T.M. and Czyzak, S.J., 1963 [14]
	0.675	2.339		
	0.7	2.332		
	0.8	2.324		
	0.9	2.310		
	1.0	2.301		
	1.2	2.290		
	1.4	2.285		
25	(T=298 K)		Synthetic single crystal; hexagonal structure; prism specimen; spectroscopic analysis revealed the presence of impurities: Mg, Si, Fe, each less than 10^{-4}%; crystal structure confirmed by X-ray and lattice constants were found to be a_o=3.820 Å and c_o=6.260 Å; Rochon prism was used to separate the ordinary and extraordinary rays; refractive index data were determined by deviation method; data for the extraordinary ray were extracted from a table.	Bieniewski, T.M. and Czyzak, S.J., 1963 [14]
	0.360	2.709		
	0.375	2.640		
	0.400	2.564		
	0.410	2.544		
	0.420	2.525		
	0.425	2.514		
	0.430	2.505		
	0.440	2.488		
	0.450	2.477		
	0.460	2.463		
	0.470	2.453		
	0.475	2.449		
	0.480	2.443		
	0.490	2.433		
	0.500	2.425		
	0.525	2.407		
	0.550	2.392		
	0.575	2.378		
	0.600	2.368		
	0.625	2.358		
	0.650	2.350		
	0.675	2.343		
	0.700	2.337		
	0.800	2.328		
	0.900	2.315		
	1.000	2.303		
	1.200	2.294		
	1.400	2.288		
26	(T=300 K)		Thin films on transparent substrates of glass or fused silica; refractive index was determined by Brewster angle measurement; data taken from a table; accuracy in refractive index about ±0.0002 to ±0.0006; it was found that this technique is independent of index of refraction of the substrate and thickness of the film.	Hacskaylo, M., 1964 [38]
	0.589	2.3547		
27	(T=298 K)		Single crystal; hexagonal structure; obtained from Semi-Elements, Inc., Saxonburg, PA; freshly cleaved prior to reflectivity measurements; optical constants were deduced from reflection spectrum by means of Kramers-Kronig technique; data for ordinary-ray read from a figure.	Cardona, M. and Harbeke, G., 1965 [23]
	0.113	0.851		
	0.116	0.869		
	0.119	0.905		
	0.125	1.012		
	0.130	1.137		
	0.135	1.298		
	0.139	1.370		
	0.143	1.352		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
27	0.146	1.281		Cardona, M. and
cont.	0.149	1.281		Harbeke, G., 1965 [23]
	0.155	1.281		
	0.161	1.353		
	0.171	1.531		
	0.177	1.764		
	0.179	1.978		
	0.183	2.103		
	0.187	2.085		
	0.190	2.068		
	0.193	2.068		
	0.201	1.961		
	0.206	1.961		
	0.210	2.032		
	0.217	2.318		
	0.220	2.532		
	0.227	2.658		
	0.233	2.693		
	0.241	2.640		
	0.250	2.604		
	0.266	2.604		
	0.280	2.605		
	0.291	2.587		
	0.307	2.551		
	0.318	2.605		
	0.333	2.748		
	0.337	2.748		
	0.430	2.534		
	0.527	2.427		
	0.620	2.374		
	0.796	2.338		
	1.263	2.303		
28	(T=298 K)		Single crystal; hexagonal structure; obtained	Cardona, M. and
	0.120	1.012	from Semi-Elements, Inc., Saxonburg, PA;	Harbeke, G., 1965 [23]
	0.124	1.101	freshly cleaved prior to reflectivity meas-	
	0.126	1.136	urements; optical constants were deduced from	
	0.129	1.243	reflection spectrum by means of Kramers-Kronig	
	0.132	1.421	technique; data for extraordinary-ray read	
	0.135	1.598	from a figure.	
	0.139	1.669		
	0.141	1.634		
	0.143	1.598		
	0.147	1.528		
	0.150	1.510		
	0.152	1.510		
	0.157	1.546		
	0.161	1.581		
	0.164	1.652		
	0.168	1.812		
	0.174	1.954		
	0.176	2.061		
	0.178	2.239		
	0.180	2.345		
	0.183	2.327		
	0.188	2.310		
	0.191	2.274		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
28	0.194	2.274		Cardona, M. and
cont.	0.198	2.203		Harbeke, G., 1965 [23]
	0.201	2.203		
	0.205	2.239		
	0.210	2.346		
	0.212	2.541		
	0.213	2.683		
	0.216	2.896		
	0.220	2.967		
	0.227	3.020		
	0.230	3.003		
	0.234	2.967		
	0.247	2.896		
	0.263	2.808		
	0.278	2.790		
	0.302	2.737		
	0.315	2.773		
	0.316	2.879		
	0.317	2.986		
	0.323	2.950		
	0.337	3.022		
	0.338	2.986		
	0.347	2.844		
	0.365	2.720		
	0.396	2.560		
	0.461	2.436		
	0.624	2.330		
	0.850	2.295		
	1.473	2.260		
29	(T=298 K)		Single crystal; cubic structure; obtained from Semi-Elements, Inc., Saxonburg, PA; freshly cleaved prior to reflectivity measurements; optical constants were deduced from reflection spectrum by means of Kramers-Kronig technique; data read from a figure.	Cardona, M. and Harbeke, G., 1965 [23]
	0.062	0.670		
	0.067	0.669		
	0.073	0.669		
	0.083	0.737		
	0.088	0.805		
	0.093	0.896		
	0.097	0.987		
	0.100	0.987		
	0.103	0.941		
	0.105	0.873		
	0.108	0.850		
	0.113	0.895		
	0.116	0.941		
	0.120	1.055		
	0.125	1.261		
	0.130	1.535		
	0.135	1.649		
	0.138	1.717		
	0.139	1.672		
	0.142	1.580		
	0.145	1.466		
	0.150	1.443		
	0.155	1.534		
	0.161	1.671		
	0.165	1.831		
	0.167	2.014		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)— Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
29 cont.	0.173	2.174		Cardona, M. and Harbeke, G., 1965 [23]
	0.177	2.654		
	0.178	2.700		
	0.182	2.654		
	0.187	2.585		
	0.188	2.471		
	0.193	2.425		
	0.203	2.288		
	0.204	2.242		
	0.209	2.288		
	0.210	2.311		
	0.211	2.585		
	0.217	3.042		
	0.221	3.179		
	0.224	3.179		
	0.228	3.179		
	0.229	3.088		
	0.236	3.042		
	0.285	2.744		
	0.304	2.676		
	0.310	2.721		
	0.311	2.767		
	0.318	2.836		
	0.334	2.858		
	0.342	2.767		
	0.381	2.630		
	0.473	2.447		
	0.654	2.332		
	1.382	2.263		
30	(T=300 K)		Natural cubic crystal from San Antander, Spain; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; the crystal was not transparent beyond 2.4 μm.	Bond, W.L., 1965 [15]
	0.45	2.4709		
	0.5	2.4208		
	0.6	2.3640		
	0.7	2.3333		
	0.8	2.3146		
	0.9	2.3026		
	1.0	2.2932		
	1.2	2.2822		
	1.4	2.2762		
	1.6	2.2716		
	1.8	2.2680		
	2.0	2.2653		
	2.2	2.2637		
	2.4	2.2604		
31	(T=300 K)		Cubic crystal; grown at Aerospace Research Laboratories, Wright Patterson Air Force Base, OH; sample was polished to a mirror-like finish; near normal (12° incident angle) reflectivity was measured; refractive indices were deduced from reflection spectrum by Drude dispersion theory; data extracted from a figure.	Manabe, A., Mitsuishi, A., and Yoshinaga, H., 1967 [16]
	19.845	2.117		
	22.009	2.046		
	23.308	1.829		
	25.185	1.467		
	26.774	0.885		
	27.931	0.375		
	28.508	0.230		
	29.663	0.158		
	31.537	0.234		
	32.545	0.527		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
31 cont.	33.120	1.039		Manabe, A., et al., 1967 [16]
	34.265	2.792		
	35.257	6.224		
	35.435	8.341		
	35.531	9.071		
	36.116	7.612		
	36.700	6.153		
	37.858	5.352		
	39.015	4.623		
	40.604	4.187		
	43.635	3.826		
	47.098	3.539		
	49.695	3.396		
	56.474	3.259		
	59.791	3.263		
	61.667	3.192		
32	(T=300 K)		Multilayer film; measured by transmission method; refractive index of bulk ZnS obtained by this method for the wavelength 0.6328 μm at room temperature.	Heitmann, W. and Koppelmann, G., 1967 [39]
	0.6328	2.35		
33	(T=300 K)		Thin films; sputtered or evaporated onto sapphire substrates; refractive indices were determined by interference method; average index data extracted from a smooth curve.	Burgiel, J.C., Chen, Y.S., Vratny, F., and Smelinsky, G., 1968 [40]
	0.289	2.804		
	0.298	2.770		
	0.308	2.731		
	0.322	2.681		
	0.335	2.643		
	0.347	2.609		
	0.362	2.567		
	0.381	2.528		
	0.400	2.486		
	0.417	2.459		
	0.435	2.433		
	0.452	2.406		
	0.476	2.379		
	0.494	2.356		
	0.519	2.333		
	0.555	2.314		
	0.592	2.291		
	0.624	2.276		
	0.677	2.257		
	0.739	2.238		
	0.790	2.230		
	0.895	2.223		
	1.007	2.215		
	1.151	2.219		
34	(T=300 K)		ZnS layers deposited onto glass substrate in a vacuum of about 5.0×10^{-5} mm Hg at the rate of 0.050 μm/min.; refractive indices were determined from transmission and reflection data assuming the absence of absorption and scattering; data extracted from a smooth curve which represents the average of measurements for five different layers.	Shklyarevskii, I.N., El Shazli, A.F.A., and Lysova, G.V., 1971 [41]
	0.4514	2.449		
	0.4549	2.442		
	0.4654	2.428		
	0.4712	2.420		
	0.4816	2.407		
	0.4908	2.393		
	0.5012	2.385		
	0.5105	2.375		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)—Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
34 cont.	0.5313	2.363		Shklyarevskii, I.N., et al., 1971 [41]
	0.5509	2.350		
	0.5716	2.339		
	0.5866	2.332		
	0.6016	2.324		
	0.6212	2.316		
	0.6385	2.310		
	0.6500	2.306		
35	(T=300 K)		Thin films; 13.3 μm thick; evaporated onto antimony substrate in vacuum of 10^{-5} mm Hg; refractive index data were determined by ellipsometrical method; data extracted from a figure.	Shklyarevskii, I.N., El-Shazly, A.F.A., and Idczak, E., 1971 [42]
	0.476	2.429		
	0.499	2.398		
	0.525	2.391		
	0.549	2.364		
	0.574	2.341		
	0.600	2.339		
	0.625	2.310		
36	(T=300 K)		Thin films; 8.6 μm thick; evaporated onto antimony substrate in vacuum of 10^{-5} mm Hg; refractive index data were determined by ellipsometrical method; data extracted from a figure.	Shklyarevskii, I.N., et al., 1971 [42]
	0.477	2.297		
	0.501	2.263		
	0.525	2.245		
	0.549	2.228		
	0.574	2.190		
	0.600	2.166		
	0.625	2.149		
37	(T=300 K)		Thin films; 4.7 μm thick; evaporated onto antimony substrate in vacuum of 10^{-5} mm Hg; refractive index data were determined by ellipsometrical method; data extracted from a figure.	Shklyarevskii, I.N., et al., 1971 [42]
	0.476	2.189		
	0.500	2.132		
	0.525	2.132		
	0.550	2.113		
	0.575	2.108		
	0.600	2.094		
	0.624	2.085		
38	(T=298 K)		Hot-pressed polycrystalline compact, Irtran 2, product of Kodak Co.; data extracted from a table.	Kodak publication U-72, 1971 [21]
	1.0000	2.2907		
	1.2500	2.2777		
	1.5000	2.2706		
	1.7500	2.2662		
	2.0000	2.2631		
	2.2500	2.2608		
	2.5000	2.2589		
	2.7500	2.2573		
	3.0000	2.2558		
	3.2500	0.2544		
	3.5000	2.2531		
	3.7500	2.2518		
	4.0000	2.2504		
	4.2500	2.2491		
	4.5000	2.2477		
	4.7500	2.2462		
	5.0000	2.2447		
	5.2500	2.2432		
	5.5000	2.2416		
	5.7500	2.2399		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
38 cont.	6.0000	2.2381		Kodak publication U-72, 1971 [21]
	6.2500	2.2363		
	6.5000	2.2344		
	6.7500	2.2324		
	7.0000	2.2304		
	7.2500	2.2282		
	7.5000	2.2260		
	7.7500	2.2237		
	8.0000	2.2213		
	8.2500	2.2188		
	8.5000	2.2162		
	8.7500	2.2135		
	9.0000	2.2107		
	9.2500	2.2078		
	9.5000	2.2048		
	9.7500	2.2018		
	10.0000	2.1986		
	11.0000	2.1846		
	12.0000	2.1688		
	13.0000	2.1508		
39	(T=300 K)		Pure crystal of mixed cubic and hexagonal structure; grown by Bridgiman method under high temperature and high pressure; specimens of 500 to 1000 μm thickness with deviation of surface flatness smaller than 0.4%; refractive indices were determined by interference method; data extracted from a figure.	Hattori, T., Homma, Y., Mitsuishi, A., and Tache, M., 1973 [19]
	133.989	2.947		
	137.885	2.950		
	146.811	2.930		
	154.643	2.930		
	158.401	2.928		
	162.851	2.930		
	168.098	2.933		
	172.548	2.923		
	177.841	2.915		
	184.118	2.911		
	188.783	2.912		
	195.137	2.909		
	201.159	2.910		
	209.223	2.907		
	217.061	2.906		
	225.505	2.905		
	232.542	2.904		
	243.392	2.901		
	252.825	2.898		
	265.703	2.900		
	279.963	2.900		
	306.260	2.891		
	321.357	2.888		
	342.454	2.889		
	363.954	2.892		
	391.252	2.891		
	416.216	2.893		
	444.603	2.898		
	490.605	2.888		
	535.963	2.905		
	583.942	2.892		
40	(T=80 K)		Pure crystal of mixed cubic and hexagonal structure; grown by Bridgiman method under high temperature and high pressure; specimens	Hattori, T., et al., 1973 [19]
	132.291	2.900		
	144.774	2.898		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)— Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
40 cont.	148.483	2.887	of 500 to 1000 μm thickness with deviation of surface flatness smaller than 0.4%; refractive indices were determined by interference method; data extracted from a figure.	Hattori, T., et al., 1973 [19]
	152.386	2.889		
	160.349	2.883		
	164.390	2.878		
	169.739	2.882		
	174.277	2.878		
	180.300	2.874		
	186.088	2.874		
	191.556	2.872		
	198.855	2.872		
	205.922	2.869		
	212.635	2.869		
	221.671	2.866		
	230.484	2.865		
	238.931	2.863		
	250.401	2.860		
	261.705	2.860		
	275.528	2.863		
	287.687	2.852		
	300.960	2.851		
	319.387	2.850		
	340.217	2.850		
	358.950	2.854		
	382.643	2.856		
	409.685	2.852		
	440.839	2.850		
	477.145	2.855		
	525.155	2.856		
	577.501	2.850		
41	(T=2 K)		Pure crystal of mixed cubic and hexagonal structure; grown by Bridgiman method under high temperature and high pressure; specimens of 500 to 1000 μm thickness with deviation of surface flatness smaller than 0.4%; refractive indices were determined by interference method; data extracted from a figure.	Hattori, T., et al., 1973 [19]
	92.113	2.944		
	93.099	2.937		
	94.791	2.938		
	96.367	2.933		
	97.630	2.928		
	99.302	2.935		
	100.838	2.921		
	102.421	2.923		
	104.263	2.918		
	106.174	2.921		
	108.155	2.918		
	109.978	2.911		
	112.347	2.914		
	114.067	2.909		
	116.358	2.901		
	118.202	2.900		
	120.942	2.893		
	123.229	2.896		
	125.601	2.889		
	128.069	2.882		
	131.624	2.882		
	134.335	2.884		
	137.885	2.882		
	140.485	2.879		
	144.373	2.881		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
41 cont.	147.641	2.875		Hattori, T., et al., 1973 [19]
	151.062	2.870		
	155.567	2.869		
	159.857	2.872		
	164.390	2.872		
	169.190	2.869		
	173.696	2.865		
	179.678	2.865		
	184.771	2.863		
	190.854	2.863		
	197.352	2.855		
	204.307	2.850		
	211.775	2.850		
	218.881	2.846		
	228.467	2.847		
	237.840	2.849		
	249.203	2.846		
	259.108	2.845		
	272.650	2.849		
	287.687	2.845		
	302.709	2.843		
	317.440	2.842		
	335.841	2.842		
	358.950	2.838		
	379.853	2.840		
	409.685	2.845		
	437.158	2.840		
	477.145	2.841		
	519.940	2.841		
	564.972	2.835		
	641.396	2.841		
42	(T=300 K)		99% pure ZnS; thin film specimen of 0.16 μm; evaporated at a rate of 3.7 Å/sec onto a BK7 glass substrate maintained at 353 K in a vacuum of 5×10^{-9} bar; refractive index was determined from thickness and synchronous angle measurements; data extracted from a table.	Kersten, R.Th., Mahlein, H.F., and Rauscher, W., 1975 [43]
	0.6328	2.381		
43	(T=298 K)		Thin films; evaporated onto glass substrate in a vacuum of 5×10^{-6} mm Hg at temperature 298 K; deposition rate 500 Å/min.; refractive index determined by interference method; data extracted from a figure.	Stipancic, M. and Lugamer, S., 1976 [44]
	0.420	2.490		
	0.445	2.448		
	0.466	2.423		
	0.489	2.404		
	0.516	2.386		
	0.547	2.369		
	0.576	2.354		
	0.613	2.338		
	0.661	2.321		
	0.702	2.307		
	0.731	2.298		
	0.750	2.294		
44	(T=300 K)		Thin film; refractive index at wavelength 0.6328 μm was determined in the vacuum by	Netterfield, R.P., 1976 [45]
	0.6328	2.345		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
44 cont.			measurements of the transmittance maxima during deposition; average value of refractive indices obtained for every λ/4 thickness of the film was taken from a table.	Netterfield, R.P., 1976 [45]
45	(T=300 K)		Thin film specimens of various thicknesses (about 1 μm); coated with silver on both faces; refractive index determined by interference method; data extracted from a table.	Barakat, N., El-Shazly, A.F.A., and El-Shair, H.T., 1977 [46]
	0.4461	2.455		
	0.4783	2.413		
	0.5183	2.375		
	0.5677	2.341		
	0.6314	2.315		
46	(T=294.6 K)		Polycrystalline material grown by CVD method; prismatic specimen measured on precision spectrometer by minimum deviation method; refractive indices determined to fifth decimal places; average absolute residual of n from a best fit dispersion equation is 5.4×10^{-5}; data extracted from a table.	Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]
	0.55	2.38579		
	0.60	2.36237		
	0.65	2.34509		
	0.70	2.33189		
	0.75	2.32155		
	0.80	2.31327		
	0.85	2.30652		
	0.90	2.30093		
	0.95	2.29626		
	1.00	2.29230		
	1.50	2.27209		
	2.00	2.26453		
	2.50	2.26030		
	3.00	2.25719		
	3.50	2.25445		
	4.00	2.25178		
	4.50	2.24903		
	5.00	2.24610		
	5.50	2.24294		
	6.00	2.23953		
	6.50	2.23583		
	7.00	2.23183		
	7.50	2.22749		
	8.00	2.22280		
	8.50	2.21775		
	9.00	2.21231		
	9.50	2.20645		
	10.00	2.20016		
	10.50	2.19340		
47	(T=294.9 K)		Polycrystalline material grown by CVD method; prismatic specimen measured on precision spectrometer by minimum deviation method; refractive indices determined to fifth decimal places; average absolute residual of n from a best fit dispersion equation is 4.6×10^{-5}; data extracted from a table.	Feldman, A., et al., 1978 [17]
	0.55	2.38579		
	0.60	2.36232		
	0.65	2.34503		
	0.70	2.33184		
	0.75	2.32150		
	0.80	2.31322		
	0.85	2.30647		
	0.90	2.30089		
	0.95	2.29622		
	1.00	2.29226		
	1.50	2.27206		
	2.00	2.26451		
	2.50	2.26029		

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Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(a), year [ref.]
47 cont.	3.00	2.25719		Feldman, A., et al., 1978 [17]
	3.50	2.25447		
	4.00	2.25182		
	4.50	2.24907		
	5.00	2.24616		
	5.50	2.24303		
	6.00	2.23963		
	6.50	2.23595		
	7.00	2.23196		
	7.50	2.22763		
	8.00	2.22296		
	8.50	2.21791		
	9.00	2.21246		
	9.50	2.20660		
	10.00	2.20029		
	10.50	2.19351		
48	(T=295.9 K)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-4} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	0.6328	2.3514		
	1.0	2.2949		
	1.5	2.2754		
	2.0	2.2679		
	2.5	2.2634		
	3.0	2.2601		
	3.5	2.2574		
	4.0	2.2545		
	4.5	2.2518		
	5.0	2.2486		
	5.5	2.2453		
	6.0	2.2421		
	6.5	2.2380		
	7.0	2.2337		
	7.5	2.2295		
	8.0	2.2247		
	8.5	2.2199		
	9.0	2.2141		
	9.5	2.2080		
	10.0	2.2014		
	10.5	2.1947		
	11.0	2.1874		
	11.5	2.1793		
	12.0	2.1708		
	12.5	2.1618		
	13.0	2.1522		
	13.5	2.1418		
	14.0	2.1306		
49	(T=295.8 K)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-4} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	0.6328	2.3516		
	1.0	2.2958		
	1.5	2.2755		
	2.0	2.2679		
	2.5	2.2635		
	3.0	2.2600		
	3.5	2.2570		
	4.0	2.2546		

Table A-1. Experimental data on the refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
49 cont.	4.5	2.2521		Wolfe, W.L. and Korniski, R., 1978 [18]
	5.0	2.2490		
	5.5	2.2455		
	6.0	2.2429		
	6.5	2.2384		
	7.0	2.2345		
	7.5	2.2305		
	8.0	2.2252		
	8.5	2.2200		
	9.0	2.2145		
	9.5	2.2082		
	10.0	2.2020		
	10.5	2.1950		
	11.0	2.1877		
	11.5	2.1796		
	12.0	2.1709		
	12.5	2.1623		
	13.0	2.1521		
	13.5	2.1417		
	14.0	2.1305		
50	(T=84.9 K)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-4} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	0.6328	2.3375		
	1.0	2.2837		
	1.5	2.2643		
	2.0	2.2572		
	2.5	2.2527		
	3.0	2.2483		
	3.5	2.2465		
	4.0	2.2440		
	4.5	2.2412		
	5.0	2.2381		
	5.5	2.2345		
	6.0	2.2314		
	6.5	2.2275		
	7.0	2.2233		
	7.5	2.2192		
	8.0	2.2143		
	8.5	2.2093		
	9.0	2.2041		
	9.5	2.1977		
	10.0	2.1913		
	10.5	2.1846		
	11.0	2.1771		
	11.5	2.1693		
	12.0	2.1608		
	12.5	2.1516		
	13.0	2.1420		
	13.5	2.1315		
	14.0	2.1204		
51	(T=300 K)		Refractive index was determined by infrared spectroscopic method; the wavelength region, 3-5 μm, was found to be nondispersive having a constant refractive index of 2.380 ± 0.01.	Kulakov, M.P. and Fadeev, A.V., 1980 [47]
	3-5	2.38		

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Table A-2. Experimental data on the refractive index of zinc sulfide (temperature dependence)

[Temperature, T, K; wavelength, λ, μm; refractive index, n]

Data set	T	n	Specifications and remarks	Author(s), year [ref.]
1	(λ=0.436 μm)		Natural crystal; prismatic specimens of apex angles about 22° to 25°; refractive indices at various temperatures were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	194	2.4804		
	273	2.4882		
	293	2.4917		
	477	2.5093		
	637	2.5299		
	674	2.5332		
	734	2.5441		
	873	2.5616		
	937	2.5726		
2	(λ=0.546 μm)		Natural crystal; prismatic specimens of apex angles about 22° to 25°; refractive indices at various temperatures were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	135	2.3792		
	195	2.3828		
	273	2.3867		
	293	2.3890		
	477	2.4007		
	673	2.4177		
	736	2.4240		
	854	2.4340		
	874	2.4364		
	913	2.4399		
	934	2.4420		
	977	2.4452		
3	(λ=0.578 μm)		Natural crystal; prismatic specimens of apex angles about 22° to 25°; refractive indices at various temperatures were determined by the minimum deviation method; data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	195	2.3673		
	273	2.3709		
	293	2.3733		
	478	2.3841		
	635	2.3979		
	673	2.3996		
	735	2.4053		
	794	2.4103		
	853	2.4148		
	875	2.4177		
	913	2.4202		
	934	2.4214		
	979	2.4258		
4	(λ=0.619 μm)		Natural crystal; prismatic specimens of apex angles about 22° to 25°; refractive indices at various temperatures were determined by the minimum deviation method: data were extracted from a table; uncertainties less than 0.001 in refractive index value.	Mell, M., 1923 [8]
	198	2.3508		
	273	2.3549		
	294	2.3561		
	477	2.3667		
	674	2.3813		
	875	2.3982		
5	(λ=1.0 μm)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-5} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	93	2.28033		
	113	2.28103		
	123	2.28146		
	133	2.28204		
	143	2.28245		
	153	2.28270		
	163	2.28327		

Table A-2. Experimental data on the refractive index of zinc sulfide (temperature dependence)--Continued

Data set	T	n	Specifications and remarks	Author(s), year [ref.]
5 cont.	173	2.28363		Wolfe, W.L. and Korniski, R., 1978 [18]
	183	2.28406		
	193	2.28458		
	203	2.28507		
	213	2.28567		
	223	2.28651		
	233	2.28748		
	243	2.28802		
	253	2.28887		
	263	2.28961		
	273	2.29007		
	283	2.29076		
6	(λ=2.5 μm)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-4} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	98	2.24552		
	108	2.24581		
	118	2.24611		
	128	2.24640		
	138	2.24681		
	148	2.24717		
	158	2.24751		
	168	2.24801		
	178	2.24851		
	188	2.24881		
	198	2.24925		
	208	2.24974		
	218	2.25030		
	228	2.25123		
	238	2.25192		
	248	2.25251		
	258	2.25319		
	268	2.25377		
	278	2.25477		
	288	2.25513		
7	(λ=7.0 μm)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-4} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	103	2.2211		
	112	2.2223		
	123	2.2227		
	133	2.2228		
	142.5	2.2233		
	152.8	2.2237		
	162.3	2.2241		
	172.8	2.2247		
	183	2.2250		
	193	2.2255		
	203	2.2262		
	213	2.2265		
	223.1	2.2272		
	232.9	2.2286		
	243	2.2292		
	252.9	2.2298		
	263.5	2.2303		
	272.9	2.2308		
	283	2.2314		

Table A-2. Experimental data on the refractive index of zinc sulfide (temperature dependence)--Continued

Data set	T	n	Specifications and remarks	Author(s), year [ref.]
8	(λ=10.5 μm)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were determined by minimum deviation method; data extracted from a table; reported uncertainty 2.86 x 10^{-4} rms value.	Wolfe, W.L. and Korniski, R., 1978 [18]
	103	2.1906		
	113	2.1908		
	123	2.1913		
	133	2.1913		
	143	2.1919		
	153	2.1923		
	163	2.1928		
	173	2.1933		
	183	2.1938		
	193	2.1941		
	203	2.1946		
	213	2.1953		
	223	2.1958		
	233	2.1965		
	243	2.1972		
	253	2.1980		
	263	2.1987		

Table A-3. Experimental data on the temperature derivative of refractive index of zinc sulfide (wavelength dependence)

[Temperature, T, K; wavelength, λ, μm; temperature derivative of refractive index, dn/dT, $10^{-5}K^{-1}$]

Data set	λ	dn/dT	Specifications and remarks	Author(s), year [ref.]
1	(T=298-338 K)		Polycrystalline; produced by chemical-vapor-deposit grown by Raytheon; plate specimen; dn/dT data were determined from shifts of Fizeau interference fringes; data extracted from a table; uncertain about 1 unit in the first decimal place.	Harris, R.J., Johnson, G.T., Kepple, G.A., Krok, P.C., and Mukai, H., 1977 [3]
	0.6328	6.35		
	1.15	4.98		
	3.39	4.59		
	10.6	4.63		
2	(T=93 K)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the thermal expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about 2 units in the first decimal place.	Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]
	1.15	3.5		
	3.39	2.8		
	10.6	2.7		
	(T=113 K)			
	1.15	3.7		
	3.39	3.1		
	10.6	3.0		
	(T=133 K)			
	1.15	3.8		
	3.39	3.3		
	10.6	3.3		
	(T=153 K)			
	1.15	4.0		
	3.39	3.5		
	10.6	3.5		
	(T=173 K)			
	1.15	4.1		
	3.39	3.7		
	10.6	3.7		
	(T=193 K)			
	1.15	4.2		
	3.39	3.9		
	10.6	3.8		
	(T=213 K)			
	1.15	4.3		
	3.39	4.0		
	10.6	3.9		
	(T=233 K)			
	1.15	4.4		
	3.39	4.1		
	10.6	4.0		
	(T=253 K)			
	1.15	4.5		
	3.39	4.1		
	10.6	4.0		
	(T=273 K)			
	1.15	4.5		
	3.39	4.2		
	10.6	4.1		
	(T=293 K)			
	1.15	4.6		
	3.39	4.2		
	10.6	4.1		

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Table A-3. Experimental data on the temperature derivative of refractive index of zinc sulfide (wavelength dependence)--Continued

Data set	λ	dn/dT	Specifications and remarks	Author(s), year [ref.]
2 cont.	(T=313 K)			Feldman, A., et al., 1978 [17]
	1.15	4.6		
	3.39	4.3		
	10.6	4.1		
	(T=333 K)			
	1.15	4.7		
	3.39	4.3		
	10.6	4.1		
	(T=353 K)			
	1.15	4.7		
	3.39	4.3		
	10.6	4.1		
	(T=373 K)			
	1.15	4.7		
	3.39	4.3		
	10.6	4.2		
	(T=393 K)			
	1.15	4.8		
	3.39	4.4		
	10.6	4.2		
	(T=413 K)			
	1.15	4.8		
	3.39	4.4		
	10.6	4.3		
	(T=433 K)			
	1.15	4.9		
	3.39	4.4		
	10.6	4.4		
	(T=453 K)			
	1.15	4.9		
	3.39	4.5		
	10.6	4.5		
	(T=473 K)			
	1.15	5.0		
	3.39	4.6		
	10.6	4.7		

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Table A-4. Experimental data on the temperature derivative of refractive index of zinc sulfide (temperature dependence)

[Temperature, T, K; wavelength, λ, μm; temperature derivative of refractive index, dn/dT, $10^{-5}K^{-1}$]

Data set	T	dn/dT	Specifications and remarks	Author(s), year [ref.]
1	(λ=1.15 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the thermal expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about 2 units in the first decimal place.	Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]
	93	3.5		
	113	3.7		
	133	3.8		
	153	4.0		
	173	4.1		
	193	4.2		
	213	4.3		
	233	4.4		
	253	4.5		
	273	4.5		
	293	4.6		
	313	4.6		
	333	4.7		
	353	4.7		
	373	4.7		
	393	4.8		
	413	4.8		
	433	4.9		
	453	4.9		
	473	5.0		
2	(λ=3.39 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the thermal expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about 2 units in the first decimal place.	Feldman, A., et al., 1978 [17]
	93	2.8		
	113	3.1		
	133	3.3		
	153	3.5		
	173	3.7		
	193	3.9		
	213	4.0		
	233	4.1		
	253	4.1		
	273	4.2		
	293	4.2		
	313	4.3		
	333	4.3		
	353	4.3		
	373	4.3		
	393	4.4		
	413	4.4		
	433	4.4		
	453	4.5		
	473	4.6		
3	(λ=10.6 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the thermal expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about 2 units in the first decimal place.	Feldman, A., et al., 1978 [17]
	93	2.7		
	113	3.0		
	133	3.3		
	153	3.5		
	173	3.7		
	193	3.8		
	213	3.9		
	233	4.0		
	253	4.0		
	273	4.1		
	293	4.1		

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Table A-4. Experimental data on the temperature derivative of refractive index of zinc sulfide (temperature dependence)--Continued

Data set	T	dn/dT	Specifications and remarks	Author(s), year [ref.]
3 cont.	313	4.1		Feldman, A., et al., 1978 [17]
	333	4.1		
	353	4.1		
	373	4.2		
	393	4.2		
	413	4.3		
	433	4.4		
	453	4.5		
	473	4.7		
4	(λ=1.0-10.5 μm)		Polycrystalline; hot pressed ZnS (Irtran 2); obtained from Eastman Kodak Co.; prism specimen; refractive indices were measured by minimum deviation method and dn/dT values were determined from $\Delta n/\Delta T$; averaged data extracted from a figure.	Wolfe, W.L. and Korniski, R., 1978 [18]
	113	3.8		
	134	4.3		
	153	4.8		
	173	5.2		
	192	5.6		
	212	6.1		
	232	6.6		
	253	7.0		
	272	7.4		
	281	7.6		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)

[Temperature, T, K; wavelength, λ, μm; refractive index, n]

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
1	(T=300 K)		Single crystals; grown by the vapor growth technique; reflection spectra in various regions either directly measured or converted from measured refractive index; data reduced by Kramer-Kronig analysis and presented in the form of n^2-k^2 and 2nk; data extracted from the curves and converted to desired quantities.	Aven, M., Marple, D.T.F., and Segall, B., 1961 [57]
	4.429	2.40		
	3.875	2.40		
	2.952	2.42		
	2.480	2.42		
	2.102	2.43		
	2.033	2.42		
	1.824	2.44		
	1.653	2.44		
	1.512	2.46		
	1.363	2.46		
	1.240	2.46		
	1.228	2.47		
	1.170	2.47		
	1.069	2.48		
	0.976	2.49		
	0.899	2.50		
	0.892	2.49		
	0.844	2.51		
	0.780	2.52		
	0.729	2.54		
	0.705	2.55		
	0.685	2.56		
	0.656	2.57		
	0.6200	2.58		
	0.5415	2.66		
	0.5188	2.70		
	0.5000	2.74		
	0.4715	2.85		
	0.4627	2.90		
	0.4509	2.83		
	0.4336	2.83		
	0.4133	2.88		
	0.4039	2.92		
	0.3839	2.93		
	0.3647	3.00		
	0.3464	3.12		
	0.3255	3.20		
	0.3077	3.24		
	0.2890	3.23		
	0.2756	3.23		
	0.2690	3.25		
	0.2638	3.11		
	0.2583	2.87		
	0.2536	2.58		
	0.2480	2.57		
	0.2412	2.45		
	0.2375	2.30		
	0.2271	2.36		
	0.2179	2.43		
	0.2138	2.49		
	0.2067	2.57		
	0.2013	2.67		
	0.1975	2.65		
	0.1944	2.42		
	0.1905	2.13		

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Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
1 cont.	0.1859	1.88		Aven, M., et al., 1961 [57]
	0.1810	1.66		
	0.1754	1.44		
	0.1696	1.33		
	0.1642	1.27		
	0.1584	1.30		
	0.1550	1.33		
	0.1529	1.43		
	0.1498	1.48		
	0.1478	1.45		
	0.1464	1.42		
	0.1400	1.30		
	0.1352	1.19		
	0.1301	1.10		
	0.1240	1.00		
2	(T=300 K)		Thin film specimen; vacuum evaporated onto Pyrex glass substrate; refractive indices were determined from interference pattern and thickness measurements; data extracted from a table.	Fischer, A.G., Fonger, W., and Mason, A.S., 1962 [66]
	0.50	2.72		
	0.51	2.70		
	0.52	2.68		
	0.53	2.66		
	0.54	2.65		
	0.55	2.64		
	0.56	2.63		
	0.57	2.62		
	0.58	2.61		
	0.60	2.59		
	0.70	2.53		
	0.80	2.50		
	0.90	2.47		
	1.00	2.46		
	1.10	2.45		
	1.20	2.44		
	1.30	2.43		
	1.50	2.42		
	1.70	2.41		
	1.90	2.40		
3	(T=298 K)		Single crystal; impurities 0.001-0.002% Cd, P, 0.0005-0.001% As, <0.0005% Sb, Si, Al, Fe, trace of Ag, Au, B, Co, Cr, Cu, Ga, In, Li, Mn, Ni, >0.002% oxygen and halogens; crystal grown in sealed, argon-filled quartz tube by sublimation of the compound from a hot furnace zone into a cooler zone where crystals formed; prismatic specimen with faces flat to within one wavelength of sodium D line; data extraction by using the equation (given by the author) $n^2=A+[B\lambda^2/(\lambda^2-C^2)]$, where A=4.00, B=1.90, C=0.113, and λ in unit of μm; the above equation fitted experimental data within experimental error of 0.002 at each n in the wavelength region of 0.48 to 2.5 μm.	Marple, D.T.F., 1964 [48]
	0.48	2.780		
	0.50	2.732		
	0.52	2.695		
	0.54	2.665		
	0.57	2.629		
	0.60	2.601		
	0.63	2.580		
	0.66	2.562		
	0.70	2.543		
	0.74	2.528		
	0.78	2.516		
	0.82	2.506		
	0.87	2.496		
	0.92	2.488		
	0.97	2.481		
	1.02	2.476		
	1.08	2.470		
	1.14	2.466		

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Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
3 cont.	1.20	2.462		Marple, D.T.F., 1964 [48]
	1.26	2.458		
	1.33	2.455		
	1.40	2.452		
	1.47	2.450		
	1.54	2.448		
	1.62	2.446		
	1.70	2.444		
	1.78	2.443		
	1.86	2.442		
	1.95	2.440		
	2.04	2.439		
	2.13	2.439		
	2.22	2.438		
	2.31	2.437		
	2.40	2.436		
	2.50	2.436		
4	(T=298 K)		Single crystal; less pure than above specimen; crystal grown in sealed, argon-filled quartz tube by sublimation of the compound from a hot furnace zone into a cooler zone where crystals formed; prismatic specimen with faces flat to within one wavelength of sodium D line; data extraction by using the equation (given by the author) $n^2=A+[B\lambda^2/(\lambda^2-C^2)]$, where $A=5.71$, $B=2.39$, $C^2=0.105$, and λ in unit of μm; the above equation fitted experimental data within experimental error of 0.002 at each n in the wavelength region of 0.48 to 2.5 μm.	Marple, D.T.F., 1964 [48]
	0.48	2.781		
	0.50	2.736		
	0.52	2.700		
	0.54	2.670		
	0.57	2.635		
	0.60	2.608		
	0.63	2.586		
	0.66	2.568		
	0.70	2.549		
	0.74	2.533		
	0.78	2.521		
	0.82	2.511		
	0.87	2.500		
	0.92	2.492		
	0.97	2.485		
	1.02	2.479		
	1.08	2.473		
	1.14	2.468		
	1.20	2.464		
	1.26	2.460		
	1.33	2.457		
	1.40	2.454		
	1.47	2.451		
	1.54	2.449		
	1.62	2.447		
	1.70	2.445		
	1.78	2.444		
	1.86	2.443		
	1.95	2.441		
	2.04	2.440		
	2.13	2.439		
	2.22	2.438		
	2.31	2.438		
	2.40	2.437		
	2.50	2.436		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
5	(T=297 K)		Single crystal having an orange-yellow hue; impurities 0.0001% Al, Fe, Ag, and Pb; supplied by Aerospace Research Laboratories; prismatic specimen with faces of 1.5 x 1.5 cm and apex angle of 20°58'26"; deviation method used in the wavelength region of 0.49 to 0.65 μm with uncertainties of $\pm 1 \times 10^{-4}$ in n; reflection method used in the region <0.49 μ with uncertainties of $\pm 5 \times 10^{-2}$ in n; data extracted from a table.	Rambauske, W.R., 1964 [50]
	0.404414	2.65		
	0.434750	2.69		
	0.455535	2.82		
	0.491604	2.7493		
	0.508582	2.7113		
	0.535046	2.6689		
	0.546074	2.6541		
	0.576959	2.6219		
	0.578966	2.6199		
	0.587562	2.6125		
	0.588995	2.6113		
	0.589592	2.6106		
	0.621287	2.5875		
	0.636235	2.5781		
	0.643847	2.5735		
6	(T=297 K)		Polycrystalline samples having yellow hue; 0.01-0.1% Cd, 0.001% Al, Fe, Sn, Ba, Pb, and 0.0001% Bi; supplied by the Hanshaw Chemical Co.; two prismatic specimens with faces of 1.5 x 1.5 cm and 1.0 x 1.0 cm, respectively, and apex angles of 30°4'9" and 30°3'40"; uncertainties of n are of $\pm 1 \times 10^{-3}$ in region >0.49 μ by deviation method, of $\pm 5 \times 10^{-2}$ in region <0.49 μ by reflection; digitized data extracted from a table.	Rambauske, W.R., 1964 [50]
	0.404414	2.25		
	0.434750	2.31		
	0.455535	2.52		
	0.508582	2.724		
	0.535046	2.678		
	0.546074	2.664		
	0.576959	2.630		
	0.578966	2.628		
	0.588995	2.620		
	0.589592	2.620		
	0.643847	2.584		
7	(T=300 K)		Crystal; grown at Aerospace Research Laboratories, Wright-Patterson Air Force Base, OH; reflection spectra analyzed by Drude dispersion theory; data extracted from a smooth curve.	Manabe, A., Mitsuishi, A., and Yoshinaga, H., 1967 [16]
	20.0	2.24		
	28.1	2.16		
	32.2	2.06		
	36.1	1.71		
	38.2	1.41		
	39.3	1.17		
	40.3	0.78		
	41.2	0.25		
	43.5	0.25		
	44.9	0.42		
	46.0	0.66		
	46.5	0.90		
	47.0	1.22		
	47.4	1.72		
	48.8	7.73		
	49.7	6.13		
	50.6	5.18		
	51.4	4.71		
	52.6	4.31		
	53.7	4.02		
	55.1	3.77		
	57.6	3.48		
	61.1	3.32		
	67.8	3.07		
	85.0	2.92		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
8	(T=100 K)		Crystal; grown at Aerospace Research Laboratories, Wright-Patterson Air Force Base, OH; reflection spectra analyzed by Drude dispersion theory; data extracted from a smooth curve.	Manabe, A., et al., 1967 [16]
	32.2	2.06		
	35.2	1.62		
	37.5	1.21		
	38.5	0.87		
	39.8	0.29		
	40.8	0.15		
	43.6	0.15		
	44.8	0.26		
	45.5	0.52		
	45.9	0.95		
	46.6	2.49		
	47.8	8.82		
	48.6	6.82		
	49.1	5.84		
	49.9	5.20		
	51.0	4.66		
	52.5	4.22		
	53.7	3.97		
	55.1	3.77		
9	(T=300 K)		Polycrystalline, Irtran 4; reflection spectrum analyzed by Kramer-Kronig method; data extracted from a smooth curve.	Handi, A., Henry, P., Lambert, J.P., Morlot, G., Strimer, P., and Chanal, D., 1967 [55]
	14.7	2.50		
	22.8	2.25		
	31.2	1.75		
	37.3	1.15		
	41.3	0.00		
	43.7	0.34		
	45.4	1.14		
	46.6	1.83		
	47.7	8.73		
	48.3	9.19		
	49.2	8.61		
	50.5	6.58		
	51.5	5.52		
	52.6	4.92		
	55.8	4.48		
	61.7	4.01		
	70.2	3.62		
	104.3	3.31		
	124.5	3.31		
10	(T=90 K)		Polycrystalline, Irtran 4; reflection spectrum analyzed by Kramer-Kronig method; data extracted from a smooth curve.	Handi, A., et al., 1967 [55]
	5.1	2.40		
	18.0	2.40		
	24.6	2.23		
	30.4	1.94		
	33.5	1.61		
	36.2	1.21		
	41.0	0.00		
	43.7	0.00		
	45.7	0.33		
	46.6	0.94		
	47.5	21.94		
	48.5	8.10		
	49.1	6.84		
	49.4	6.11		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
10 cont.	50.5	5.52		Handi, A., et al., 1967 [55]
	52.3	5.08		
	54.6	4.64		
	57.1	4.29		
	59.8	4.00		
	66.7	3.75		
	119.6	3.58		
11	(T=300 K)		Multilayer film; measured by transmission method; refractive index of bulk ZnSe obtained by this method for the wavelength 0.6328 μm at room temperature; uncertainty in n ±0.03.	Heitmann, W. and Koppelmann, G., 1967 [39]
	0.6328	2.60		
12	(T=295 K)		Polycrystalline; Irtran 4; wedge specimen of apex angle 15-20°; refractive indices were determined using minimum deviation method; experimental error about ±0.0003; data extracted from a figure; dn/dT at 5 μm was found to be $4.8 \times 10^{-5} K^{-1}$.	Hilton, A.R. and Jones, C.E., 1967 [52]
	2.633	2.445		
	3.440	2.441		
	4.060	2.438		
	5.360	2.433		
	6.165	2.430		
	7.343	2.424		
	8.148	2.421		
	9.265	2.415		
	10.07	2.410		
	11.19	2.404		
	12.00	2.398		
	13.30	2.386		
	14.11	2.379		
13	(T=198 K)		Polycrystalline, Irtran 4; wedge specimen of apex angle 15-20°; refractive indices were determined using minimum deviation method; experimental error about ±0.0003; data extracted from a figure; dn/dT at 5 μm was found to be $4.8 \times 10^{-5} K^{-1}$.	Hilton, A.R. and Jones, C.E., 1967 [52]
	2.577	2.440		
	3.631	2.434		
	4.127	2.433		
	5.304	2.428		
	6.171	2.425		
	7.410	2.420		
	8.092	2.416		
	9.394	2.410		
	10.14	2.406		
	11.13	2.399		
	11.94	2.393		
	12.56	2.388		
	13.06	2.383		
14	(T=290 K)		Polycrystalline, Irtran 4; plate specimen; reflection spectrum analyzed by Kramer-Kronig analysis; data extracted from a smooth curve.	Handi, A., Claudel, J., and Strimer, P., 1968 [56]
	66.667	3.78		
	63.492	3.73		
	58.207	4.06		
	54.437	4.79		
	51.760	5.84		
	50.302	7.54		
	49.751	8.38		
	48.780	5.53		
	48.473	3.11		
	48.008	1.96		
	47.393	1.22		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
14 cont.	45.269	0.40		Handi, A., et al., 1968 [56]
	43.365	0.28		
	40.339	0.29		
	39.032	0.74		
	37.951	1.22		
	36.860	1.42		
	28.843	1.82		
15	(T=290 K)		Polycrystalline, Irtran 4; plate specimen; reflection spectrum analyzed by Lorentz oscillator model (one oscillator only); data extracted from a smooth curve.	Handi, A., et al., 1968 [56]
	66.667	3.80		
	61.958	3.89		
	59.032	4.14		
	56.786	4.44		
	54.765	4.85		
	52.994	5.48		
	51.626	6.22		
	50.942	7.04		
	49.677	9.81		
	49.092	9.42		
	48.123	2.29		
	47.755	1.67		
	47.192	1.06		
	45.956	0.53		
	40.950	0.27		
	39.635	0.57		
	38.625	1.17		
	37.300	1.48		
	35.524	1.67		
	29.985	2.02		
16	(T=80 K)		Polycrystalline, Irtran 4; plate specimen; reflection spectrum analyzed by Kramer-Kronig analysis; data extracted from a smooth curve.	Handi, A., et al., 1968 [56]
	66.667	3.78		
	64.103	3.54		
	60.060	3.53		
	57.176	3.80		
	54.437	4.15		
	52.549	4.66		
	51.361	5.15		
	50.226	5.92		
	49.432	7.08		
	48.356	10.05		
	47.962	10.48		
	47.461	10.15		
	46.598	1.68		
	45.788	0.58		
	44.170	0.24		
	39.139	0.16		
	38.417	0.51		
	37.750	1.03		
	36.590	1.34		
	28.843	1.82		
17	(T=80 K)		Polycrystalline, Irtran 4; plate specimen; reflection spectrum analyzed by Lorentz oscillator model (one oscillator only); data extracted from a smooth curve.	Handi, A., et al., 1968 [56]
	65.531	3.59		
	59.773	3.84		
	55.617	4.28		
	53.648	4.62		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
17 cont.	52.056	5.01		Handi, A., et al., 1968 [56]
	51.046	5.41		
	49.776	6.30		
	48.780	7.49		
	47.529	14.67		
	47.103	5.15		
	46.970	2.54		
	46.642	1.60		
	45.788	0.63		
	43.197	0.30		
	39.793	0.00		
	38.865	0.23		
	37.258	1.02		
	36.630	1.32		
	34.977	1.57		
	29.985	2.02		
18	(T=300 K)		ZnSe film deposited on aluminum layer; refractive index was determined from transmittance and thickness measurement; data extracted from a table.	Heitmann, W., 1968 [67]
	0.633	2.57		
19	(T=300 K)		ZnSe film deposited on silver layer; refractive index was determined from transmittance and thickness measurements; data extracted from a table.	Heitmann, W., 1968 [67]
	0.633	2.54		
20	(T=300 K)		Vacuum deposited thin layer specimen; 1.06 μm thick; vacuum annealed for 50 hr. at 623 K; refractive index at 0.50 μm determined by interference method; data extracted from a table.	Kot, M.V. and Tyrziu, V.G., 1970 [68]
	0.50	2.65		
21	(T=298 K)		Hot-pressed polycrystalline compact, Irtran 4; product of Kodak Co.; data extracted from a table.	Kodak publication U-72, 1971 [21]
	1.0000	2.485		
	1.2500	2.466		
	1.5000	2.456		
	1.7500	2.450		
	2.0000	2.447		
	2.2500	2.444		
	2.5000	2.442		
	2.7500	2.441		
	3.0000	2.440		
	3.2500	2.438		
	3.5000	2.437		
	3.7500	2.436		
	4.0000	2.435		
	4.2500	2.434		
	4.5000	2.433		
	4.7500	2.433		
	5.0000	2.432		
	5.2500	2.431		
	5.5000	2.430		
	5.7500	2.429		
	6.0000	2.428		
	6.2500	2.426		
	6.5000	2.425		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
21 cont.	6.7500	2.424		Kodak publication U-72, 1971 [21]
	7.0000	2.423		
	7.2500	2.422		
	7.5000	2.421		
	7.7500	2.419		
	8.0000	2.418		
	8.2500	2.417		
	8.5000	2.416		
	8.7500	2.415		
	9.0000	2.413		
	9.2500	2.411		
	9.5000	2.410		
	9.7500	2.409		
	10.0000	2.407		
	11.0000	2.401		
	12.0000	2.394		
	13.0000	2.386		
	14.0000	2.378		
	15.0000	2.370		
	16.0000	2.361		
	17.0000	2.352		
	18.0000	2.343		
	19.0000	2.333		
	20.0000	2.323		
22	(T=300 K)		Crystals; pure; grown by Bridgiman method under high temperature and high pressure; specimens of thicknesses ranging from 500 to 1000 μm; measured by interference method; data extracted from a figure.	Hattori, T., Homma, Y., Mitsuishi, A., and Tacke, M., 1973 [19]
	540.54	2.999		
	502.51	3.012		
	460.83	3.011		
	425.53	3.006		
	400.00	3.010		
	374.53	3.018		
	349.65	3.012		
	333.33	3.012		
	316.46	3.017		
	300.30	3.014		
	286.53	3.016		
	273.97	3.021		
	261.78	3.019		
	250.63	3.025		
	240.96	3.026		
	232.02	3.028		
	223.71	3.028		
	215.52	3.030		
	207.90	3.027		
	201.61	3.046		
	194.93	3.035		
	188.68	3.039		
	183.82	3.034		
	168.92	3.047		
	164.20	3.049		
	160.26	3.055		
	156.25	3.063		

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Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
23	(T=80 K)		Crystals; pure; grown by Bridgiman method under high temperature and high pressure; specimens of thicknesses ranging from 500 to 1000 μm; measured by interference method; data extracted from a figure.	Hattori, T., et al., 1973 [19]
	421.94	2.971		
	396.83	2.969		
	370.37	2.971		
	350.88	2.976		
	330.03	2.975		
	311.53	2.976		
	297.62	2.979		
	283.29	2.977		
	270.27	2.981		
	258.40	2.980		
	248.14	2.986		
	238.10	2.986		
	228.83	2.989		
	220.75	2.988		
	213.68	2.989		
	205.76	2.990		
	198.41	2.995		
	192.68	2.995		
	187.27	2.998		
	181.49	3.001		
	175.75	3.000		
	171.23	3.001		
	166.11	3.006		
24	(T=2 K)		Crystals; pure; grown by Bridgiman method under high temperature and high pressure; specimens of thicknesses ranging from 500 to 1000 μm; measured by interference method; data extracted from a figure.	Hattori, T., et al., 1973 [19]
	1162.79	2.949		
	980.39	2.954		
	833.33	2.938		
	735.29	2.944		
	657.89	2.954		
	591.72	2.949		
	534.76	2.948		
	492.61	2.960		
	454.55	2.947		
	420.17	2.951		
	392.16	2.954		
	369.00	2.959		
	347.22	2.950		
	328.95	2.962		
	309.60	2.960		
	294.12	2.962		
	280.11	2.960		
	268.10	2.963		
	257.07	2.966		
	246.91	2.970		
	238.10	2.972		
	228.31	2.971		
	218.82	2.975		
	208.77	2.978		
	192.68	2.985		
	179.21	2.988		
	168.07	2.995		
	157.48	3.001		
	148.81	3.008		
	140.06	3.013		
	133.51	3.021		

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Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)-- Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
24 cont.	127.55	3.031		Hattori, T., et al., 1973 [19]
	121.65	3.041		
	116.41	3.049		
	111.98	3.064		
	107.53	3.071		
	103.63	3.082		
	100.10	3.092		
	96.62	3.105		
	93.72	3.122		
	90.74	3.132		
	88.34	3.149		
	85.76	3.165		
	83.54	3.181		
25	(T=300 K)		Polycrystalline; chemical vapor deposited; refractive index determined by deviation method; data extracted from a table.	Franzen, D.L., 1975 [69]
	10.6	2.41		
26	(T=300 K)		Thin film; cubic crystal; specimens of thickness 0.75 to 3.50 μm; substrate held at room temperature during deposition; refractive index data determined by interference method; data extracted from a figure.	Thutupalli, G.K.M. and Tomlin, S.G., 1976 [70]
	0.342	3.011		
	0.353	2.952		
	0.376	2.893		
	0.409	2.848		
	0.451	2.804		
	0.475	2.804		
	0.486	2.789		
	0.492	2.757		
	0.550	2.624		
	0.618	2.543		
	0.701	2.495		
	0.826	2.452		
	1.022	2.430		
	1.233	2.420		
	1.660	2.414		
	2.070	2.408		
27	(T=300 K)		Thin film; cubic crystal; specimens of thickness 0.75 to 3.50 μm; substrate held at 773 K during deposition; refractive index data determined by interference method; data extracted from a figure.	Thutupalli, G.K.M. and Tomlin, S.G., 1976 [70]
	0.344	3.100		
	0.353	3.056		
	0.369	2.996		
	0.392	2.952		
	0.415	2.907		
	0.442	2.907		
	0.459	2.878		
	0.469	2.863		
	0.492	2.797		
	0.512	2.741		
	0.546	2.660		
	0.618	2.587		
	0.709	2.533		
	0.821	2.499		
	1.031	2.475		
	1.235	2.467		
	1.660	2.456		
	2.070	2.455		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
28	(T=300 K)		Prism specimen having faces 14 mm x 5 mm and apex angle 16°; refractive index determined using the minimum deviation method; data extracted from a table; reported uncertainty ±0.002.	Wunderlich, J.A. and DeShazer, L.G., 1977 [53]
	0.4765	2.826		
	0.4880	2.784		
	0.4965	2.759		
	0.5017	2.746		
	0.5145	2.721		
	0.5676	2.645		
	0.5868	2.627		
	0.6072	2.611		
	0.6328	2.592		
29	(T=300 K)		Specimens of crystals and films; refractive indices at 10.6 μm were determined by a modulated light ellipsometer; averaged value of n was extracted from a table; average uncertainty for bulk crystal ±0.02, for film ±0.09.	Pedinoff, M.E., Braunstein, M., and Stafsudd, O.M., 1977 [71]
	10.6	2.46		
30	(T=293.3 K)		Polycrystalline material grown by CVD method; prismatic specimen measured on precision spectrometer by minimum deviation method; refractive indices determined to fifth decimal places; data extracted from a table.	Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]
	0.55	2.66246		
	0.60	2.61380		
	0.65	2.58054		
	0.70	2.55636		
	0.75	2.53804		
	0.80	2.52373		
	0.85	2.51230		
	0.90	2.50298		
	0.95	2.49528		
	1.00	2.48882		
	1.50	2.45708		
	2.00	2.44620		
	2.50	2.44087		
	3.00	2.43758		
	3.50	2.43517		
	4.00	2.43316		
	4.50	2.43132		
	5.00	2.42953		
	5.50	2.42772		
	6.00	2.42584		
	6.50	2.42388		
	7.00	2.42181		
	7.50	2.41961		
	8.00	2.41728		
	8.50	2.41481		
	9.00	2.41218		
	9.50	2.40939		
	10.00	2.40644		
	10.50	2.40331		
	11.00	2.40000		
	11.50	2.39650		
	12.00	2.39281		
	12.50	2.38892		
	13.00	2.38481		
	13.50	2.38048		
	14.00	2.37593		
	14.50	2.37114		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
30 cont.	15.00	2.36610		Feldman, A., et al., 1978 [17]
	15.50	2.36080		
	16.00	2.35523	THIS SPACE FOR CHAPTER NUMBER AND TITLE	
	16.50	2.34937		
	17.00	2.34322		
	17.50	2.33675		
	18.00	2.32996		
31	(T=293.8 K)		Polycrystalline material grown by CVD method; prismatic specimen measured on precision spectrometer by minimum deviation method; refractive indices determined to fifth decimal places; data extracted from a table.	Feldman, A., et al., 1978 [17]
	0.55	2.66278		
	0.60	2.61409		
	0.65	2.58090		
	0.70	2.55676		
	0.75	2.53846		
	0.80	2.52415		
	0.85	2.51270		
	0.90	2.50336		
	0.95	2.49563		
	1.00	2.48915		
	1.50	2.45721		
	2.00	2.44624		
	2.50	2.44086		
	3.00	2.43755		
	3.50	2.43513		
	4.00	2.43312		
	4.50	2.43128		
	5.00	2.42949		
	5.50	2.42769		
	6.00	2.42582		
	6.50	2.42387		
	7.00	2.42181		
	7.50	2.41962		
	8.00	2.41731		
	8.50	2.41485		
	9.00	2.41224		
	9.50	2.40947		
	10.00	2.40653		
	10.50	2.40342		
	11.00	2.40014		
	11.50	2.39666		
	12.00	2.39299		
	12.50	2.38913		
	13.00	2.38505		
	13.50	2.38075		
	14.00	2.37623		
	14.50	2.37148		
	15.00	2.36647		
	15.50	2.36121		
	16.00	2.35568		
	16.50	2.34987		
	17.00	2.34376		
	17.50	2.33735		
	18.00	2.33060		

Table A-5. Experimental data on the refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
32	(T=300 K)		Refractive index was determined by infrared spectroscopic method; the wavelength region, 3-5 μm, was found to be nondispersive having a constant refractive index of 2.408 ± 0.008.	Kulakov, M.P. and Fadeev, A.V., 1980 [47]
	3-5	2.408		

Table A-6. Experimental data on the refractive index of zinc selenide (temperature dependence)

[Temperature, T, K; wavelength, λ, μm; refractive index, n]

Data set	T	n	Specifications and remarks	Author(s), year [ref.]
1	(λ=10.6 μm)		CVD ZnSe product of RCA Inc.; prism (sample No. 1) specimen of 15° apex angle and the face flat to λ/4 in the visible; refractive indices were determined by a minimum deviation method and accurate to approximately $\pm 2 \times 10^{-4}$; data extracted from a figure.	Thompson, C.J.C., DeBell, A.C., and Wolfe, W.L., 1979 [54]
	80	2.3955		
	100	2.3966		
	125	2.3980		
	150	2.3993		
	175	2.4007		
	200	2.4021		
	225	2.4035		
	250	2.4048		
	275	2.4062		
	300	2.4076		
2	(λ=3.8 μm)		CVD ZnSe product of RCA Inc.; prism (sample No. 2) specimen of 15° apex angle and the face flat to λ/4 in the visible; refractive indices were determined by a minimum deviation method and accurate to approximately $\pm 2 \times 10^{-4}$; data extracted from a figure.	Thompson, C.J.C., et al., 1979 [54]
	80	2.4236		
	100	2.4247		
	125	24.261		
	150	2.4276		
	175	2.4290		
	200	2.4304		
	225	2.4318		
	250	2.4333		
	275	2.4347		
	300	2.4361		
3	(λ=3.8 μm)		CVD ZnSe product of RCA Inc.; prism (sample No. 1) specimen of 15° apex angle and the face flat to λ/4 in the visible; refractive indices were determined by a minimum deviation method and accurate to approximately $\pm 2 \times 10^{-4}$; data extracted from a figure.	Thompson, C.J.C., et al., 1979 [54]
	80	2.4245		
	100	2.4253		
	125	2.4268		
	150	2.4285		
	175	2.4299		
	200	2.4313		
	225	2.4327		
	250	2.4342		
	275	2.4356		
	300	2.4370		
4	(λ=10.6 μm)		CVD ZnSe product of RCA Inc.; prism (sample No. 2) specimen of 15° apex angle and the face flat to λ/4 in the visible; refractive indices were determined by a minimum deviation method and accurate to approximately $\pm 2 \times 10^{-4}$; data extracted from a figure.	Thompson, C.J.C., et al., 1979 [54]
	80	2.3946		
	100	2.3957		
	125	2.3971		
	150	2.3984		
	175	2.3998		
	200	2.4012		
	225	2.4026		
	250	2.4039		
	275	2.4053		
	300	2.4067		

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Table A-7. Experimental data on the temperature derivative of refractive index of zinc selenide (wavelength dependence)

[Temperature, T, K; wavelength, λ, μm; temperature derivative of refractive index, dn/dT, $10^{-5}K^{-1}$]

Data set	λ	dn/dT	Specifications and remarks	Author(s), year [ref.]
1	(T=300 K)		Polycrystalline wedge sample (Irtran 4); refractive indices in the wavelength region between 2.5 and 14 μm were measured at two temperatures by deviation method; dn/dT at 5.0 μm was determined.	Hilton, A.R. and Jones, C.E., 1967 [52]
	5.0	4.8		
2	(T=300 K)		Plate specimen; dn/dT determined based on the change of specimen thickness with temperature and known values of refractive index, thickness of specimen, and linear expansion coefficient; data extracted from a table.	Kolosovskii, O.A. and Ustimenko, L.N., 1972 [62]
	10.6	5.9		
3	(T=296-358 K)		Polycrystalline specimen (Irtran 4); the temperature derivative of the refractive index was measured by a modified interferometry using a laser Doppler interferometer for accurate monitoring of the sample temperature change in the temperature range from 296 K to 358 K.	Skolnik, L.H. and Clark, O.M., 1974 [63]
	10.6	5.8		
4	(T=296-335 K)		Polycrystalline specimen (Raytheon CVD); the temperature derivative of the refractive index was measured by a modified interferometry using a laser Doppler interferometer for accurate monitoring of the sample temperature change in the temperature range from 296 K to 335 K.	Skolnik, L.H. and Clark, O.M., 1974 [63]
	10.6	10.0		
5	(T=335-355 K)		Polycrystalline specimen (Raytheon CVD); the temperature derivative of the refractive index was measured by a modified interferometry using a laser Doppler interferometer for accurate monitoring of the sample temperature change in the temperature range from 335 K to 355 K.	Skolnik, L.H. and Clark, O.M., 1974 [63]
	10.6	12.0		
6	(T=293-473 K)		Polycrystalline CVD, grown by Raytheon Co.; prism specimen of 22.5° apex angle; dn/dT determined based on refractive index data measured at various temperatures; small correction to dn due to expansion of air was included in the calculation; data extracted from a table.	Mangir, M.S. and Hellwarth, R.W., 1977 [64]
	3.51	6.9		
	6.32	6.7		
	7.53	6.66		
	8.67	6.57		
	9.73	6.56		
	13.15	6.5		
	15.07	6.4		
7	(T=298-338 K)		Polycrystalline; produced by chemical-vapor-deposit grown by Raytheon; plate specimen; dn/dT data were determined from shifts of Fizeau interference fringes; data extracted from a table; uncertainty about one unit in the first decimal place.	Harris, R.J., Johnson, G.T., Kepple, G.A., Krok, P.C., and Mukai, H., 1977 [3]
	0.6328	9.11		
	1.15	5.97		
	3.39	5.34		
	10.6	5.20		

Table A-7. Experimental data on the temperature derivative of refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	dn/dT	Specifications and remarks	Author(s), year [ref.]
8	(T=93 K)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the thermal expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about one unit in the first decimal place.	Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]
	0.6328	7.6		
	1.15	5.4		
	3.39	5.0		
	10.6	4.9		
	(T=113 K)			
	0.6328	8.2		
	1.15	5.7		
	3.39	5.2		
	10.6	5.1		
	(T=133 K)			
	0.6328	8.7		
	1.15	6.0		
	3.39	5.4		
	10.6	5.4		
	(T=153 K)			
	0.6328	9.1		
	1.15	6.3		
	3.39	5.6		
	10.6	5.5		
	(T=173 K)			
	0.6328	9.4		
	1.15	6.5		
	3.39	5.8		
	10.6	5.7		
	(T=193 K)			
	0.6328	9.7		
	1.15	6.6		
	3.39	5.9		
	10.6	5.8		
	(T=213 K)			
	0.6328	10.0		
	1.15	6.7		
	3.39	6.0		
	10.6	5.9		
	(T=233 K)			
	0.6328	10.2		
	1.15	6.8		
	3.39	6.1		
	10.6	6.0		
	(T=253 K)			
	0.6328	10.3		
	1.15	6.9		
	3.39	6.1		
	10.6	6.0		
	(T=273 K)			
	0.6328	10.5		
	1.15	7.0		
	3.39	6.2		
	10.6	6.1		

Table A-7. Experimental data on the temperature derivative of refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	dn/dT	Specifications and remarks	Author(s), year [ref.]
8 cont.	(T=293 K)			Feldman, A., et al., 1978 [17]
	0.6328	10.6		
	1.15	7.0		
	3.39	6.2		
	10.6	6.1		
	(T=313 K)			
	0.6328	10.7		
	1.15	7.0		
	3.39	6.2		
	10.6	6.1		
	(T=333 K)			
	0.6328	10.8		
	1.15	7.1		
	3.39	6.3		
	10.6	6.1		
	(T=353 K)			
	0.6328	10.9		
	1.15	7.1		
	3.39	6.3		
	10.6	6.2		
	(T=373 K)			
	0.6328	11.0		
	1.15	7.2		
	3.39	6.3		
	10.6	6.2		
	(T=393 K)			
	0.6328	11.1		
	1.15	7.2		
	3.39	6.4		
	10.6	6.3		
	(T=413 K)			
	0.6328	11.3		
	1.15	7.3		
	3.39	6.4		
	10.6	6.3		
	(T=433 K)			
	0.6328	11.5		
	1.15	7.4		
	3.39	6.5		
	10.6	6.4		
	(T=453 K)			
	0.6328	11.8		
	1.15	7.6		
	3.39	6.6		
	10.6	6.6		
	(T=473 K)			
	0.6328	12.1		
	1.15	7.8		
	3.39	6.7		
	10.6	6.7		

Table A-7. Experimental data on the temperature derivative of refractive index of zinc selenide (wavelength dependence)--Continued

Data set	λ	dn/dT	Specifications and remarks	Author(s), year [ref.]
9	(T=80-300 K)		CVD ZnSe produced by RCA Inc.; two prism specimens of 15° apex angle and the faces flat to λ/4 in the visible; refractive indices over temperature range 80 K to 300 K were measured by minimum deviation method; the dn/dT values determined are independent of temperature.	Thompson, C.J.C., DeBell, A.G., and Wolfe, W.L., 1979 [54]
	3.8	7.0		
	10.6	6.0		
10	(T=293-353 K)		Single crystal grown from the melt under argon atmosphere by the Bridgiman method; disk-shaped specimen with a thickness of 4-10 mm and a diameter of 35-50 mm; dn/dT was determined from interference fringe shifting observation; data extracted from a table; accuracy ±5-10%.	Afanas'ev, I.I. and Nosov, V.B., 1979 [65]
	0.63	11.1		

Table A-8. Experimental data on the temperature derivative of refractive index of zinc selenide (temperature dependence)

[Temperature, T, K; wavelength, λ, μm; temperature derivative of refractive index, dn/dT, $10^{-5}K^{-1}$]

Data set	T	dn/dT	Specifications and remarks	Author(s), year [ref.]
1	(λ=0.6328 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about one unit in the first decimal place.	Feldman, A., Horowitz, D., Waxler, R.M., and Dodge, M.J., 1978 [17]
	93	7.6		
	113	8.2		
	133	8.7		
	153	9.1		
	173	9.4		
	193	9.7		
	213	10.0		
	233	10.2		
	253	10.3		
	273	10.5		
	293	10.6		
	313	10.7		
	333	10.8		
	353	10.9		
	373	11.0		
	393	11.1		
	413	11.3		
	433	11.5		
	453	11.8		
	473	12.1		
2	(λ=1.15 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about one unit in the first decimal place.	Feldman, A., et al., 1978 [17]
	93	5.4		
	113	5.7		
	133	6.0		
	153	6.3		
	173	6.5		
	193	6.6		
	213	6.7		
	233	6.8		
	253	6.9		
	273	7.0		
	293	7.0		
	313	7.0		
	333	7.1		
	353	7.1		
	373	7.2		
	393	7.2		
	413	7.3		
	433	7.4		
	453	7.6		
	473	7.8		
3	(λ=3.39 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about one unit in the first decimal place.	Feldman, A., et al., 1978 [17]
	93	5.0		
	113	5.2		
	133	5.4		
	153	5.6		
	173	5.8		
	193	5.9		
	213	6.0		
	233	6.1		
	253	6.1		
	273	6.2		

Table A-8. Experimental data on the temperature derivative of refractive index of zinc selenide (temperature dependence)--Continued

Data set	T	dn/dT	Specifications and remarks	Author(s), year [ref.]
3 cont.	293	6.2		Feldman, A., et al., 1978 [17]
	313	6.2		
	333	6.3		
	353	6.3		
	373	6.3		
	393	6.4		
	413	6.4		
	433	6.5		
	453	6.6		
	473	6.7		
4	(λ=10.6 μm)		Polycrystalline material grown by CVD method; plate specimen; dn/dT data were determined from a knowledge of the expansion coefficient and by measuring the shift of Fizeau fringes in the heated specimen; data extracted from a table; standard deviation about one unit in the first decimal place.	Feldman, A., et al., 1978 [17]
	93	4.9		
	113	5.1		
	133	5.4		
	153	5.5		
	173	5.7		
	193	5.8		
	213	5.9		
	233	6.0		
	253	6.0		
	273	6.1		
	293	6.1		
	313	6.1		
	333	6.1		
	353	6.2		
	373	6.2		
	393	6.3		
	413	6.3		
	433	6.4		
	453	6.6		
	473	6.7		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)

[Temperature, T, K; wavelength, λ, μm; refractive index, n]

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
1	(T=300 K)		Crystal grown by vacuum sublimation method; prismatic specimen; refractive indices determined by minimum deviation method; data extracted from a figure.	Aten, A.C., Van Doorn, C.Z., and Vink, A.T., 1962 [72]
	0.563	3.162		
	0.588	3.094		
	0.624	3.026		
	0.667	2.966		
	0.723	2.913		
	0.801	2.868		
	0.908	2.831		
	1.069	2.786		
	1.329	2.756		
	1.739	2.734		
	2.335	2.727		
2	(T=300 K)		Small crystal; cut into a prism with apex angle 15°43' and optically polished; refractive indices were determined by minimum deviation method; data extracted from a figure.	Shiozawa, L.R., Devlin, S.S., Barrett, J.L., Jost, J.M., and Chotkevys, G.P., 1962 [73]
	0.518	3.184		
	0.520	3.174		
	0.522	3.166		
	0.526	3.160		
	0.540	3.135		
	0.553	3.120		
	0.559	3.114		
	0.568	3.106		
	0.574	3.100		
	0.579	3.096		
	0.589	3.089		
	0.600	3.082		
	0.620	3.069		
	0.640	3.056		
	0.659	3.044		
	0.680	3.032		
	0.700	3.020		
3	(T=297 K)		Single crystal; cubic; grown from vapor deposition; prism specimen of apex angle 22°15'; refractive indices were determined by minimum deviation method; data extracted from a table.	Shiozawa, L.R., Jost, J.M., Chotkevys, G.P., Devlin, S.S., Barrett, J.L., and Sliker, T.R., 1963 [74]
	0.569	3.111		
	0.577	3.085		
	0.579	3.079		
	0.589	3.054		
	0.600	3.035		
	0.600	3.035		
	0.616	3.005		
	0.650	2.962		
	0.700	2.912		
	0.700	2.914		
	0.725	2.893		
	0.750	2.878		
	0.750	2.880		
	0.760	2.871		
	0.770	2.866		
	0.800	2.853		
	1.000	2.790		
	1.200	2.758		
	1.300	2.748		
	1.400	2.741		
	1.500	2.7342		
	1.515	2.7336		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
4	(T=298 K)		Single crystal; impurities 0.001-0.002% P, 0.0005-0.001% As, Fe, Si, <0.0005% Cd, Sb, trace of Ag, Al, Au, B, Co, Cu, Ga, In, Li, Mn, Ni, >0.002% oxygen and halogens; crystal grown in sealed, argon-filled, quartz tube by sublimation of the compound from a hot furnace zone into a cooler zone where crystals formed; prism specimen consisted of two to four single crystal grains strongly bonded together in optical contact; data extraction by using the equation $n^2=A+[B\lambda^2/(\lambda^2-C^2)]$, where A=4.27, B=3.01, C^2=0.142, and λ in units of μm; uncertainties in refractive indices about ±0.003.	Marple, D.T.F., 1964 [48]
	0.57	3.101		
	0.6	3.040		
	0.7	2.917		
	0.8	2.853		
	1.0	2.789		
	1.1	2.771		
	1.2	2.759		
	1.3	2.749		
	1.4	2.741		
	1.5	2.736		
	1.7	2.727		
	1.9	2.721		
	2.0	2.719		
	2.2	2.715		
	2.4	2.712		
	2.6	2.710		
5	(T=300 K)		Thin films of varying thickness deposited on KRS-5 substrate with back surface roughened to eliminate second surface reflection; refractive indices of ZnTe were from reflectance measurements; data extracted from a figure.	Bausch & Lomb Inc., 1964 [76]
	1.321	2.660		
	2.317	2.654		
	3.254	2.650		
	4.717	2.646		
	6.531	2.645		
	8.754	2.642		
	10.569	2.635		
	12.677	2.627		
	14.668	2.617		
	16.719	2.603		
	18.770	2.590		
	20.763	2.576		
	22.931	2.560		
	24.749	2.545		
	26.800	2.529		
	29.028	2.511		
	31.081	2.492		
	32.606	2.478		
	34.071	2.467		
6	(T=297 K)		Optical constants were obtained by the Kramers-Kronig analysis of the normal-incidence reflection spectrum; data extracted from a figure.	Cardona, M., 1965 [77]
	0.062	0.803		
	0.064	0.835		
	0.069	0.883		
	0.076	0.914		
	0.084	1.012		
	0.092	1.093		
	0.098	1.125		
	0.101	1.142		
	0.104	1.108		
	0.111	1.074		
	0.124	1.023		
	0.135	0.989		
	0.144	0.955		
	0.153	0.905		
	0.158	0.855		
	0.160	0.904		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
6 cont.	0.164	0.954		Cardona, M., 1965 [77]
	0.167	1.020		
	0.180	1.069		
	0.182	1.119		
	0.187	1.152		
	0.191	1.151		
	0.202	1.018		
	0.213	0.952		
	0.220	0.985		
	0.226	1.018		
	0.234	1.448		
	0.255	1.978		
	0.269	2.127		
	0.279	2.143		
	0.290	2.160		
	0.303	2.591		
	0.316	2.756		
	0.323	2.723		
	0.337	2.673		
	0.345	2.723		
	0.346	2.822		
	0.347	3.303		
	0.356	3.402		
	0.393	3.368		
	0.440	3.302		
	0.467	3.235		
	0.515	3.169		
	0.553	3.119		
	0.574	3.069		
	0.648	2.969		
	0.744	2.853		
	1.061	2.753		
	1.853	2.719		
7	(T=300 K)		Thin film specimen of 0.07 μm thickness; vacuum evaporated onto a fused silica substrate from 99.999% pure ZnTe; also a quasi-single crystal from commercial; one face of the crystal was polished with 0.05 μm alumina; refractive indices were determined from the reflectances measured at angles 20° and 70°; data extracted from a figure.	Crandell, M.E. and Linton, R.C., 1974 [81]
	0.0550	0.7564		
	0.0570	0.7697		
	0.0590	0.7760		
	0.0618	0.7962		
	0.0653	0.8163		
	0.0663	0.8231		
	0.0684	0.8224		
	0.0711	0.8217		
	0.0729	0.8212		
	0.0766	0.8345		
	0.0801	0.8337		
	0.0814	0.8405		
	0.0824	0.8474		
	0.0842	0.8541		
	0.0872	0.8465		
	0.0913	0.8457		
	0.0950	0.8309		
	0.0988	0.8304		
	0.1021	0.8299		
	0.1045	0.8438		
	0.1071	0.8222		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
7 cont.	0.1108	0.8146		Crandell, M.E. and Linton, K.C., 1974 [81]
	0.1126	0.8215		
	0.1196	0.8563		
	0.1229	0.8702		
	0.1266	0.9338		
	0.1294	1.005		
	0.1299	1.026		
	0.1344	1.068		
	0.1371	1.089		
	0.1399	1.117		
	0.1416	1.153		
	0.1428	1.167		
	0.1445	1.181		
	0.1470	1.174		
	0.1495	1.131		
	0.1508	1.081		
	0.1521	1.024		
	0.1547	1.010		
	0.1583	1.010		
	0.1605	1.038		
	0.1628	1.095		
	0.1635	1.109		
	0.1667	1.102		
	0.1699	1.109		
	0.1769	1.186		
	0.1885	1.314		
	0.1927	1.328		
	0.1948	1.335		
	0.1993	1.313		
	0.2016	1.285		
	0.2039	1.285		
	0.2064	1.299		
	0.2089	1.320		
	0.2142	1.512		
	0.2226	1.618		
	0.2286	1.781		
	0.2364	1.816		
	0.2397	1.845		
	0.2468	2.008		
	0.2504	2.079		
	0.2505	2.150		
	0.2507	2.256		
	0.2508	2.320		
	0.2545	2.349		
	0.2580	2.157		
	0.2620	2.249		
	0.2726	2.490		
	0.2866	2.732		
	0.2940	2.795		
	0.2992	2.873		
	0.3045	2.930		
	0.3047	3.001		
	0.3082	3.378		
	0.3159	3.065		
	0.3158	3.001		
	0.3283	3.257		
	0.3351	3.470		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
8	(T=300 K)		Crystal (structure not given); grown at the Aerospace Research Laboratories, Wright-Patterson Air Force Base, OH; sample was polished to a mirror-like finish; near normal (12° incident angle) reflectivity was measured; refractive indices were deduced from reflection spectrum by Drude dispersion theory; data extracted from a figure.	Manabe, A., Mitsuishi, A., and Yoshinaga, H., 1967 [16]
	24.747	2.488		
	29.795	2.494		
	29.796	2.421		
	39.749	2.069		
	42.346	1.927		
	45.233	1.565		
	46.965	1.203		
	48.700	0.329		
	49.855	0.111		
	52.018	0.260		
	53.459	0.481		
	54.611	0.848		
	54.898	1.140		
	55.608	3.331		
	56.175	5.375		
	56.738	8.223		
	56.876	9.464		
	57.606	7.567		
	58.769	5.889		
	59.493	5.306		
	61.371	4.579		
	63.682	4.071		
	67.001	3.710		
	68.588	3.566		
	72.916	3.426		
	80.272	3.362		
	85.176	3.369		
9	(T=100 K)		Crystal (structure not given); grown at the Aerospace Research Laboratories, Wright-Patterson Air Force Base, OH; sample was polished to a mirror-like finish; near normal (12° incident angle) reflectivity was measured; refractive indices were deduced from reflection spectrum by Drude dispersion theory; data extracted from a figure.	Manabe, A., et al., 1967 [16]
	42.202	1.853		
	45.234	1.346		
	46.534	0.910		
	47.690	0.401		
	48.701	0.110		
	49.711	0.038		
	52.018	0.187		
	53.601	1.065		
	54.604	2.234		
	55.310	5.374		
	55.729	8.002		
	55.717	10.411		
	56.448	8.368		
	57.323	6.544		
	58.627	5.305		
	59.639	4.796		
	63.250	3.924		
	66.568	3.710		
10	(T=300 K)		Specimen prepared from ZnTe pellet; optical constants were determined from reflection spectrum by Lorentz oscillator fitting; data extracted from a figure.	Handi, A., Henry, P., Lambert, J.P., Morlot, G., Strimer, P., and Chanal, D., 1967 [55]
	7.538	2.424		
	20.346	2.422		
	29.703	2.370		
	36.590	2.219		
	40.026	2.019		
	44.436	1.643		
	46.384	1.268		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
10 cont.	47.341	0.817		Handi, A., et al., 1967 [55]
	48.319	0.692		
	47.334	0.692		
	50.288	0.667		
	51.284	0.842		
	53.291	1.442		
	54.327	2.266		
	54.370	2.966		
	55.382	3.391		
	55.428	4.141		
	56.438	4.541		
	55.960	4.791		
	57.934	4.841		
	58.417	4.691		
	62.332	4.265		
	66.741	3.864		
	70.671	3.689		
	74.602	3.538		
	79.521	3.412		
	89.861	3.336		
	101.188	3.284		
	113.997	3.307		
	125.818	3.280		
11	(T=90 K)		Specimen prepared from ZnTe pellet; optical constants were determined from reflection spectrum by Lorentz oscillator fitting; data extracted from a figure.	Handi, A., et al., 1967 [55]
	21.713	2.447		
	26.639	2.446		
	32.547	2.245		
	39.932	1.944		
	44.848	1.343		
	46.812	0.893		
	47.795	0.742		
	49.764	0.692		
	50.259	0.842		
	51.746	1.392		
	53.739	2.891		
	54.254	4.291		
	55.257	5.491		
	55.762	6.291		
	55.774	7.041		
	56.268	7.141		
	57.245	6.641		
	58.213	5.491		
	58.697	4.941		
	62.138	4.440		
	66.565	4.039		
	73.948	3.638		
	87.737	3.386		
	101.037	3.334		
	115.322	3.282		
	124.681	3.230		
12	(T=290 K)		Specimen prepared from ZnTe pellet; optical constants were determined by transmission and reflection measurements in the infrared using Lorentz oscillator model; it was found that	Handi, A., Claudel, J., and Strimer, P., 1968 [56]
	35.187	2.174		
	37.185	2.114		
	39.746	2.053		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
12 cont.	42.684	1.902	at 290 K ν_1=177 cm^{-1} and ν_{20}=205 cm^{-1}; data extracted from a figure.	Handi, A., et al., 1968 [56]
	44.565	1.781		
	45.827	1.601		
	46.351	1.510		
	46.888	1.390		
	47.434	1.119		
	47.994	0.908		
	48.279	0.788		
	48.861	0.668		
	51.022	0.728		
	52.009	0.818		
	53.038	1.088		
	54.477	1.539		
	55.614	2.140		
	56.014	2.832		
	56.818	3.614		
	57.639	4.065		
	58.055	4.155		
	59.331	4.035		
	60.213	3.914		
	61.583	3.674		
	66.655	3.342		
	77.515	3.041		
	92.619	3.010		
	136.395	3.008		
13	(T=80 K)		Specimen prepared from ZnTe pellet; optical constants were determined by transmission and reflection measurements in the infrared using Lorentz oscillator model; it was found that at 290 K ν_1=181 cm^{-1} and ν_{20}=209 cm^{-1}; data extracted from a figure.	Handi, A., et al., 1968 [56]
	34.636	2.205		
	36.025	2.174		
	38.423	2.113		
	40.748	2.023		
	42.910	1.902		
	44.565	1.751		
	45.826	1.570		
	46.886	1.270		
	47.154	0.909		
	48.278	0.728		
	49.159	0.668		
	50.702	0.728		
	52.693	1.148		
	53.758	1.840		
	54.502	2.802		
	55.267	3.795		
	56.052	4.667		
	56.845	4.847		
	56.843	4.787		
	57.651	4.606		
	58.903	4.215		
	60.659	3.704		
	65.572	3.312		
	71.357	3.131		
	76.056	3.041		
	83.095	3.040		
	98.252	3.040		
	143.672	3.008		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
14	(T=300 K)		Vacuum deposited thin layer specimen; 1-1.3 μm thick; vacuum annealed for 80 hr. at 623 K; refractive index at 0.50 μm determined by interference method; data extracted from a table.	Kot, M.V. and Tyrziu, V.G., 1970 [68]
	0.50	2.80		
15	(T=300 K)		Single crystals; grown by a vapor phase method in vacuum and in Ar atmosphere of about 1 atm, and grown from a melt; impurities Cu, Al, and Fe were introduced into some specimens but the effect on the optical properties negligible; refractive index determined by prism method; data calculated from a best fit dispersion equation.	Horikoshi, Y., Ebina, A., and Takahashi, T., 1971 [80]
	0.55	3.148		
	0.56	3.119		
	0.57	3.094		
	0.58	3.071		
	0.59	3.050		
	0.60	3.031		
	0.62	2.998		
	0.63	2.984		
	0.64	2.970		
	0.65	2.958		
	0.66	2.946		
	0.67	2.936		
	0.69	2.917		
	0.71	2.900		
	0.72	2.892		
	0.75	2.872		
16	(T=97 K)		Single crystals; grown by a vapor phase method in vacuum and in Ar atmosphere of about 1 atm, and grown from a melt; impurities Cu, Al, and Fe were introduced into some specimens but the effect on the optical properties negligible; refractive index determined by prism method; average values of the results extracted from a figure.	Horikoshi, Y., et al., 1971 [80]
	0.533	3.156		
	0.536	3.145		
	0.545	3.113		
	0.552	3.094		
	0.555	3.082		
	0.564	3.059		
	0.575	3.037		
	0.586	3.017		
	0.593	3.001		
	0.608	2.980		
	0.621	2.959		
	0.634	2.942		
	0.648	2.927		
	0.661	2.913		
	0.678	2.896		
	0.695	2.883		
	0.713	2.869		
	0.730	2.858		
	0.749	2.847		
	0.761	2.840		
17	(T=300 K)		Crystal; pure; grown by Bridgiman method under high temperature and high pressure; specimens of 500 to 1000 μm thick; deviation of surface flatness smaller than 0.4%; refractive indices were determined by interference method; data extracted from a figure.	Hattori, T., Homma, Y., Mitsuishi, A., and Tacke, M., 1973 [19]
	184.118	3.213		
	195.137	3.197		
	209.222	3.200		
	217.964	3.209		
	224.532	3.196		
	232.541	3.188		
	240.032	3.181		
	251.610	3.191		
	261.704	3.186		
	287.687	3.168		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
17 cont.	302.709	3.169		Hattori, T., et al., 1973 [19]
	317.440	3.167		
	333.689	3.165		
	354.070	3.167		
	374.405	3.160		
	400.256	3.151		
	429.941	3.158		
	460.299	3.155		
	500.000	3.162		
	541.535	3.154		
18	(T=80 K)		Crystal; pure; grown by Bridgiman method under high temperature and high pressure; specimens of 500 to 1000 μm thick; deviation of surface flatness smaller than 0.4%; refractive indices were determined by interference method; data extracted from a figure.	Hattori, T., et al., 1973 [19]
	161.339	3.167		
	165.434	3.159		
	170.852	3.159		
	176.040	3.158		
	180.923	3.155		
	186.088	3.151		
	192.259	3.150		
	198.854	3.146		
	205.111	3.145		
	212.634	3.145		
	219.804	3.135		
	229.473	3.140		
	237.840	3.133		
	248.022	3.132		
	257.825	3.129		
	269.825	3.132		
	281.476	3.128		
	295.840	3.126		
	311.749	3.126		
	331.565	3.127		
	349.332	3.121		
	369.099	3.119		
	394.213	3.123		
	419.568	3.110		
	452.304	3.117		
19	(T=2 K)		Crystal; pure; grown by Bridgiman method under high temperature and high pressure; specimens of 500 to 1000 μm thick; deviation of surface flatness smaller than 0.4%; refractive indices were determined by interference method; data extracted from a figure.	Hattori, T., et al., 1973 [19]
	102.021	3.278		
	103.437	3.272		
	105.529	3.269		
	107.044	3.265		
	108.831	3.265		
	110.679	3.252		
	112.346	3.246		
	113.965	3.242		
	116.357	3.232		
	118.470	3.228		
	120.942	3.220		
	122.937	3.218		
	125.300	3.213		
	127.754	3.209		
	130.309	3.204		
	132.964	3.199		
	135.733	3.195		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
19 cont.	138.987	3.190		Hattori, T., et al., 1973 [19]
	142.015	3.181		
	145.175	3.181		
	148.482	3.177		
	151.941	3.169		
	156.033	3.169		
	159.856	3.165		
	164.389	3.164		
	169.190	3.159		
	173.695	3.153		
	178.450	3.149		
	184.118	3.148		
	190.157	3.148		
	195.871	3.144		
	202.720	3.140		
	209.222	3.139		
	217.964	3.136		
	225.504	3.134		
	234.631	3.128		
	244.528	3.127		
	255.303	3.127		
	265.703	3.123		
	276.993	3.125		
	294.169	3.121		
	308.071	3.118		
	323.342	3.117		
	342.454	3.114		
	363.954	3.109		
	391.251	3.116		
	416.215	3.111		
	448.430	3.108		
	490.604	3.111		
	530.504	3.098		
	583.941	3.099		
20	(T=300 K)		Thin film; specimens of thickness 0.75 to 3.50 μm; substrate held at room temperature during deposition; refractive index data determined by interference method; data extracted from a figure.	Thutupalli, G.K.M. and Tomlin, S.G., 1976 [70]
	0.354	3.862		
	0.381	3.610		
	0.409	3.416		
	0.438	3.298		
	0.472	3.224		
	0.504	3.164		
	0.533	3.135		
	0.547	3.090		
	0.570	3.016		
	0.595	2.956		
	0.645	2.867		
	0.744	2.793		
	0.859	2.734		
	1.057	2.705		
	1.393	2.660		
	1.996	2.661		

Table A-9. Experimental data on the refractive index of zinc telluride (wavelength dependence)--Continued

Data set	λ	n	Specifications and remarks	Author(s), year [ref.]
21	(T=300 K)		Thin film; specimens of thickness 0.75 to 3.50 μm; substrate held at 598 K during deposition; refractive index data determined by interference method; data extracted from a figure.	Thutupalli, G.K.M. and Tomlin, S.G., 1976 [70]
	0.349	3.937		
	0.368	3.788		
	0.396	3.580		
	0.424	3.431		
	0.467	3.283		
	0.498	3.239		
	0.520	3.239		
	0.533	3.209		
	0.555	3.150		
	0.578	3.075		
	0.626	3.001		
	0.688	2.942		
	0.809	2.838		
	1.018	2.764		
	1.306	2.735		
	1.904	2.720		