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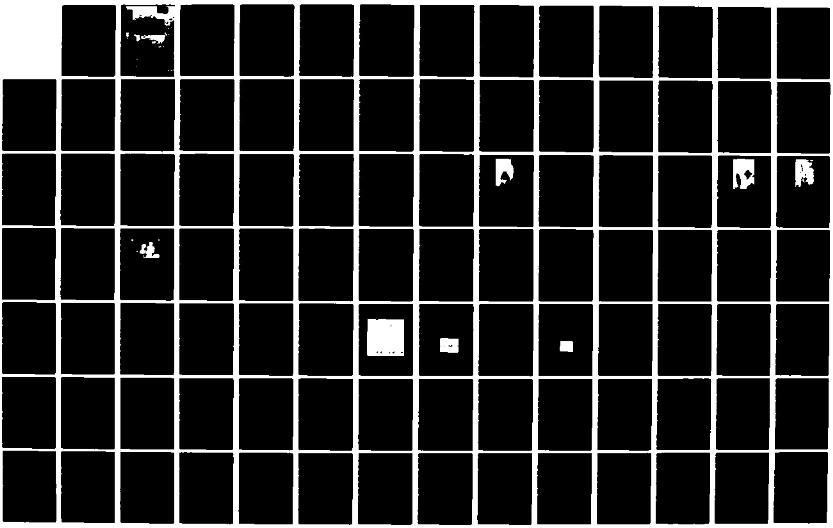

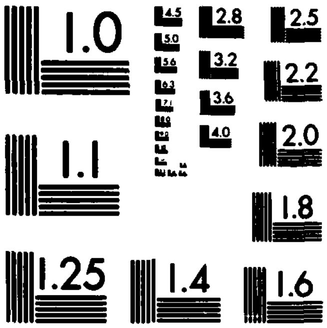

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ANNUAL PROGRESS REPORT

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REPORT OF SIGNIFICANT ACCOMPLISHMENTS

Joint Services Electronics Program

Contract N00014-75-C-0632

1 April 1982 through 31 March 1983

G.L. Report No. 3568

Edward L. Ginzton Laboratory

OF THE

W. W. HANSEN LABORATORIES OF PHYSICS

STANFORD UNIVERSITY, STANFORD, CALIFORNIA 94305

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Edward L. Ginzton Laboratory
Stanford University
Stanford, CA 94305

Submitted by A.E. Siegman on behalf
of the faculty and staff of the
Edward L. Ginzton Laboratory

August 1983

Edward L. Ginzton Laboratory
W.W. Hansen Laboratories of Physics
STANFORD UNIVERSITY

ANNUAL PROGRESS REPORT

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JSEP CONTRACT NO. N00014-75-C-0632

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Submitted by A.E. Siegman on behalf of the faculty and staff of
the Edward L. Ginzton Laboratory

Ginzton Laboratory Report No. G.L. 3568

SECTION I

INTRODUCTION

This is the second annual progress report for the JSEP program in the Edward L. Ginzton Laboratory at Stanford University. The report covers the period running from 1 April 1982 to 31 March 1983. The research activities during this period were organized into five Work Units, as outlined in our original proposal, covering the following topics:

Work Unit #82-1. Nonlinear Interactions of Acoustic Waves With Domains in Ferroic Materials (B. A. Auld)

Work Unit #82-2. High-T_c Superconducting Weak-Link Josephson Junctions and Circuits (M. R. Beasley)

Work Unit #82-3. Optical and Nonlinear Optical Studies of Single Crystal Fibers (R. L. Byer)

Work Unit #82-4. Acoustic Surface Wave Scanning of Optical Images (G. S. Kino)

Work Unit #82-5. Picosecond Raman Studies of Electronic Solids (A. E. Siegman)

Significant progress is reported in each of our on-going Work Units. Professor Byer and his students have now succeeded in growing single crystal optical fibers with lengths of 15 cm and diameter variations of less than 1%. Devices based on these fibers are now being developed. In potentially very important work, Professor Auld and his group have learned to inject domain walls into ferroelastic materials and have shown that a high intensity acoustic wave may be used for the positioning of these walls. Ferroelectric crystals of this type have the potential for realizing a new generation of programmable acoustic and acousto-optical devices. Professor Beasley and his group have developed the first viable and practical high-T_c Josephson junction devices and have made substantial improvements in the technology of the fabrication of these devices. Applications include high-speed analog signal processing similar in spirit to that developed by Kino and his group using surface acoustic waves. Professor Kino and his students have shown that surface acoustic waves may be combined with VLSI technology to make delay lines, convolvers, and programmable filters with totally new capabilities and the potential for ultra-high speed processing of electrical signals.

In Section II of this report we summarize the significant accomplishments of the different Work Units; Section III presents the annual progress reports for each Work Unit; Section IV lists publications citing JSEP sponsorship; Section V lists reports and publications of the Edward L. Ginzton Laboratory; and Section VI lists laboratory contract and grant support.

SECTION II

REVIEW OF SIGNIFICANT ACCOMPLISHMENTS

A brief review of significant accomplishments during the past year for each of the current Work Units is given in this section. More details of each of these projects will be found in the longer Annual Progress Reports for each of the Work Units, which follow this section.

WORK UNIT #82-1. Nonlinear Interactions of Acoustic Waves With Domains in Ferroic Materials (B. A. Auld)

A. NEW ADVANCES

1. Techniques for Fabricating Domain Wall Arrays in Ferroelastic Materials

We have fabricated and tested a programmable domain injection station utilizing the lateral domain injection technique described in our latest publication [S. W. Meeks, B. A. Auld, P. Maccagno, and A. Miller, "Interaction of Acoustic Waves and Ferroelastic Domain Walls," presented at the 1983 IEEE International Symposium on Applications of Ferroelastics (ISAF), Gaithersburg, Maryland (to appear in Ferroelectrics)]. This consists of a jig with micropositioner controlled placement of the ferroelastic crystal between a pair of electrically controlled knife edges for applying a precisely-located pair of offset line forces to the upper and lower faces of the crystal. As explained in the reference cited and in our progress report, a ferroelastic domain wall is injected under each knife edge when the applied force exceeds a certain threshold. Once a pair of domains has been injected the crystal can be stepped along with the micropositioners to -reate an entire array. Using this device we have injected domains into samples with as much as 1 cm × 1 cm cross section and have created a domain wall array with spacing less than 1 mm. For some applications it is anticipated that wall spacings in the range of 10-30 μm will be required. A number of concepts specifically directed to fabrication of these finer-scale gratings have been invented, and patent disclosures will be made. These include the use of ruled micro-gratings on glass or metal plates for application of precisely spaced domain-injection forces, the use of accurately ruled scratches on the crystal surface to provide mechanical traps for the periodically spaced domain walls, and the use of microlithographed electrode arrays to be used as programmable electrical traps for stacking the domains as they are mechanically injected from one end of the crystal.

2. First Demonstration of Ferroelastic Domain Wall Motion Under the Influence of an Acoustic Wave

A high intensity acoustic wave in a crystal generates, through the nonlinear elastic properties of the medium, both second harmonic and static components of elastic stress having a spatial periodicity determined by the acoustic wavelength. We have made, in neodymium pentaphosphate, the first observation of ferroelastic domain wall displacement under the influence of this nonlinearly-generated static stress. This effect, when combined with a spatially uniform static bias stress, provides a means for fine tuning domain wall gratings created by the techniques described in Section A.1.

B. RELATION TO PRESENT TECHNOLOGY

1. Phasematching for Optical Harmonic Generation and Parametric Interactions

No practical solution has yet been found for phasematched colinear optical second harmonic generation that can be compensated with respect to temperature changes. In a number of laboratories, experiments have been performed on domain grating arrays in ferroelectric crystals, but these are not easy to fabricate and cannot be adjusted once fabricated. The ferroelastic domain wall gratings we have been studying project substantial improvement in the facility of fabrication and an almost real time adjustability that is not otherwise available. This will have its principle impact in nonlinear fiber optics devices, where it has been predicted that phasematching in a periodically poled $LiNbO_3$ fiber will produce a 20-fold improvement in frequency doubling efficiency. Ferroelastic domain wall phasematching for frequency doubling in GMO will provide similar improvement, since we calculate that its nonlinear figure of merit is superior to that of KDP, but with much improved means of injecting and controlling the phasematching grating.

2. Programmable and Latching Optical Spectral Filters

Tunable optical spectral filters occupy an important place in current spectrometer and optical image processing technology. Both electro-optic and acousto-optic versions of these filters suffer from the disadvantage of limited optical aperture and the acousto-optic filter also has a limitation imposed by the fact that it must be driven continuously by a relatively high power. Our new ferroelastic domain wall grating technology interfaces with present spectrometer and image processing technology through its potential for providing larger aperture filters that require an applied voltage only during the tuning operation — i.e., they are latching-type devices. We have demonstrated the injection of domain wall pairs with wall surfaces as large as 1 cm × 1 cm and ferroelastic crystals, particularly GMO, are available commercially in this size.

Furthermore, GMO has an intrinsic switchable birefringence $\Delta n = -4 \times 10^{-4}$, which would require an acoustic power density of 100 W/mm^2 in a photoelastic material with $p = 0.1$.

WORK UNIT #82-2. High-T_c Superconducting Weak-Link Josephson Junctions and Circuits (M. R. Beasley)

Under this program we have developed the first really practical Josephson junction that can operate at temperatures in excess of 10^oK where small cryogenic refrigerators are available. The device is a planar, superconductor/normal metal/superconductor (SNS) microbridge. Useful Josephson behavior has been obtained from 2^oK up to at least 15^oK, the largest temperature range of operation of any Josephson device. The existence of this device opens up for the first time consideration of circuit applications based on the high-T_c superconducting materials. The I-V curves and low capacitance of these devices makes them ideal for SQUID instruments and rf applications. Logic circuits have been built in Japan using Nb microbridges. If this turns out to constitute a viable logic technology, then our devices would likely be suitable for such applications as well.

Development of this device also entailed developing the necessary thin film deposition and processing procedures suitable for its fabrication with the high-T_c superconducting materials. Our approach is based on "step-edge patterning" in which the edge of a step in the substrate defines the critical length dimension of the bridge. A patent has been issued on this process. The beauty of this approach is that it is suitable for use with all the known high-T_c superconductors. Hence it represents a generic solution to high-T_c SNS microbridge fabrication. We have successfully implemented it with Nb ($T_c = 9^{o}K$), Nb_3Sn ($T_c = 18^{o}K$) and Nb_3Ge ($T_c = 23^{o}K$), the latter being the highest critical temperature superconductor known.

Finally, theoretical models of the device behavior have been developed. Thus application and further development of the device can proceed with theoretical guidance.

WORK UNIT #82-3. Optical and Nonlinear Optical Studies of Single Crystal Fibers (R. L. Byer)

The principal accomplishments of the single crystal fiber research effort are the demonstration that oriented single crystal fibers can be grown from less than 15 μm diameter to greater than 1 mm diameter using a laser heated pedestal growth technique. Following the demonstration that growth is indeed possible, and in many ways, straightforward, the research program has led to other accomplishments.

We have designed and implemented a second generation growth machine that incorporates unique optics and fiber translation control. The machine has successfully gorwn over 100 fibers during its initial two months of operation. The machine has also produced fibers with less than 1% diameter variations and fibers of up to 15 cm in length. The second generation fiber machine design has been patented.

We have successfully grown fibers of sapphire, Nd:YAG, $LiNbO_3$, $LiGeO_3$, $CaWO_3$ and $GdMoO_3$. We have also grown $Cr^{+++}Al_2O_3$ (ruby) and $Ti^{+++}Al_2O_3$ (a new laser material).

We have characterized the optical properties of the single crystal fibers and have learned to launch radiation into the fibers. Devices based on the single crystal fiber properties are now being developed.

We have invented and demonstrated a new fiber diameter measurement device that can measure the fiber diameter to ± 500 Å in 1 msec. This device will be used to actively control the diameter of single crystal fibers during growth.

The single crystal fibers allow passive fiber devices such as polarizers and filters to be constructed in a fiber format. Other potential applications of single crystal fibers include high temperature thermometry and transmission of high power laser radiation.

Active fiber devices include laser oscillators and amplifiers in fiber format. Nd:YAG fibers 100 μm in diameter have been operated as laser oscillators.

Single crystal fibers of nonlinear materials potentially allow efficient nonlinear conversion of milliwatt cw laser sources. Fibers can also be used for infrared generation by mixing and for the generation of tunable output by parametric processes. Work is in progress to demonstrate these useful nonlinear devices.

The rapid growth rate of single crystal fibers from powdered starting material allows surveys of new materials to be conducted at minimum time and cost. We have initiated the growth of new laser crystals using our single crystal fiber growth capability.

The realization of these advances requires continued research and the development of new techniques. Progress in the understanding of fiber growth has been rapid. The next phase is to demonstrate the utility of single crystal fibers in devices.

WORK UNIT #82-4. Acoustic Surface Wave Scanning of Optical Images

(G. S. Kino)

The main contribution of our work has been to demonstrate that surface wave devices can be constructed on silicon substrates along with sophisticated integrated circuitry. Not only is it possible to make surface wave devices connected to integrated circuits at input and output, but also to make the integrated circuits part of the surface wave device itself. This has necessitated developing, over the years, a sophisticated ZnO on Si technology and taming the problems associated with surface states in silicon, zinc oxide deposition, and the marriage of the two technologies. We have pioneered these techniques and have made the first ZnO on Si convolvers and storage correlators. Our path to this goal has meant that we have had to have heavy cooperation between the Integrated Circuit Laboratory and the acoustics group in the Ginzton Laboratory. This has worked very well and has ended with the construction of the SAW/FET device, the largest integrated circuit yet made by our IC Lab. The integrated circuit was made there, the ZnO depositions were made in the Ginzton Laboratory, and the students involved worked in both laboratories. Thus, the students on this program and our closely related storage correlator program have received a very broad training in a wide range of technologies: semiconductor processing, thin film deposition, signal processing, and acoustic wave techniques and theory. They have been very much in demand when applying for industrial positions.

On the way to the building of the SAW/FET, we have developed a new type of acoustic waveguide device and a detailed theory of focused transducers on anisotropic substrates. This has given alternative, and perhaps simpler, techniques than those presently used for making high-efficiency convolvers suitable for use in radar systems and spread spectrum systems. The ultimate realization of the technology was to make the SAW/FET device a device which allows us to insert UHF signals into it, store them and read out replicas of them at relatively low frequencies in a range suitable for computer interfacing. Conversely, we can convolve high-frequency signals with a filter whose characteristics are set by low-frequency inputs from a computer. This should ultimately lead to the capability of carrying out fast Fourier transforms at high processing speeds in times comparable to the length of the low-frequency signal itself rather than in times much longer than the time of the low-frequency signal itself. Still more important, there is the possibility of making adaptive filters and other devices in which all the processing takes place at high frequencies in times comparable to the length of the signal which is required to be processed. As we have shown, adaptive SAW filters can be made to set themselves to remove interfering signals or to remove distortion. These filters normally operate by carrying out several iterations. It therefore takes a time comparable to many times the length of the original signal to do this. Now, however, by iterating at high frequencies, it should be possible to carry out processing of a lower frequency signal almost instantaneously. Because of the marriage between analog and digital processing that is enabled by these techniques, we may therefore be able to take major advantage of both types of technology.

We have finished the program by transferring this technology to Lincoln Laboratories where we expect that the work will be continued into applications to spread spectrum communications and radar signal processing. They have built an air-gap device using tapped CCD delay lines with the taps connected to diodes in the SAW delay. This device had limited dynamic range, was very complicated and needed difficult optical finishing and mechanical technology because of the small air gap (3000 Å) required. Our SAW/FET device is monolithic, is simpler in concept and construction, and has a larger dynamic range. It is therefore important to try it out in their application. We believe that this is the correct time to stop this work, for the sophistication requires a more directed and applied effort than we should and could bring to bear on it in a university.

WORK UNIT #82-5. Picosecond Raman Studies of Electronic Solids (A. E. Siegman)

In the past two years we have been able to upgrade the picosecond Raman spectroscopy system and use it to acquire data concerning the interaction of picosecond laser pulses with semiconductors — specifically silicon. Our initial experiments indicate that we have seen, through the Raman spectrum, large temperature rises in crystalline silicon under illumination by picosecond laser pulses. Although it is generally accepted that silicon surfaces melt under intense laser illumination, to date no other time-resolved Raman measurements have indicated that this is so.

The interaction of laser light with solids provides the materials processing field with capabilities which are unavailable through other methods. Laser annealing, for example, allows very localized and short time scale heating — capabilities not possible with standard furnace annealing. In addition, short laser pulses provide very rapid heating and cooling rates. These features allow the annealing of defects without disturbing impurity dopant profiles, the tailoring of impurity concentration profiles, the freezing of very high impurity concentrations into crystals, and the growth of single crystal semiconductor material from polycrystalline or amorphous layers grown on other substrates. The use of these techniques would allow the construction of electronic devices with improved characteristics, help lower the cost of manufacturing solar cells, and help make possible the construction of three-dimensional integrated circuits.

The use of tools such as time-resolved Raman spectroscopy gives us information about the fundamental physics of the interaction of intense, ultra-short laser pulses with solid state materials. Such information not only gives us insight into how processes like annealing work, but also tell us what kind of changes in materials and their characteristics we can achieve.

SECTION III

ANNUAL PROGRESS REPORTS

Unit 82-1

NONLINEAR INTERACTIONS OF ACOUSTIC WAVES WITH DOMAINS IN FERROIC MATERIALS

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A. INTRODUCTION — OBJECTIVES

Ferroelastic domains in GMO and NPP are regions of large spontaneous shear strain, associated in GMO with a relatively large spontaneous electrical polarization. Two possible states of strain exist, so that a single crystal may contain many domains. These ferroelastic domains are separated by domain walls that are, from energetic considerations, accurately planar and of a thickness comparable with a lattice spacing. The optical index of refraction changes from domain to domain, due primarily to the electro-optic effect in GMO and the photoelastic effect in NPP, as do the nonlinear optical constants and the elastic properties. Similar features occur in domains of ferroelectric crystals, such as lithium niobate, and periodic domain wall gratings in lithium niobate have been fabricated in China[1] and France with the aim of exploiting the same device goals as those to be discussed below. However, domain wall gratings in lithium niobate must be poled-in and do not have the flexible programmable capability of ferroelastic domain wall gratings, which are easily moved by the application of external forces.

During the current three-year period of research attention is focused primarily on studying the properties of domain walls in two ferroelastic materials, gadolinium molybdate (GMO) and neodymium pentaphosphate (NPP), with particular attention paid to methods for injecting and positioning these walls in programmed arrays. The aim is to gain a better understanding of the physics and technology of domain wall arrays in these materials, which offer exciting prospects in the areas of optical and acoustic signal processing. This work is linked to JSEP-supported single-crystal fiber research at the Ginzton Laboratory (Work Unit 81-3, "Optical and Nonlinear Optical Studies of Single Crystal Fibers") and to the NSF-supported Fiber Thrust Program at the Center for Materials Research, through efforts under these programs to produce single crystal fibers of gadolinium molybdate.

Our new techniques for programming periodic arrays of domain walls into ferroelastic crystals,[2] discussed below under Sections B and C, and new concepts for fine-tuning these arrays open the door to important improvements in a number of optical devices, some of which are listed in the following.

1. <u>Colinear Phasematched Optical SHG</u>

The importance of phasematching in optical second harmonic generation is well-known and is frequently achieved by appropriately angling the beams.[3] Colinear SHG is not generally realizable in a single crystal because of the frequency dependence of the index, although compensation can sometimes be achieved by operating with two polarizations and an appropriate temperature. Another approach is the so-called "stack of crystals" technique[3] using an assembly of plates of thickness such that the phase transit difference between a beam at ω and a beam at 2ω is π. A stack of such plates having alternate orientations, such that the sign of the appropriate nonlinear optical constant periodically reverses sign, keeps the fundamental and second harmonic waves in phase. More elegantly, an array of anti-parallel ferroelectric domains can be used to the same effect and has been found in barium titanate to give an order of magnitude enhancement over that achieved in a single domain crystal.[4] Similar domain grating enhancement can be achieved in GMO, but only when the ω and 2ω waves are both polarized along the c-axis.[5] In this case, the spacing of the anti-parallel domain walls is approximately 30 μm, greater than domain wall spacings already reported in the literature on GMO. The advantage of using ferroelastic domains in GMO for this purpose, which has not yet been exploited quantitatively, is that these domains are easily movable. This application becomes particularly attractive in fiber optics, where there is a need for generating other optical wavelengths than those available from currently available sources. In this context, domain grating phasematching is also of interest for high efficiency parametric interactions. For all such applications programmable tunability of the grating is of basic importance.

2. Tunable Optical Spectral Filters

Current technology in this area uses filters of birefringent,[6] acousto-optic (AO)[7] and electro-optic (EO)[8,9] types. All of these depend on birefringence as the basic physical mechanism, but only the AO and EO types currently have the rapid response capability associated with electrical control. Conversely, they have the disadvantages of small optical apertures and a need for continuous acoustic or electric drive. Ferroelastic domain arrays, by contrast, offer the prospect of filters with relatively large apertures (we have injected and positioned domains 1 cm square in blocks of NPP) and require power only when being switched. The saving in drive power can be estimated by noting that the birefringence of GMO is $\Delta n = -4 \times 10^{-4}$, a value that would require an acoustic power density of ≈ 100 W/mm^2 in a material with a photoelastic constant of 0.1. Special problems will, however, have to be attacked in order to realize this potential, since the reversible birefringence required in all filters of this class can be realized in GMO only by propagating the optical beam at an angle to the planes of the domain walls constituting the filter structure. Since GMO is slightly biaxial, care will have to be taken in dealing with the weak double refraction occurring at the domain wall planes. Programmable tuning of the GMO domain wall filter is projected to be realized by using electrode arrays, as discussed below, controlled with integrated digital circuitry. Since the domain wall and control electrode spacing will be on the order of a quarter-wave plate thickness (≈ 0.4 mm) and domain wall velocities are on the order of 1 m/s, switching rates in the 10-100 kHz range can be readily contemplated.

3. Programmable Optical Spatial Filters

An important basic unit in many optical image and data processing systems is the spatial modulator (or spatial filter). These are usually required to impose a spatially periodic modulation on an optical field. Such devices operate with a spatial resolution on the order of 30 line pairs/mm (about 15 μm).[10] Domain walls in GMO have been spaced at closer distances than this and, when viewed from the side through crossed polarizers,[11] present a large dynamic range spatial modulation pattern corresponding to the domain wall pattern. Such patterns could be programmed by the control electrode structures described above.

Programmable positioning of domain walls in ferroelastics also offer intriguing possibilities for a variety of acoustic devices such as variable latching delay lines and comb filters,[2] as well as tunable acoustic grating filters.

B. PROGRESS AND ACCOMPLISHMENTS

At the present time, in the early part of the third year of the current program, many of our research objectives have been demonstrated — for example, realization of a programmable technique for injecting arrays of domains into a crystal and demonstration of the positioning of a domain wall by nonlinear interaction with a high intensity acoustic wave. We feel that these, and other, developments, summarized briefly in the following,[2] have significantly advanced the practical potential of ferroelastic domain wall devices.

1. Lateral Injection and Positioning of Domain Walls

A novel technique has been developed for injecting pairs of domain walls by applying pairs of lateral forces to the side faces of a crystal, perpendicular to the plane of a domain wall. Above a certain threshold level of force a domain wall is created under each of the force points. By maintaining the force applied and moving the load point along the crystal, the associated domain wall can be positioned at will. A device has been constructed and tested for injecting a pair of domains by electrically-controlled lateral forces and subsequently repeating the process with the crystal accurately displaced in steps determined by a micromanipulator. This technique, which has been applied to both GMO and NPO, provides a programmable method for creating arrays of domain walls with spacings on the order of 1 mm.

2. Displacement of a Domain Wall Under the Influence of a Rectified Acoustic Wave

This effect, which was predicted in our earlier proposals, was observed in NPP, using a level of acoustic intensity in good agreement with the predicted value.[12] In this first reported observation of the effect, the static stress generated through the third-order elastic constants by a high intensity acoustic wave provides the mechanism for displacing the domain wall. Our observations demonstrated motion of an "a" domain wall in NPP under the influence of a "c" polarized "a" propagating shear wave and motion of a "c" domain wall under the influence of an "a" polarized "c" propagating shear wave. Some experiments also exhibited creation of blade and stripe domain structures by application of a high intensity acoustic wave.

3. Low Insertion Loss Variable Delay Line

A mechanically-controlled variable delay line (0-4.5 μs) with less than 20 dB insertion loss and low level spurious echoes was realized in an NPP platelet at ≈ 6 MHz center frequency. The variable delay is realized by launching an acoustic wave with a transducer at one end of the platelet and reflecting it back to the transducer from a movable domain wall. These observations were made on a 9.3 mm × 2.77 mm × 0.86 mm NPP plate driven by a miniature PZT shear wave transducer bonded to the narrow side of the plate. Shear-shear reflection from the domain wall was measured to be - 13.7 dB, compared with - 29 dB longitudinal-shear reflection reported for GMO in the literature. Low insertion loss variable delay lines, with delays reducible to a fraction of the pulse width, have applications as adaptive delay equalizers.

4. Tunable Acoustic Resonators

Figure 1 shows the electrical input impedance of the delay line structure described above, when driven with a cw input and observed for different positions of the domain wall. NPP, unlike GMO, is nonpiezoelectric and must be fabricated in composite resonator form, as shown in the figure. These successful composite resonators, a culmination of our earlier reported efforts to develop such structures, were also used in the nonlinear domain wall motion experiment described above. On the left side of the figure the broad and widely-spaced peaks of the impedance curve correspond to low-Q length resonances of the region between the transducer and the domain wall. When the domain wall is moved to the position on the right side of the figure the resonance peaks are higher Q and have a much closer spacing, corresponding to the greater length between the transducer and the wall. These results indicate a strong reflection from the domain wall.

C. FUTURE OBJECTIVES

Several tasks remain to be completed before the potential of the above described domain wall grating devices can be realized:

(1) All of the programmable device applications described above require for their realization accurately controllable means for injecting and adjusting arrays of ferroelastic domain walls in GMO and NPP. Although we have now demonstrated a mechanical technique for laterally injecting and adjusting domains with spacings down to the order of a millimeter, it is not clear that this method will be feasible for the 10 to 30 μm domain wall spacings required for these devices. During the remainder of the current research period we will be performing further experiments on the alignment of domain

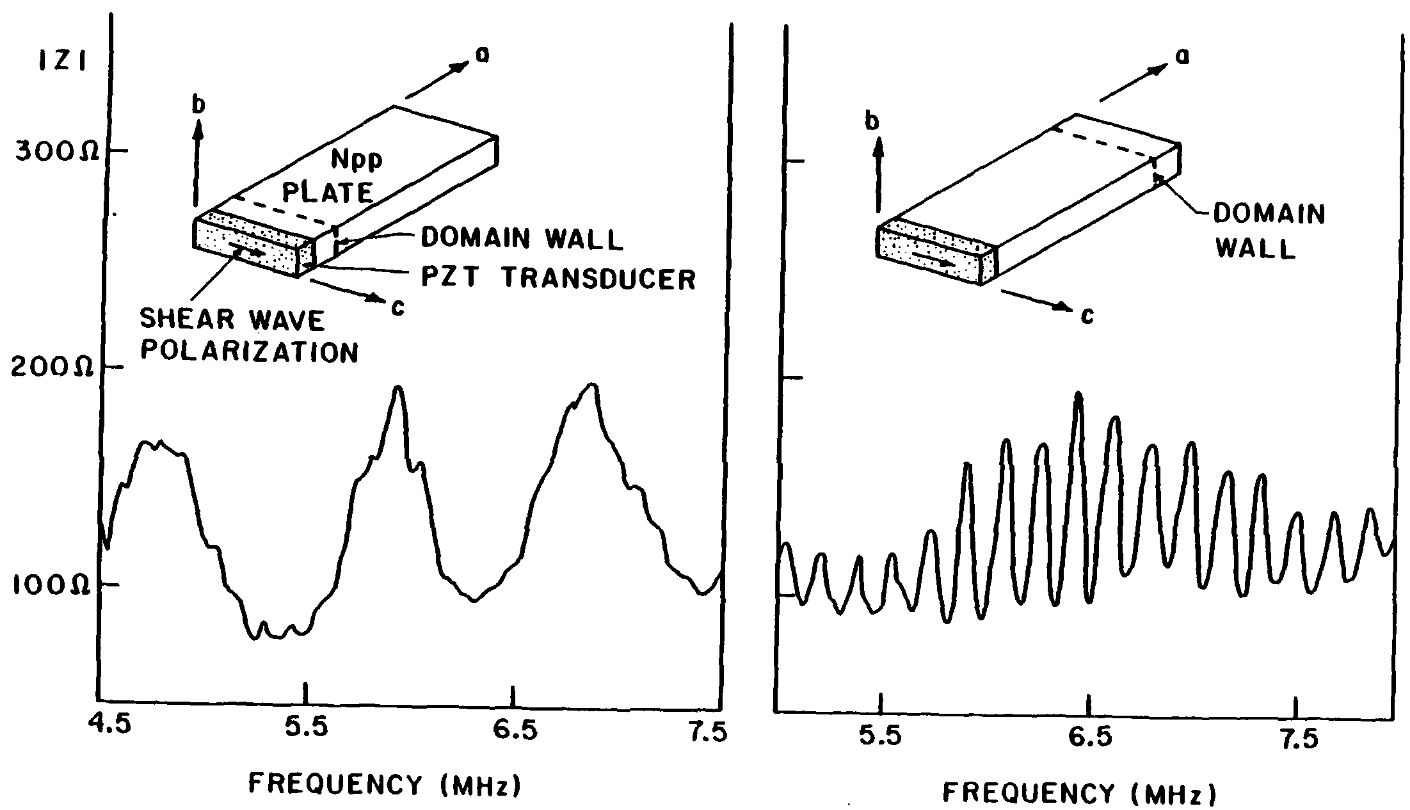

Fig. 1--Measured electrical input impedance curves for tunable composite PZT-NPP composite resonators.

walls by nonlinear interaction with a standing acoustic wave.[12] With this technique also, certain difficulties are anticipated in fabricating gratings having the required characteristics and adaptable to electronic programming by digital circuitry. A major task will be to perfect a combination of the mechanical injection and acoustic tuning techniques with other methods of trapping domains in specific positions (such as, for example, microarrays of deposited blocking electrodes or mechanical surface traps) so that the domain walls can be stacked in a grating under microcomputer control.

(2) A second major task will be to perform experiments on optical SHG with grating phasematching enhancement in GMO to verify that the planarity of the domain walls is adequate for this purpose.

(3) Evaluation of the potential of ferroelastic domain wall arrays in birefringent optical filter applications requires a detailed study of double refraction effects in an oblique grating structure and calculation of design parameters.

(4) Exploitation of acoustic variable delay lines and grating filters in NPP requires excitation of SAW on NPP plates at frequencies on the order of 100 MHz, where such devices find their applications. For initial tests SAW excitation on NPP, which is nonpiezoelectric, can be achieved by using the water coupling technique described in Ref. 13.

D. PUBLICATIONS, INVITED PAPERS, ORAL DISCLOSURES, AND PATENTS

1. Publications and Oral Disclosures

(1) B. A. Auld, S. Ayter, M. Tan, and D. Hauder, "Filter Detection of Phase-Modulated Laser Probe Signals," Elect. Lett. 17, 662 (1981).

(2) B. A. Auld and M. M. Fejer, "Elastic Nonlinearity and Domain Wall Motion in Ferroelastic Crystals," Ferroelectrics 38, 931 (1981); presented at the Fifth International Meeting on Ferroelectricity, Pennsylvania State University (August 1981).

(3) P. Toledano, M. M. Fejer, and B. A. Auld, "Nonlinear Elasticity in Proper Ferroelastics," Phys. Rev. B 27, 5717 (1983).

(4) S. W. Meeks, B. A. Auld, P. Maccagno, and A. Miller, "Interaction of Acoustic Waves and Ferroelastic Domain Walls," Ferroelectrics (to be published); presented at the 1983 IEEE International Symposium on Applications of Ferroelectrics (ISAF), Gaithersburg, Maryland (June 1983).

2. Patents

Several disclosures on domain grating fabrication and domain wall spectral filters will be submitted before the end of the contract.

E. REFERENCES

1. Duan Feng, et al., presented at the First International Quantum Electronics Conference, Shanghai, China (May 1980).
2. S. Meeks, B. A. Auld, P. Maccagno, and A. Miller, "Interaction of Acoustic Waves and Ferroelastic Domain Walls," Ferroelectrics (to be published).
3. J. A. Armstrong, et al., "Interactions Between Light Waves in a Nonlinear Dielectric," Phys. Rev. 127, 1918 (1962).
4. R. C. Miller, "Optical Harmonic Generation in Single Crystal $BaTiO_3$," Phys. Rev. A 134, 1313 (1964).

5. R. C. Miller, et al., "Nonlinear Optical Properties of $Gd_2(MoO_4)_3$ and $Tb_2(MoO_4)_3$," Ferroelectrics 2, 97 (1971).

6. A. M. Title and W. J. Rosenberg, "Tunable Birefringent Filters," Optical Engineering 20, 815 (1981).

7. I. C. Chang, "Acousto-Optic Tunable Filters," Optical Engineering 20, 824 (1981).

8. J. F. Lotspeich, "Electro-Optic Tunable Filter," Optical Engineering 20, 830 (1981).

9. W. J. Gunning, "Electro-Optically Tuned Spectral Filters: A Review," Optical Engineering 20, 837 (1981).

10. D. Casasent, "Performance Evaluation of Spatial Light Modulators," Appl. Optics 18, 2445 (1979).

11. A. Kumada, "Optical Properties of Gadolinium Molybdate and Their Device Applications," Ferroelectrics 3, 115 (1972).

12. B. A. Auld and M. M. Fejer, "Elastic Nonlinearity and Domain Wall Motion in Ferroelastic Crystals," Ferroelectrics 38, 931 (1981).

13. P. Khuri-Yakub and G. S. Kino, "A New Technique for Exciting Surface Waves on Nonpiezoelectric Materials," Appl. Phys. Lett. 32, 513 (1978).

Unit 82-2

HIGH-T_c SUPERCONDUCTING WEAK-LINK JOSEPHSON JUNCTIONS AND CIRCUITS

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A. INTRODUCTION — OBJECTIVES

The underlying, long-term objective of our program is to explore the feasibility of high-T_c Josephson junction superconducting thin-film circuits; to establish the relevant physics, fabrication procedures, and operating characteristics of such devices; and hopefully to lay the ground work for a superconducting integrated circuit technology based on these materials. This objective requires the development of practical high-T_c Josephson devices and also the passive circuits elements necessary for a complete circuit technology. Success in this program is leading to devices capable of operating at substantially higher temperatures ($\sim$ 10-15 K) and more rugged circuits resistant to damage due to thermal cycling, handling, and hostile field environments.

Toward this general objective, we have been developing superconducting weak-link (i.e., non-tunneling) Josephson junctions using refractory and high-T_c superconducting materials, and by necessity the thin-film deposition, microlithography, and processing technologies suitable for such materials. Specifically, we have been concentrating our efforts on the A15-type superconductors, for example Nb_3Sn ($T_c \simeq$ 18K) and Nb_3Ge (T_c = 23 K) with related work on elemental Nb(T_c = 9 K) in order to more easily test some of our fabrication techniques. Research toward high-T_c tunneling Josephson junctions is being carried out in a separate (non JSEP) program. Both types of devices are desirable depending on the nature of the application. No high-T_c tunnel junction technology has been successfully developed to date.

From the theoretical point of view the most attractive type of high-T_c weak-link Josephson junction appears to be planar SNS (superconductor/normal metal/superconductor) or SSemiS (superconductor/semiconductor/superconductor) bridges, although it must be noted that granular superconducting weak links do show interesting performance. No satisfactory theoretical explanations for their operation has yet appeared, however. In this program, we are focusing on SNS bridges. These bridges are like the usual SSS superconducting microbridges but where the bridge region itself is a normal metal while the banks are superconductors. The rationale for such devices is that by making the bridge region itself from a normal metal (e.g., Cu, Au, or Ag) one can circumvent the extremely small (< 100 Å) bridge dimensions theoretically required to obtain ideal Josephson behavior in a totally superconducting high-T_c bridge. Also heating problems are eliminated because of the good thermal conductivity of these N-materials. In such SNS bridges, the dimensions need only be submicron and ideal Josephson behavior can be obtained over the entire temperature range $0 < T < T_c$.

B. APPROACH AND ACCOMPLISHMENTS

As we have reported previously the step-edge approach to high-T_c SNS Josephson junction microbridge fabrication introduced by us has proved very successful. A patent has been issued on the process. Bridges incorporating Nb_3Sn and Nb_3Ge have been made which exhibit classical Josephson behavior from about 2 K up to temperatures in excess of 15 K, well into the range of temperatures accessible to closed-cycle cryogenic refrigerators like those presently used to cool IR detectors.

Our more recent attempts to improve these devices by using electron-beam lithography to define the width of the bridges ($\gtrsim$ 0.1 to 0.2 μm) has also proved successful. It now appears that devices with impedances as high as a few ohms will be routinely available. These devices are already suitable for some practical applications — for example, high-T_c SQUID's, voltage standards, voltage controlled oscillators and possibly mixers for superconducting high-speed analog signal processing systems. Logic circuits utilizing bridge-type Josephson junctions have been proposed and built by the Japanese, although their ultimate practicality has not yet been fully assessed. Devices with higher impedances still would be desirable but will require introduction of alternative N materials.

During the past year we have begun the first serious attempts to incorporate our junctions into simple circuits. These include both dc SQUID's and linear arrays (up to $\sim$ 1000 devices), the latter being suitable for voltage standards. We have also built up a noise measuring capability in order to fully characterize our dc SQUID devices. Earlier preliminary data indicated a minimum detectable energy - bandwidth product of a few times Planck's constant. Finally we have further refined our theoretical models of these devices, in particular their finite voltage and dynamical behavior based on our adaptation of standard time-dependent Ginzburg-Landau theory.

C. FUTURE OBJECTIVES

Our principle objective for the remainder of this program is to capitalize on our present technology and to characterize fully the devices that can be made. In particular we plan to make the best dc SQUID we can and to study its performance over the temperature range from 2 K to 15 K. This should allow an assessment of both its potential for application at high temperature and also at low temperature where the ultimate performance will be obtained. It should be noted in this latter regard that utilization of the high-T_c superconducting materials makes possible not only high temperature operation but also holds the promise of superior devices at low temperatures.

D. PUBLICATIONS

1. Previously Reported

(1) R. B. van Dover, R. E. Howard and M. R. Beasley, "Fabrication and Characterization of S-N-S Planar Microbridges," IEEE Trans. on Magnetics MAG-15, 574 (1979).

(2) R. B. van Dover, A. de Lozanne, R. E. Howard, W. L. McLean and M. R. Beasley, "Refractory Superconductor S-N-S Microbridges," Appl. Phys. Lett. 37, 838 (1980).

(3) M. R. Beasley and C. J. Kircher, "Josephson Junction Electronics: Materials Issues and Fabrication Techniques," in Superconductor Materials Science, edited by S. Foner and B. B. Schwartz (Plenum Publications Corp., 1981), pg. 605

(4) R. B. van Dover, A. de Lozanne and M. R. Beasley, "S-N-S Microbridges: Fabrication, Electrical Behavior and Modeling," J. Appl. Phys. 52, 7327 (1981).

(5) A. de Lozanne, M. Di Iorio and M. R. Beasley, "Properties of High-T_c SNS Microbridges," presented at the LT-16 Conference, Los Angeles, California, August 1981, Physica 108B, 1027 (1981).

2. Recently Published

(6) M. R. Beasley, "Material Science of Josephson Junctions," Proceedings of the 1982 IEEE International Electron Devices Meeting, San Francisco, California, December 13-15, 1982, pg. 758 (Invited Talk).

(7) M. S. Di Iorio, A. de Lozanne and M. R. Beasley, "High-T_c SNS dc SQUIDS Produced by Electron Beam Lithography," IEEE Trans. on Magnetics MAG-19, 308 (1983).

(8) M. S. Di Iorio, A. de Lozanne and M. R. Beasley, "High-T_c SNS SQUIDS," Bull. Am. Phys. Soc. 27, 267 (1982).

(9) A. de Lozanne, M. S. Di Iorio and M. R. Beasley, "Fabrication and Josephson Behavior of High-T_c Superconductor-Normal-Superconductor Microbridges," Appl. Phys. Lett. 42, 541 (1982).

3. Pending Publications

(10) A. de Lozanne and M. R. Beasley, "Time Dependent Superconductivity in SNS Bridges: An Example of TDGL Theory," chapter in Nonequilibrium Superconductivity, D. N. Langenberg and A. I. Larkin, editors (North-Holland Pub. Co., Amsterdam, The Netherlands).

Unit 82-3

OPTICAL AND NONLINEAR OPTICAL STUDIES OF SINGLE CRYSTAL FIBERS

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A. INTRODUCTION - OBJECTIVES

This project is concerned with the growth of single crystal fibers, the evaluation of their linear and nonlinear optical properties, and the development of optical and nonlinear fiber devices. The opportunity to obtain single crystal material properties and fiber geometry with a laser heated, crucibleless growth technique offers a number of intriguing possibilities for device and material development applications. The interface with present technology falls into four broad categories - passive devices, nonlinear devices, active devices and material surveys.

Sapphire fibers have a number of applications in passive devices. Accurate temperature measurements from 500°C to 2,000°C have recently been obtained at the National Bureau of Standards by monitoring the blackbody radiation generated in a short sapphire rod and transmitted through a silica fiber butt coupled to the rod. Good quality sapphire fibers would eliminate the need to transfer the radiation to a silica fiber, greatly enhancing the utility of the thermometer for applications in hostile thermo-chemical environments, e.g. in combustion diagnostics. Piping of high power infrared laser radiation for surgery or welding is another application to which sapphire is well suited.

Semi-conductor lasers for the technologically important 1.3 - 1.5 μm band have not been produced with the reliability or yield of 800 - 900 nm lasers, nor is their frequency stability adequate for certain multiplex or frequency encoded communication systems. The anisotropic mode pattern of semi-conductor lasers makes the laser glass fiber interface inefficient. A laser diode pumped crystal fiber laser, e.g. 1.3 μm Nd:YAG, would provide an attractive alternative to a semi-conductor laser in the above respects. We are currently investigating an electro-optic laser host crystal to allow easy modulation of the laser power or phase. Periodic modulation of the fiber diameter would provide an integrated Bragg mirror that would add considerably to the practical value of a fiber laser. The easy interfacing of a crystal fiber to glass fibers makes single crystal fibers attractive for in-line amplification in glass fiber based sensor systems, thus improving the detection sensitivity.

The efficiency of a wide variety of nonlinear optical interactions would be greatly enhanced in single crystal fibers because of their ability to maintain tightly focused beams over long lengths without diffraction. A five centimeter long twenty-five micron diameter fiber would double the frequency of a 1.06 μm Nd:YAG laser with fifty times the efficiency of a five centimeter piece of bulk crystal. This magnitude of enhancement is typical for many nonlinear interactions, and makes possible a number of important devices that are not feasible with current technology. Examples include a continuous wave $LiNbO_3$ parametric oscillator tunable from 4 μm to 650 nm, a source that would be valuable for a variety of spectroscopic applications, mixing two near infrared diode laser frequencies to produce mid-IR radiation suitable for real time gas monitoring and frequency doubling a 500 mW diode laser in a $LiNbO_3$ fiber to produce a 50 mW blue light source, a wavelength range inaccessible at present with solid state laser sources.

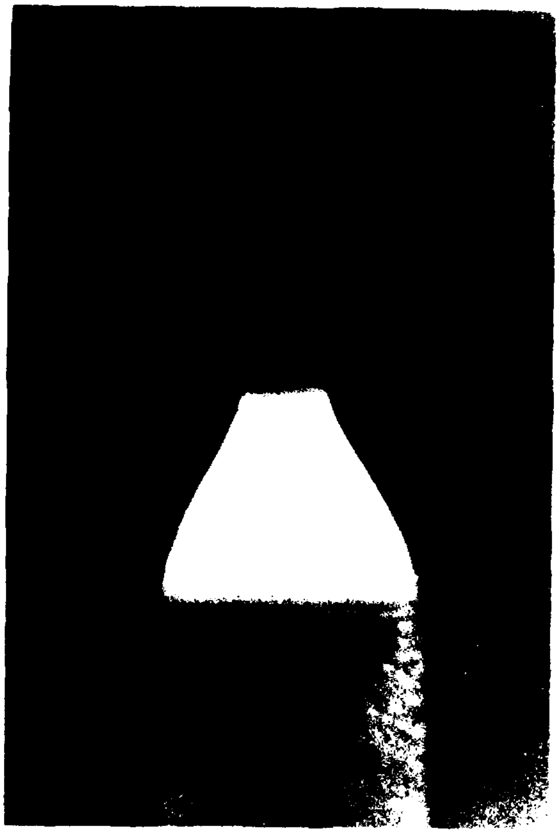
The search for improved laser ion host crystal combinations is currently an active field of investigation. However, the research is hampered by the week-long time required to grow a typical bulk crystal sample. The rapid growth rate provided by our fiber apparatus, typically five to ten fibers per day, makes it very attractive for this type of material survey. The crucibleless growth and the high temperatures attainable with laser heating further enhance its utility for this purpose.

The efficient realization of the linear, nonlinear and active devices, particularly those involving parametric processes, requires the growth of fibers with good optical and structural uniformity and the ability to launch and preserve low order propagation modes.

In the past year we have followed two approaches towards achieving these goals. We have continued to make improvements on the first generation single crystal fiber growth apparatus at the Stanford Center for Materials Research, (C.M.R.), and we have worked toward completing our own second generation device. Successful fiber growth has been delayed by equipment problems, but both efforts are now coming to fruition.

The growth technique used in both the first and second generation apparatus is known as miniature pedestal growth. The tip of a small diameter (0.5 - 1 mm) source rod is melted with a focused CO_2 laser beam as shown in Fig. 1b. A seed is dipped into the melt, forming a surface tension supported growth zone. The seed crystal is withdrawn at a constant rate to pull a crystal fiber from the melt. The diameter reduction from rod to fiber is determined by the ratio of seed to source speed. Figure 1a shows a 160 μm sapphire fiber being pulled from a 500 μm diameter source rod. The fiber is almost invisible in the photograph because of its low emmissivity and scatter loss.

1a



1b.

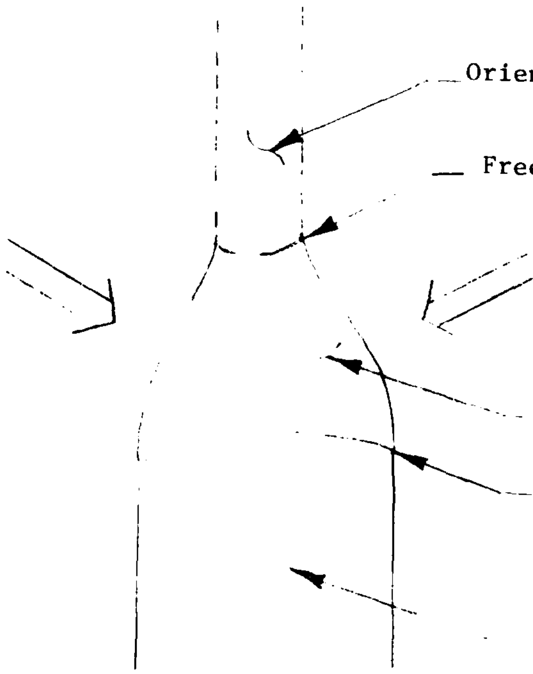


Figure 1 a) Photograph of a 170 μm diameter single crystal sapphire fiber during growth
b) Schematic of the growth process.

In its first year of operation the C.M.R. machine was used to grow a variety of oriented refractory oxide fibers, including Nd:YAG, sapphire, lithium niobate, gadolinium molybate and calcium scandate. Fiber diameters ranged from 500 down to 35 microns, in lengths up to 15 cm. Typical growth rates are 1 - 10 mm/min.

The major problem addressed in the past year was reduction of the unacceptably large variations in the fiber diameter. These were typically 5% - 10% over 5 mm lengths of larger diameter fibers, and considerably worse for longer or smaller (200 μm) fibers. Diameter variations affect fiber performance by causing mode conversion, radiation loss and variations in model propagation constants. Mode conversion and radiation loss are problems in any device application. Parametric devices suffer the additional problem of diameter induced phase mismatch. The criteria for adequate diameter control depend on the type of device to which the fiber will be applied, the frequency of periodic variations, the statistics of random variations, the radius of the fiber, the core to cladding index difference and the circumferential dependence of the diameter variation.

Our calculations show that for typical parametric device applications in a fiber with a non-diffused cladding, pure diameter variations will have to be held in the range 0.1 - 1% for efficient operation.

In the first year of the present contract, we identified several components of the C.M.R. apparatus that were the cause of diameter variation.

A primary source of diameter fluctuations is the focusing system used to direct the CO_2 laser beam into the growth zone. The beam is split into two equal parts and focused onto opposite sides of the fiber with two 5 inch focal length lenses. The assymetric heating of the melt zone and the 1 mm square source rods conspire to produce an uneven temperature distribution and unstable growth. In addition, the minimum focal spot size of $\sim 250\ \mu m$ leads to a melt zone considerably longer than the optimum (2 - 3 fiber diameters) when growing small diameter fibers.

The feed and pull mechanisms were also implicated in the diameter control problem. The fiber and source rods are chucked to lead screws, which are driven by tachometer stabilized d.c. motors. Since the point of support of the fiber moves farther from the molten zone the longer the fiber grows, the mechanical stability of the growth zone is not optimal. The problem is particularly apparent in small diameter fibers and was amplified by the lack of a chamber to completely isolate the growth zone from the environment.

The higher frequency diameter variations are probably associated with laser power fluctuations, particularly when the laser is operated near threshold during small diameter fiber growth. Our theoretical analysis of the fiber system thermal response indicates time constants of 0.1 - 0.01 second can be expected, which is consistent with the periodicity of the observed diameter variations. We have incorporated a feedback system to stabilize the laser power, but it is limited by the slow time constant of the thermal detector used to monitor the laser output.

B. PROGRESS AND ACCOMPLISHMENTS

As discussed in the introduction, we have addressed the problem of achieving stable fiber growth in two ways: design, construction and characterization of a second generation growth apparatus, which has occupied most of our time over the past year, and continued cooperation with the C.M.R. group in improving their growth station.

1. Second Generation Growth Apparatus.

At the end of the first year of the contract we had completed a conceptual design of a second generation growth apparatus that utilized the same basic growth technique as the first generation device, but incorporated refinements in many of the sub-systems.

One of the most important features of the new design is a novel optical system for focusing the CO_2 laser beam onto the fiber in a 360° symmetric distribution, illustrated in Figs. 2a and 2b. The optical elements are all diamond turned copper with a gold coating. The near diffraction limited f/2 optics allow a focused spot as small as 30 microns, important for well controlled growth of small diameter fibers. In order to achieve good optical performance, it is critical that the two cones of the reflaxicon be accurately aligned with each other. Together with the diamond turning contractor we arrived at a mating surface design that centers the two cone axes within 1 micron. The symmetric energy distribution achieved with these optics alleviates the problem of cold spots that plague the C.M.R. system.

Another significant improvement in the second generation system is the fiber and feed rod translation devices. The lead screw and chuck of the C.M.R. device have been replaced with a belt drive system, illustrated in Figs. 3a and 3b. The fiber is driven by a belt, which in turn is driven by a d.c. motor that is encoded and phase-locked to a stable reference frequency. A V-groove etched in silicon and overcoated with SiO_2 captures the fiber to prevent side-to-side wobble, and provides a smooth, hard sliding surface to allow uniform translation of the fiber along its axis. This design offers several advantages over the

2a

2b

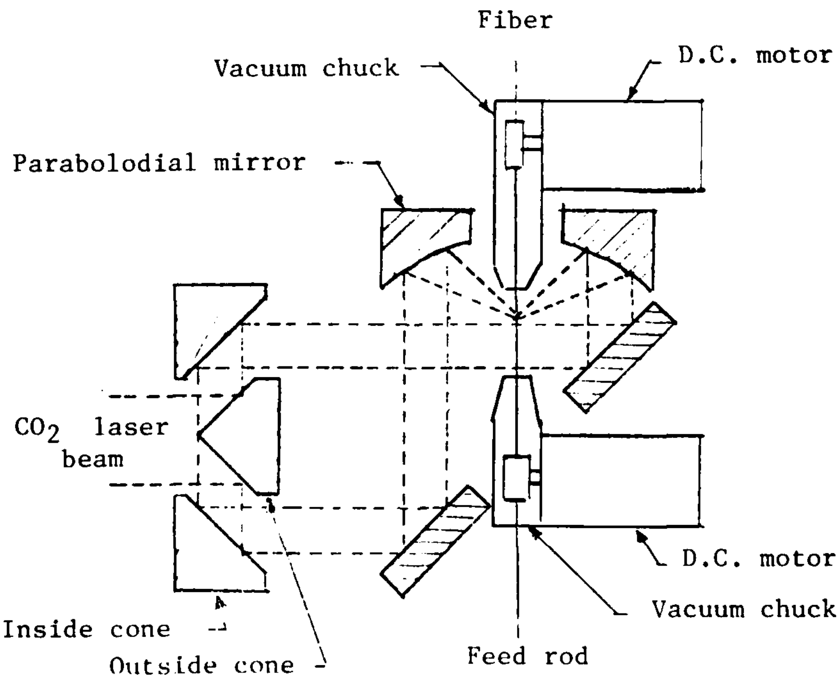
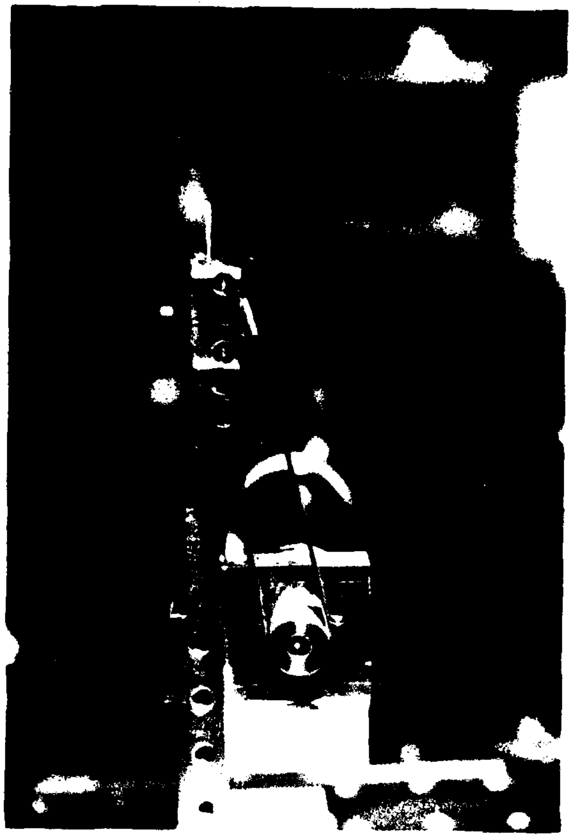


Figure 2 a) Photograph of the fiber growth apparatus showing the growth of a sapphire fiber.

b) Schematic of the growth apparatus optical arrangement.

3a



3b

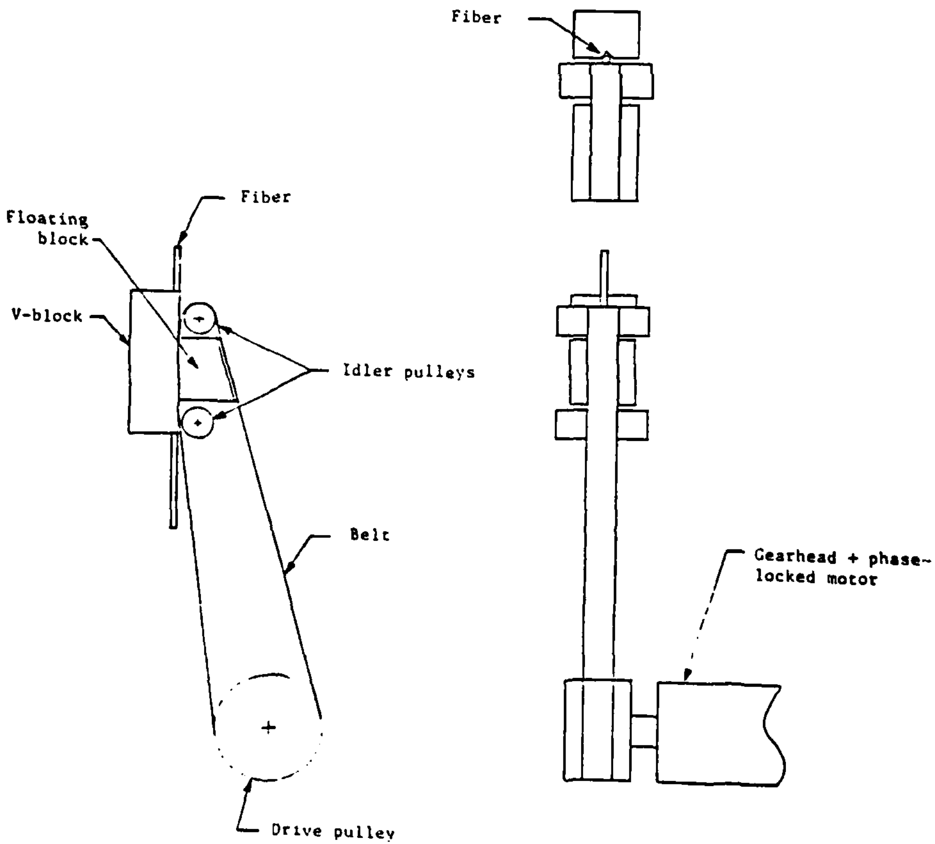


Figure 3 a) Photograph of fiber translator
b) Schematic of fiber translator

C.M.R. design:

i. the fiber is supported at a fixed point in space, no matter how long the fiber, enhancing the mechanical stability of the growth zone,

ii. the maximum fiber length is no longer limited by the length of a lead screw. A 5 cm long 0.5 mm diameter source rod could produce a 20 meter long 25 micron diameter fiber,

iii. the controlled atmosphere chamber around the growth zone does not require mechanical feed-throughs,

iv. the phase-lock system provides more accurate speed control than the analog control on the C.M.R. system.

A block diagram of the entire second generation system is shown in Fig. 4a. The focusing system and fiber translation are enclosed in a controlled atmosphere chamber which isolates the molten zone from exterior perturbations and allows growth in inert gas, oxygen or vacuum environments. In order to permit adjustment of the fiber position with the chamber sealed, the fiber and feed rod translation devices are mounted on motorized x - y stages, not shown in the figure. Figure 4b shows a student growing a crystal fiber.

The heat source is a 15 watt waveguide CO_2 laser with active cavity temperature stabilization, chosen for its stable power and beam pointing and compact size. The laser output is monitored with a temperature stabilized pyroelectric detector with kilohertz response, allowing wide bandwidth

FIBER GROWTH SYSTEM

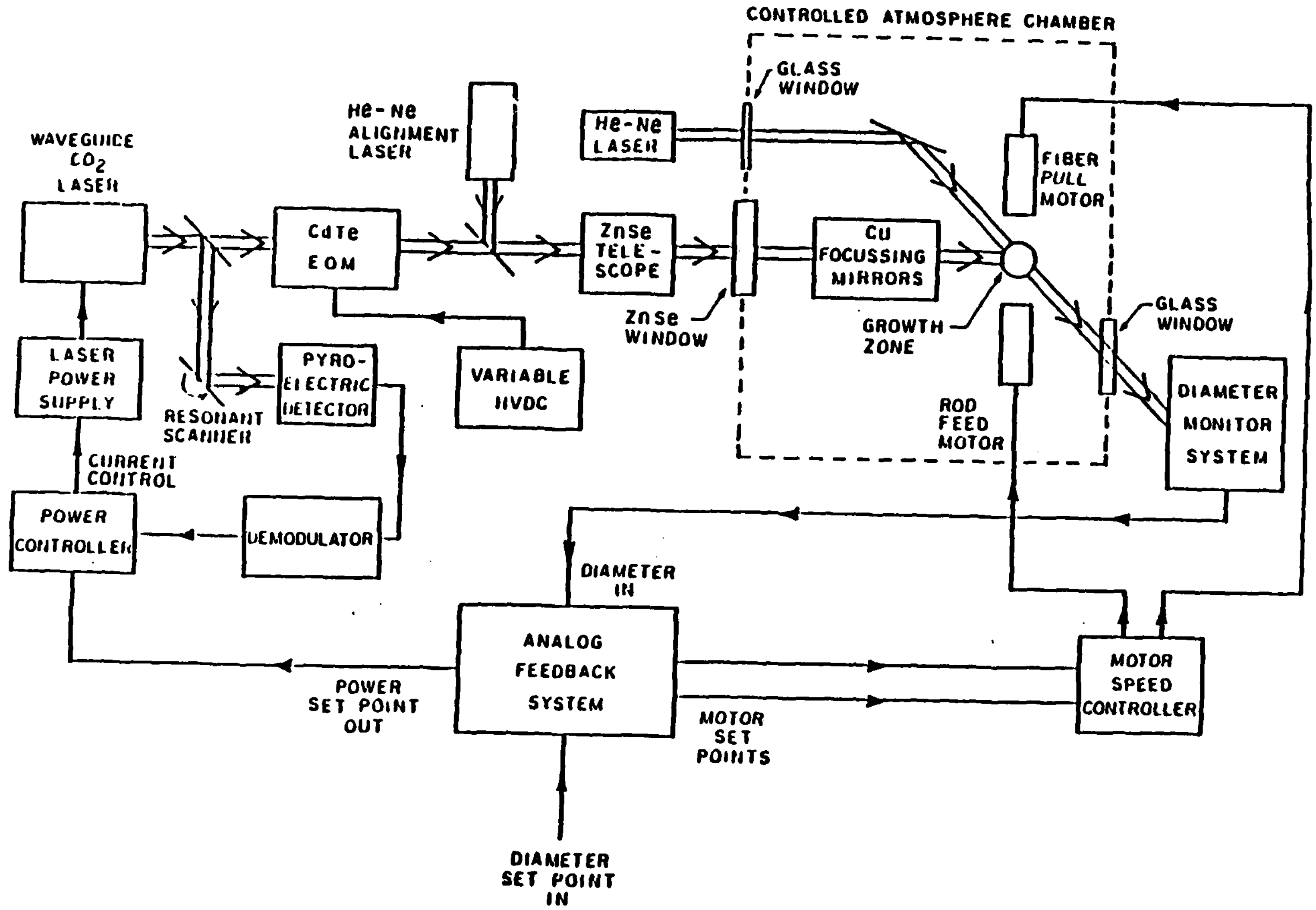


FIGURE 4a

Figure 4b--Student operating apparatus during sapphire fiber growth stabilization of the laser power by modulating the tube current. An electro-optic amplitude modulator is used to attenuate the laser beam. The laser can thus run at a constant output, enhancing power stability. An adjustable ZnSe telescope is used to vary the beam spot size input into the focusing optics, thereby varying the size of the focal spot at the fiber.

Another important feature of the growth apparatus is a high speed non-contact diameter measurement system. In order to provide a useful error signal for feedback control of diameter variations, the diameter measurement system must have a measurement rate $\geq$ 1 kHz, diameter resolution $\geq$ 0.1% , axial resolution as small as possible ($\geq$ 5 μm) and working distance $\geq$ 100 mm (to avoid obstruction of the CO_2 focusing system) . No commercial system was available meeting all these criteria, so we designed the system shown in Fig. 5. A helium-neon laser beam illuminates one side of the fiber. The rays passing through the fiber and those reflected off the surface of the fiber interfere in the far field to form a series of light and dark fringes, whose period is inversely proportional to the fiber diameter. By imaging the interference pattern on a diode array and electronically tracking one of the fringes as it changes position in response to fiber diameter changes, one can drive a voltage proportional to the diameter change. As designed, the system has a resolution of 0.05%, an axial resolution of $\sim$ 5 μm and a measurement rate of 1 kHz. The feedback system will be discussed later in this report.

2. System Status

Mechanical and optical construction of the apparatus described in the previous section, with the exception of the diameter measurement system, was completed in the Spring of 1982. A series of equipment failures delayed our making serious attempts to grow good quality fibers until June 1983. Prior to

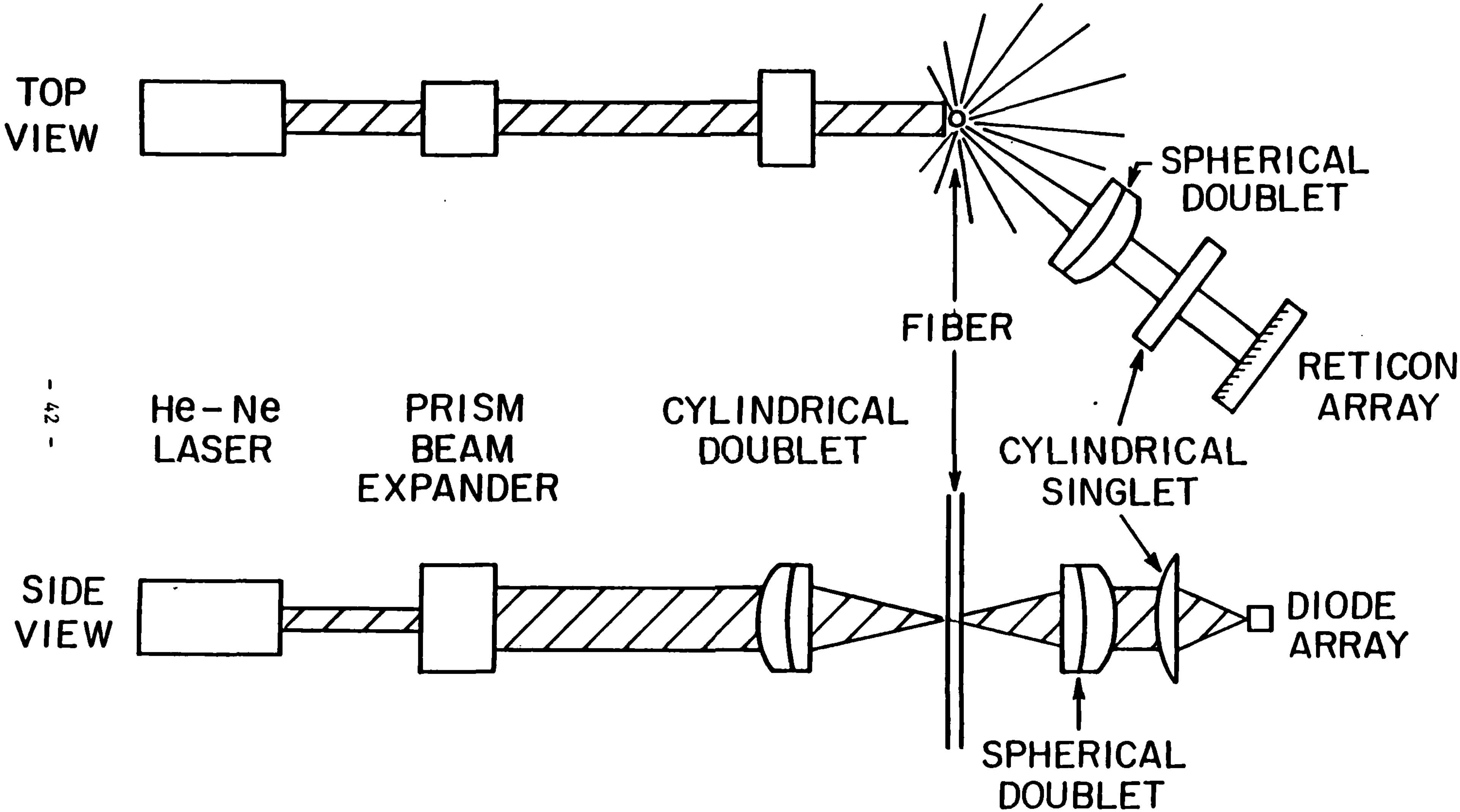


Figure 5--Schematic of the fiber diameter measurement system

that time, we were able to test and modify various elements of the system, so that progress has been rapid in the past two months.

The commercial motor control system has unacceptable start-up transients, limited speed range and appreciable velocity jitter that the manufacturer has been unable to correct. We have obtained higher density shaft encoders and designed and built a more sophisticated control system. The motors now operate over a 100:1 speed range and start in $\sim$ 100 ms with no overshoot, performance more than adequate for our application.

We have also been able to study the performance of the fiber translation devices. The side-to-side motion of a fiber translated through the drivers appears to be limited only by the smoothness of the fiber itself. In the case of a smooth source rod, the wobble was measured to be less than three microns, the measurement resolution. The fiber velocity jitter is less than the measurement resolution of 3%.

The focusing system worked well in tests on melting lithium niobate and sapphire rods. The laser beam was focused symmetrically to a spot of less than 100 microns, the limiting resolution of measurement thus far. The efficiency of these optics is somewhat higher than those of the first generation system, leading to a reduction in the power necessary to reach melting temperature, particularly for small (< 200 μm) fibers.

The beam handling optics and mechanical alignment adjustments all performed well in our tests. The electro-optic modulator cannot be tested until we obtain a laser with an HE_{11} output mode.

A prototype of the diameter measurement system was completed this Fall and performed up to design specifications described earlier except for the axial resolution which was $\sim$ 12 μm instead of 5 μm. This problem was traced to a defective lens which was replaced by the manufacturer. Since this system has a combination of features not found in any other currently available device, it may have commercial value. We are currently carrying out detailed characterization to complete an article describing the system.

We have obtained a long working distance 50 X binocular microscope and mounted it to observe the growth zone through a port in the controlled atmosphere chamber. In addition to its obvious utility in aligning the fiber with the optical system, the microscope video display can be used to study and record the growth dynamics of the crystal fibers. With a spike filter and line slicer, for example, the microscope video can be used to display a real time temperature profile of the melt zone, an important parameter for understanding the growth process.

Another recent addition to the growth effort is a centerless grinding machine, used to fabricate small diameter source rods of uniform cross-section. We have managed to grind rods of glass, YAG, $LiNbO_3$ and Li_2GeO_3 to diameters of 400 - 500 microns in lenghts up to 12 cm, with a taper of less than 1 micron/centimeter. The small diameter of these rods gives us the ability to melt materials with higher melting points, and the uniform cross-section permits more stable growth than the 1 mm square rods used previously.

The fundamental difficulty thus far encountered has been the performance of the waveguide CO_2 laser. The laser had failures in its power supply and temperature control systems which we eventually repaired. In addition, a fundamental design flaw led to multi-transverse mode oscillation of the waveguide CO_2 laser source. The manufacturer agreed to accept return of the laser for refund, and we have ordered a 15 W waveguide laser from another manufacturer,(California Laser). We have tested the mode quality of a California laser and found it to have a near perfect diffraction limited

HE_{11} output, so we expect that the laser problems will be resolved on delivery of the new laser. Unfortunately, the laser has twice been damaged in shipping, pushing back the delivery date from February 1983 to September 1983, (estimated).

The anticipated delay led us to adapt our system to accommodate a 20 watt sealed off CO_2 laser from China that happened to be available in our laboratory. It was necessary to modify the beam handling optics because the output beam of the Chinese laser is larger than that of the waveguide lasers. These modifications were completed in June 1983. Progress has been rapid in fiber growth since that time.

We chose sapphire as our model material because its properties are well known, it is easy to grow, readily available and inexpensive. The basic manipulations involved in growing a fiber, e.g. loading fibers into the drivers, aligning fibers with the optical system, setting motor speeds, optimizing laser power, are all quite easy with this system. It is possible to complete the entire set up process and grow several centimeters of fiber in about thirty minutes.

In the past several weeks we have grown more than one hundred fibers of sapphire, ruby and Nd:YAG, starting with 500 micron centerless ground source rods. In an effort to grow small diameter fibers we attempted to grow with a very large diameter reduction. We found it possible to reduce the fiber diameter by a factor of 4 but the growth process was quite unstable. Threefold diameter reduction, however, resulted in a very stable growth. The threefold diameter reduction compares favorably with the twofold reduction typically used on the C.M.R. machine.

Threefold diameter reductions have been obtained at growth rates between 0.5 and 5 mm/min. Lengths up to 20 centimeters of 170 micron fiber have been obtained. The necessary laser power is approximately 3 watts.

The quality of these fibers is substantially better than those grown at C.M.R. We are just beginning quantitative measurement of the diameter variations of the fibers. Preliminary results on one fiber indicate ~ 2% peak-peak variations on a 5 mm section and ~ 2% rms over longer sections. The remaining variations are at least in part due to a number of problems that exist with the Chinese laser. The high voltage power supply for the laser is not regulated, leading to fairly serious (several percent), power fluctuations. We have designed and recently installed a HV current regulator, and the several fibers since grown appear qualitatively to show less fine scale diameter variation. The laser is randomly polarized, which, in conjunction with some polarization sensitive dielectric turning mirrors, leads to further variation in the power delivered to the fiber. This problem will be difficult to eliminate until the new laser arrives. The large spot size and random polarization of the Chinese laser also preclude use of the detector for the closed loop power stabilization system. Given the limitations imposed by the present laser, the diameter variation results are very encouraging.

The modifications to the beam handling optics necessitated by the Chinese laser make it difficult to install the diameter measurement system,but we have obtained some qualitative information about the characteristic response lengths for diameter modulation. Both the decay length of starting transients and one preliminary experiment modulating the pull rate indicate that the diameter response will begin to roll off for modulation with a period less than ~ .5 - 1 mm.

The apparent reduction in 3 - 5 micron period variations when the laser current was regulated indicates that substantial modulation response to laser power extends to fairly short modulation periods.

3. The C.M.R. Growth Station

We are also countinuing our cooperation with the Feigelson group at the Center for Materials Research at Stanford University. They have grown several new technologically interesting materials in the past year and have made modifications to their system that have led to improved quality fibers.

One of the most important improvements to their system was the addition of an enclosure around the growth zone, eliminating the de-stabilizing effects of air currents. An attenuator system with three fixed levels and minimal beam walk and beam steering has been installed, to allow well above threshold operation of the laser even for small diameter or low melting point fibers.

An improved beam alignment system has also been installed, facilitating accurate focusing into the fiber. The effect of these modifications has been a considerable improvement in fiber quality. Nd:YAG fibers with diameters as small as 100 microns have been grown with diameter variations of several percent over centimeter lengths. These results are encouraging in their own right, but also suggest that the more sophisticated second generation system should produce usable fibers soon after being put into full operation.

The C.M.R. group has recently taken delivery of a commercial diameter measurement system and is in the process of testing and installing it in their growth apparatus. Together with a mini-computer which they also have recently obtained, the diameter measurement instrument will form the basis of a closed loop diameter control system.

While the C.M.R. group has had its greatest success with Nd:YAG fibers, they have spent a considerable amount of time on growing fibers of a variety of materials. Among the more interesting are YIG, the first flux grown fiber, Li_2GeO_3, a material with large Raman cross-section, and $Eu:Y_2O_3$, a material grown from a hot pressed ceramic source rod. This latter material is an example of a useful application of this growth technique : the rapid growth of a variety of ion/host combinations for evaluation of their fluorescence properties. The turn-around time of the process is such that several materials could be grown in a day, rather than one in a week as is common for conventional growth techniques. The hot press that has been delivered to C.M.R. will facilitate the preparation of suitable source rods for these investigations.

Also planned for the near future is an electro formed nickel sphere to surround the growth zone and re-focus scattered CO_2 light and black body radiation back onto the melt to facilitate growth of very high melting point materials and materials which do not strongly absorb the 10.6 micron CO_2 radiation.

4. Fiber Measurement Activities

While our effort has focused on developing the means to grow high quality fibers, we have also been making preparations for experiments to be done after we obtain usable fibers. Last year's report discussed fiber characterization devices that we developed, including an index of refraction profiler, a device for mapping ferro-electric domain distributions and in interference microscope to measure the flatness of fiber ends.

In order to launch light efficiently into a fiber, it is necessary to illuminate the fiber with a clean Gaussian beam of the correct radius incident normal to a flat fiber end face. We have built a set of minature gimble mounts for accurate angular positioning of the fiber and acquired a set of small x,y,z stages with differential micrometers for accurate translational positioning of the fiber. We are purchasing a zooming beam expander whicn, in conjunction with a set of focusing lenses we already have available, allows continuous tuning of the laser beam waist to the optimum size for a given fiber. Our optics shop has developed a jig suitable for holding fibers rigidly during polishing, and has obtained fractional wave flatness across the faces of 100 μm fibers.

We are also acquiring laser sources suitable for a variety of linear and nonlinear experiments in fibers. By refurbishing an old Chromatix Nd:YAG laser, we have access to cw, long pulse or Q-switched radiation at several infrared wavelengths. An integral intracavity frequency doubling crystal shifts the laser output to red, yellow and green wavelengths. We have also been in contact with researchers at Xerox, Palo Alto Research Center, who have provided us with a 200 mW phase locked laser diode array.

C. FUTURE OBJECTIVIES

In the coming year our primary goal is to overcome our equipment problems and obtain better quality fibers. Until the new laser arrives it will be difficult to grow fibers with diameters less than 160 microns. The unpolarized Chinese laser precludes the use of the electro-optic modulator to attenuate the laser beam, making the low powers necessary for the growth of small diameter fibers difficult to obtain. Instead, we will study the problems associated with growing longer fibers in the 160 micron diameter range, and continue qualitative investigations of the effects of pull rate and laser power modulation.

When the new CO_2 waveguide laser arrives, it will be necessary to test it for mode quality, output power stability and beam pointing stability. Assuming it meets specifications, we can install it in our system and interface it to the wideband power stabilization. We hope to reach this point early in October.

The next step will be quantitative evaluation of the transfer function between laser power or motor speed variations and the fiber diameter. With the transfer functons available for a variety of combinations of growth conditions and fiber diameters, it will be possible to design compensation networks for a closed loop diameter stabilization system. Throughout this process the theoretical analyses developed for bulk float zoning will serve as a qualitative guide for interpreting our results. For well characterized materials like sapphire, quantitative comparison may be possible. As these procedures are all new and untried, we estimate a mid-year completion date for this stage of the project.

At this point, or perhaps even before the closed loop control is implemented, we should be able to grow good quality fibers of our model material. We can then begin to characterize the linear properties of the fibers, e.g. mode launching, mode conversion, radiation loss, absorption loss. A video imaging system is required for these measurements. We also plan to investigate the effect of various glass and liquid claddings on the linear properties of the fibers.

Even before this process is complete we should be able to demonstrate interesting device applications of sapphire fibers. A high temperature one or two color pyrometer similar to that developed at N.B.S. could be demonstrated in a flexible, all sapphire fiber configuration. High power transmission of an infrared laser beam, e.g. 200 W at 1.06 micron, could also be demonstrated. A simple polarizer could also be made by cladding a sapphire fiber with an isotropic material intermediate between sapphire's ordinary and extraordinary index of refraction.

The next material we grow after completing the sapphire model studies will be lithium niobate. At one point we had considered lithium germanate a likely candidate, primarily because its large Raman cross-section would make possible a demonstration of unphasematched stimulated Raman scattering in a fiber of moderate quality. While we have largely conquered the materials problems associated with handling and polishing fibers of this hygroscopic material, the difficulties entailed, together with the recent result, that small 150 μm, c-axis $LiNbO_3$ fibers grow single domain, have led us to choose lithium niobate.

We are particularly excited about the prospects for $LiNbO_3$ nonlinear devices because we have recently acquired some niobate grown in China that does not exhibit significant index of refraction damage. This property greatly enhances the utility of the material for interactions involving visible wavelengths. We are studying the bulk and integrated optic waveguide properties of this 'damage-free' lithium niobate in parallel with our efforts to complete the second generation growth apparatus. The possibility of periodically poling a lithium niobate fiber and the resultant 20 fold increase in nonlinear efficiency is enticing. We have obtained some 40 μm thick lithium niobate plates and we are beginning to study poling these plates as a model system to design poling electrodes for fibers.

We have also recently begun a program to investigate the growth and spectroscopy of laser host ion combinations. One crystal of $Ti:A\ell_2O_3$ has already been grown, and plans call for the study of a variety of combinations, including co-doped materials of the Cr:Nd:GGG family. The rapid turn-around time of the fiber growth process make it ideal for this type of survey.

Our goal is to fully characterize single crystal fibers, to use them to make both linear and nonlinear devices, and to study the properties of laser crystals. There continues to be a very strong interest in the possible devices allowed by single crystal fibers. Thus we continue to obtain direct and indirect support in this program from industry.

D. PUBLICATIONS, INVITED PAPERS, ORAL DISCLOSURES AND PATENTS

This research program is in the early phases of growth and characterization of single crystal fibers. The list of publications is therefore limited. However, interest in the single crystal fiber program remains high, especially by private companies who foresee potential applications of single crystal fiber devices.

Companies who have expressed interest in single crystal fiber devices include Xerox, General Motors, Westinghouse, Spectra Physics and Newport Incorporated.

1. Publications and Oral Disclosures

(1) M. Fejer, "Growth and Characterization of Single Crystal Refractory Oxide Fibers", S.P.I.E. Conference, Los Angeles, CA. January 1982.

(2) M. Fejer, R.L. Byer, R. Feigelson and W. Kway, "Growth and Characterization of Single Crystal Refractory Oxide Fibers", in the Proceedings of the S.P.I.E. Advances In Infrared Fibers, ed. by Larry G. DeShazer, vol.320, p.50 (1982).

2. Patents

M. Fejer and R.L. Byer, "Apparatus for Growing Crystal Fibers", issued June 1983. Stanford University file #S81-97.

3. To be Published

(1) M.Fejer, G. Magel, S. Greenstreet and R.L. Byer, "High Speed non-Contact Fiber Diameter Measurement System".

(2) M. Fejer, J. Nightingale and R.L. Byer, "A Single Crystal Fiber Growth Apparatus with Symmetrical Heating".

Unit 82-4

ACOUSTIC SURFACE WAVE SCANNING OF OPTICAL IMAGES

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A. INTRODUCTION - OBJECTIVES

The broad aim of this work has been to demonstrate that acoustic surface wave devices can be constructed on silicon, and that sophisticated signal processing can be carried out by taking advantage of LSI technology. Thus, our basic aims have been to demonstrate a marriage between LSI and acoustic surface wave technology, and to develop a device which should demonstrate feasibility for single-chip processing of sophisticated spread spectrum and radar signals.

The work we have carried out is built on a base of almost ten years of development of zinc oxide on silicon technology starting with acoustic convolvers, then the acoustic surface wave storage correlator, and now the SAW/FET device. The most recent demonstration on the JSEP program has been to demonstrate these ideas by constructing a programmable delay line which has the following properties: (1) a signal can be read into the device in the form of a surface acoustic wave at relatively high frequencies, but can be read out arbitrarily slowly at a relatively low frequency into a computer or other interrogating system; (2) a signal can be read into the device from a computer to control the tap weights of the acoustic surface wave device; and (3) two acoustic signals can be correlated with each other and the correlation waveform read out at relatively low rates into a computer or other storage device.

B. PROGRESS AND ACCOMPLISHMENTS

The new device we have constructed is called the SAW/FET. The SAW/FET can operate in two different, but equally useful, modes. In one mode of operation the SAW/FET device serves as a slowly-programmable filter of high-frequency signals. Operated in the other mode, the device functions as a buffer memory for high-speed waveforms, capturing the signals for subsequent low-speed readout into a digitally-based signal processing system.

The basic SAW/FET structure is depicted in Fig. 1a. The top portion of this sketch shows two interdigital transducers used for launching and detecting surface acoustic waves which propagate in opposite directions along the device. The operating frequency of the propagating surface acoustic waves is typically around 100 MHz . Underneath a top-plate electrode, which covers a zinc oxide film, there is also an implanted silicon diode array region.

Conversion of electrical to acoustical energy, and vice versa, can be accomplished through the piezoelectric ZnO layer, which is sputter deposited onto the surface of the device. The diodes then serve as local sites for the mixing and storage of electric fields associated with the surface acoustic waves propagating in the ZnO layer. Each diode is connected, using VLSI technology, to an associated field effect transistor (FET). The drains of all the FETs are connected together to form a common line, used for inserting or retrieving low-frequency analog waveforms into or out of the diode array. The gates of the individual FETs are connected to the tapped output of a single-bit shift register.

The resulting device is of a totally monolithic design. The shift register circuitry and associated FETs and diodes are fabricated using standard NMOS integrated circuit processing, and the ZnO is then sputtered directly onto the device surface using techniques first developed in the Ginzton Laboratory. A schematic of the complete device is shown in Fig. 1b. The top-plate electrode on top of the ZnO layer is used to control the high-speed input and output of the 100 MHz analog waveforms.

Figure 2 shows a photograph of three representative devices out of twenty-seven fabricated on the same silicon wafer. This picture was taken before the ZnO and interdigital transducers were deposited onto the devices. The shift registers along the top and bottom of each device can be clearly observed. The diode interaction region between the shift registers is 1 mm wide and has been specially prepared to provide a low-loss surface for the propagating surface acoustic waves. The interdigital transducers are placed at the ends of the interaction region rectangle, between the two vertically-spaced alignment crosses. The top-plate electrodes on the finished devices cover the entire 1 mm x 7 mm interaction regions.

In order to operate the SAW/FET as an electronically-programmable transversal filter (see Fig. 3a), a low-speed waveform can be inserted into the device via the common drain line of the FET array while simultaneously clocking the single-bit tapped shift register. This low-frequency waveform

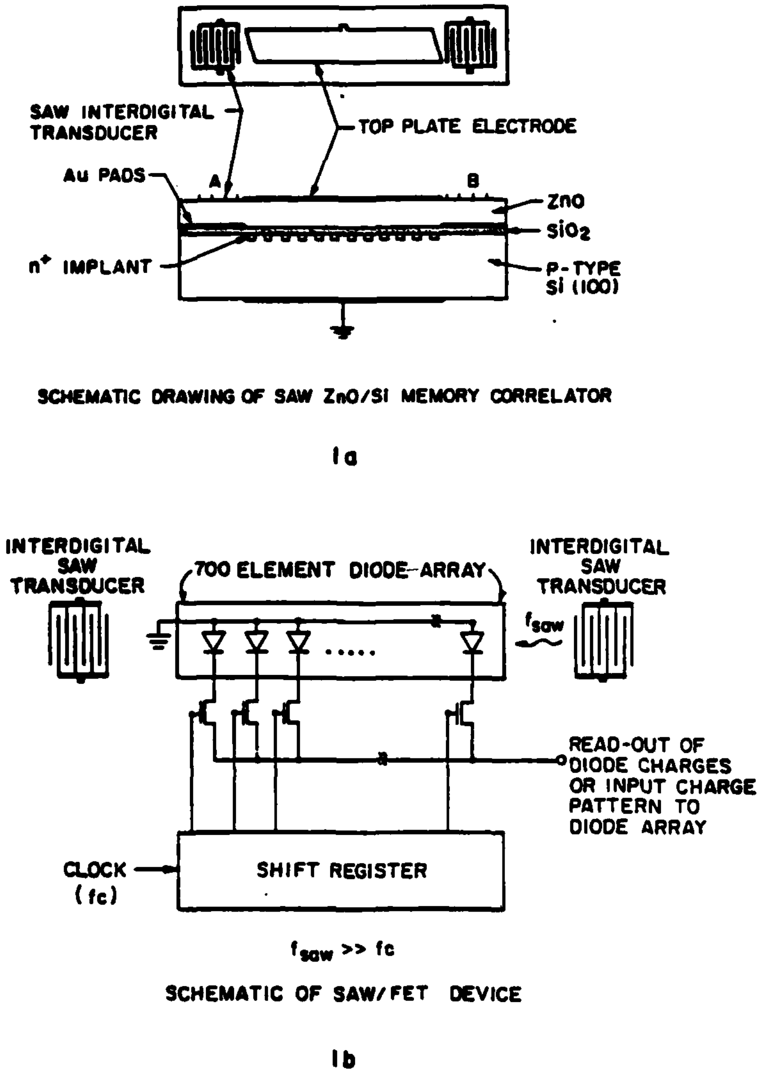


Figure 1. (a) Basic storage correlator schematic. (b) Complete SAW/FET diagram.

will then represent the desired filter characteristic. As the multiplexed FETs are switched on by the tapped shift register, a different sample of the filter function is stored in successive diodes in the array. The waveform samples are stored as charge on the reverse-biased diodes which will have a varying capacitance depending on the amount of stored charge. Since the diode array capacitance is in series with the capacitance of the ZnO layer, the application of a high-frequency signal to the plate electrode results in a spatially-varying voltage across the ZnO film. Since the ZnO film is piezoelectric, this will give rise to an acoustic surface wave signal received by the interdigital transducer that is proportional to the convolution of the original stored waveform (the filter function) and the high-frequency signal applied to the top-plate electrode.

Figure 3b shows the correlation output of a 96 MHz modulated 3-bit Barker code (++-) with a low-frequency modulated 3-bit Barker code previously stored in the device.

The same SAW/FET device can also be used as a buffer memory capable of storing high-speed waveforms until subsequent low-speed readout. A schematic illustration, showing the use of the SAW/FET as a high-frequency buffer memory, is depicted in Fig. 4a. The high-frequency input signal is launched by an interdigital transducer as a propagating surface acoustic wave. When this signal is present over the diode array, a storing pulse is applied to the top-plate electrode. This storing pulse forward-biases the diodes in the array, injecting charge into each diode that is proportional to the sample of the analog waveform present above the diode when the storing pulse is applied. After the storing signal is turned off, the remaining voltage on the

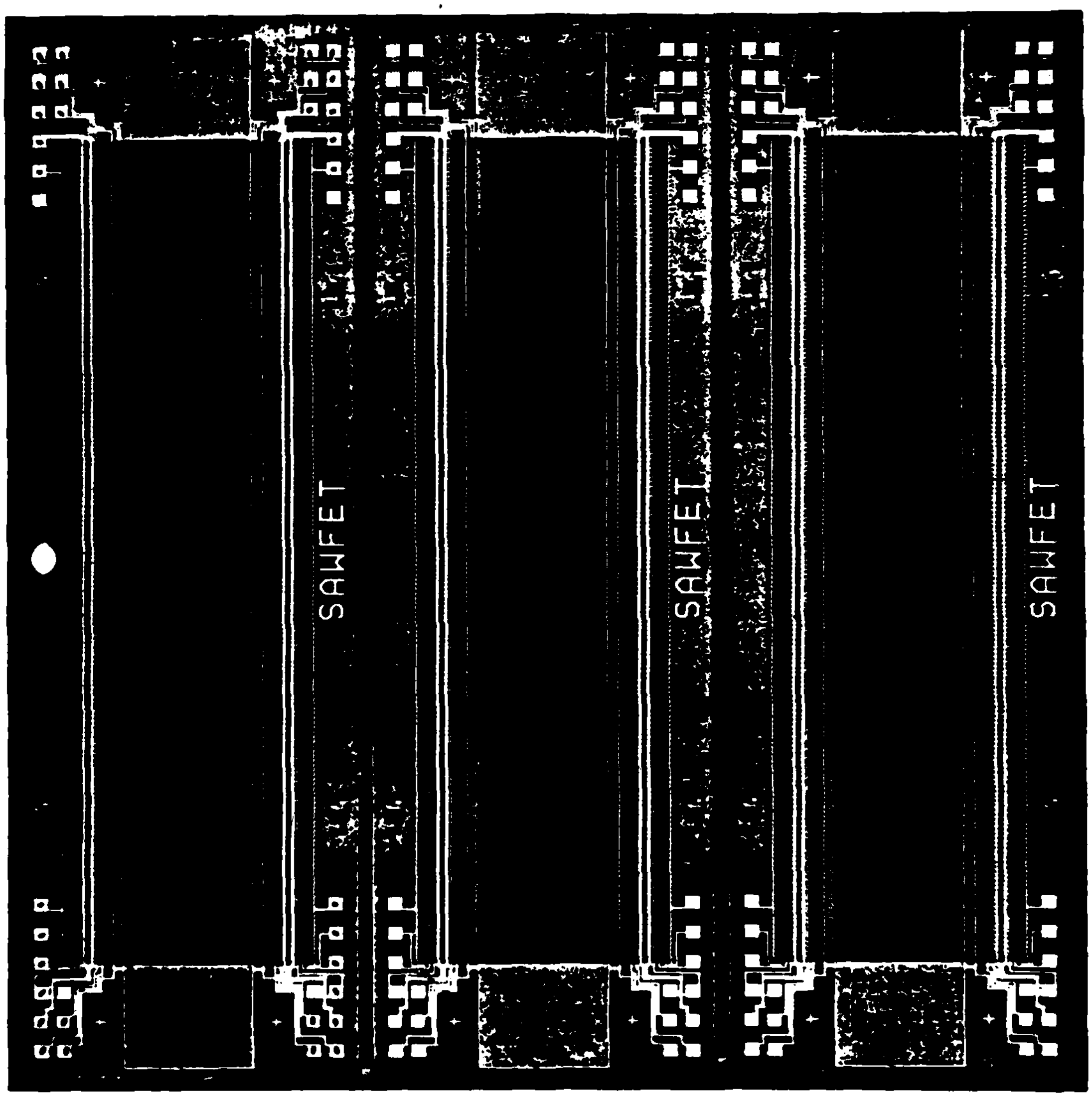
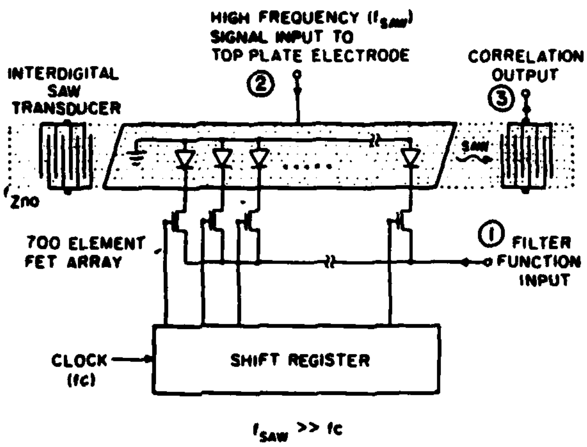
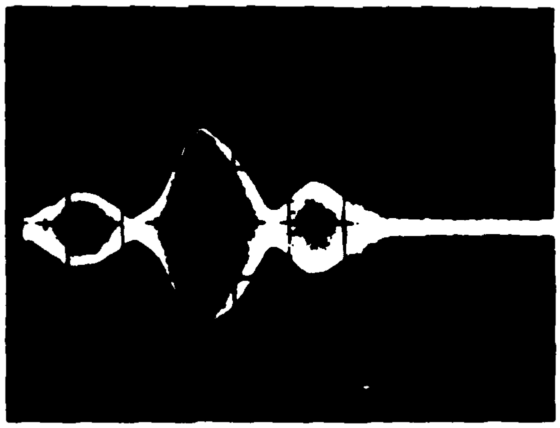


Figure 2. Optical photomicrograph of three SAW/FET devices.



SCHEMATIC OF SAW/FET PROGRAMMABLE TRANSVERSAL FILTER

3a



SAW/FET Correlation Output of Two 3-Bit Barker Codes

0.1 μsec/div

3b

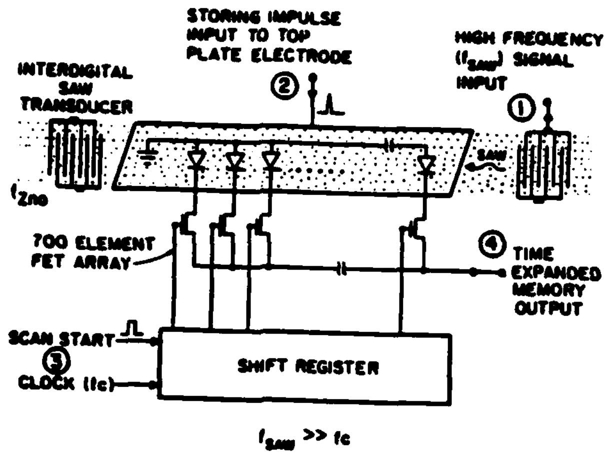
Figure 3. (a) Device operation as a programmable filter. (b) correlation output.

diodes in the array represents the high-frequency waveform originally inserted into the device.

After the waveform is stored in the diode array, it is possible to read out this waveform by simply clocking the shift register. As the propagating bit travels through the shift register, each multiplexed FET is turned on in sequence, connecting the diodes one at a time to the common drain line of the multiplexed FET array. As the voltage of each diode is sensed by the output circuitry, the analog waveform previously stored in the diode array is reconstructed at a speed commensurate with the shift register clock rate. Thus, the original high-frequency waveform is time-expanded at the output of the device. With the SAW/FET, a high-frequency signal can be captured and inserted into a low-frequency signal processing system (usually digital) without the need for an expensive high-speed A/D converter. The SAW/FET can, in principle, act as a buffer memory for signals with bandwidths in excess of 200 MHz .

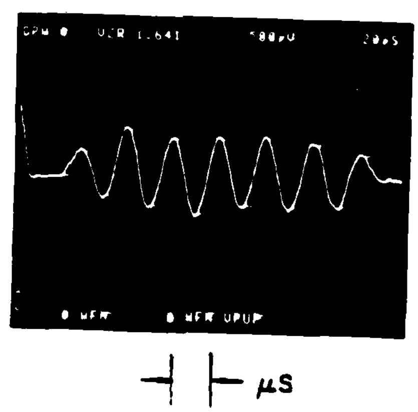
Figure 4b shows the SAW/FET output when used in the buffer memory mode, as described above. The photo shows the time-expanded output of an 800 nsec rectangularly-modulated high-frequency (f_o = 97 MHz) waveform stored in the SAW/FET diode array. Noticing that the output signal is approximately 160 μsec long, we observe that a time expansion factor of 200 has been achieved.

The SAW/FET thus provides an extraordinarily flexible device with multiple capabilities to process and record signals in the 100 MHz range. The attractive feature of this device is that it can control this high-speed signal processing via a low-speed, digitally based, signal processing



SCHEMATIC OF SAW/FET BUFFER MEMORY

4a



4b

Figure 4. (a) Device operation as a buffer memory. (b) Slow-speed readout.

system. Thus, the SAW/FET provides a much needed link between the world of high-speed analog signal processing based on the surface acoustic wave technology and low-speed digital signal processing systems.

Due to some unanticipated cross-coupling problems between elements in the original and integrated circuit, and some misconnections made in parts of the circuit, a second generation of integrated circuit was constructed and initial tests were carried out on it. At this time a thesis was finished by J. Green and further work was carried out on the new circuits by T. Kodama. Initial tests on these circuits were satisfactory, but a full set of tests have not yet been carried out.

C. FUTURE OBJECTIVES

After discussions with the program monitors and with Lincoln Laboratories, we decided to transfer the chips and the technology to Lincoln Laboratories where J. Green is now working. Lincoln Labs are developing a spread spectrum system making use of devices of this kind. In their earlier work they had used a so-called air-gap device with CCD delay lines connected to diodes in a similar configuration to ours. The zinc oxide on silicon technology would appear to be a better solution because it avoids a great deal of precision optical finishing and mechanical alignment. In addition, the SAW/FET arrangement that we have devised would appear to be able to give a larger dynamic range than the CCD system. Therefore, Lincoln Laboratories are interested in trying out this technique for their purposes. We regard this arrangement as by far the most satisfactory one for transferring the technology we have developed into the field. We expect that as Lincoln Labs develop it, further devices will be produced with much larger bandwidths and much better performance than the devices we developed to prove feasibility of the basic concepts.

We have now terminated this work and transferred all of the technology to Lincoln Laboratories.

1. Relationship to Other Contracts

This work was carried out in cooperation with our contract with DARPA/ONR on the storage correlator. We used the same ZnO on Si technology and eventually we transferred part of this work to the DARPA/ONR contract. The Joint Services Program normally does not provide enough for full project support. It was therefore necessary to carry out the program in cooperation with others. This approach was, however, extremely useful because the Joint Services Program allowed us the flexibility to try out several new ideas, including our work on acoustic waveguides and the initial work on the SAW/FET.

D. PUBLICATIONS, INVITED PAPERS, ORAL DISCLOSURES, AND PATENTS

1. J. B. Green, G. S. Kino, J. T. Walker, and J. D. Shott, "Integrated Surface Acoustic Wave/Field-Effect Transistor High-Speed Analog Memory," Appl. Phys. Lett. 42 (12) (15 June 1983).

2. J. B. Green, G. S. Kino, J. T. Walker, and J. D. Shott, "The SAW/FET: A New Programmable SAW Transversal Filter," presented at the IEEE Ultrasonics Symp. (October 1982).

3. J. E. Bowers, R. L. Jungerman, and B. T. Khuri-Yakub, "Noncontacting Sensors for Acoustic Waves," presented at the IEEE Ultrasonics Symp. (October 1982).

Unit 82-5

PICOSECOND RAMAN STUDIES OF ELECTRONIC SOLIDS

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(Charles E. Barker)

A. INTRODUCTION - OBJECTIVES

Raman scattering is an inelastic scattering of photons by phonons or electrons. Scattering from electrons reveals information about what is happening in the electronic structure of a solid, while scattering from phonons (the quantized lattice vibrations of a solid) gives information about the lattice of the solid. The frequency spectrum of the light scattered by the solid exhibits intensity peaks shifted in frequency from the incident laser. The frequency shift and width of these peaks, as well as changes in them, yields information about the lattice vibrational frequencies, lattice temperature, bonding of the atoms which make up the crystal, impurities in the crystal, lattice stress, and lattice structure. Raman spectroscopy is quite often far more sensitive to changes in the phonon spectrum, and hence changes in the lattice, than other standard techniques such as neutron scattering. By probing a solid with picosecond pulses from a mode locked laser, we are able to observe changes in the phonon spectrum which take place on picosecond to nanosecond time scales. The objective of this project is to determine what phenomena we can actually observe through picosecond time-resolved Raman spectroscopy.

B. PROGRESS AND ACCOMPLISHMENTS

A substantial portion of the last two years has been spent upgrading the picosecond Raman spectroscopy apparatus built by our group in conjunction with Professor Lubert Stryer of the Department of Structural Biology in the Stanford Medical School for time-resolved studies of rhodopsin [1]. The goal of the upgrade was to make observation of Raman spectra more quickly, more easily, and more reliably -- both for the rhodopsin studies and the solid-state studies of this project. Hence the first part of this section will describe the initial configuration of the apparatus and what has been done to upgrade it. The second part will describe the initial experiments that have been performed, what information has been obtained from them, and what directions this information indicates should be pursued. The final topic of this section will deal with experiments that are being carried out presently.

1. Experimental Apparatus

Until June of 1981 the picosecond Raman system existed in the following configuration. The laser source was a repetitively flashlamp-pumped Nd:YAG laser which was passively mode-locked and passively Q-switched. This laser produced a 1.064 μm wavelength Q-switched burst of approximately 10 to 15 pulses of 30 picosecond duration at a repetition rate of up to 40 Hz. The energy of the most intense pulses in the burst was approximately 100 μJ. This Q-switched burst was passed through a single pulse selector in order to switchout a single 30 picosecond pulse. This single pulse is then passed through a CD*A second harmonic generation crystal to produce a 532 nm wavelength pulse. The 532 nm pulse is then separated from the 1.064 μm pulse and used to illuminate the sample. The scattered light from the sample was then collected with f:1 optics and fed into a Spex 1401 double monochromator equipped with a scanning drive and a pair of 1200 groove/mm gratings. Detection was done with a cooled photomultiplier tube interfaced to the laboratory computer.

The detection method used in this system is a point-by-point spectral scan. Such a method wastes much of the available Raman signal and requires relatively large amounts of sample to obtain a spectrum. A much more efficient method of collecting the Raman signal is through the use of an optical multichannel analyzer. Such a device allows us to view a relatively wide spectral window while retaining good spectral resolution.

A Princeton Applied Research OMA II system was installed in the Raman system in June 1981. This system was not well-characterized by the manufacturer and, consequently, we have spent many months learning how the system behaves under the conditions in which it will be operating. Some of the problems and the solutions we have found are detailed below.

The detector exhibited a baseline output which fluctuated from run to run. This problem has been greatly reduced by pre-exposing the detector with an external light source and then reading down the charge on the detector with a fixed number of read scans.

Under cooled operation, the detector's vidicon tube produced readings which fluctuated with small temperature changes. The tube was initially cooled with dry ice. Switching to a closed-loop freon cooling unit has greatly reduced these fluctuations.

The photocathode of the vidicon tube has a heated window to prevent condensation under cooled operation. The heater for this window increased the noise level of the photocathode. This necessitated turning off the heater and purging the window area with a nitrogen gas jet.

The electron gun filament in the vidicon tube does not turn on early enough to equilibrate during long integration times. This has been solved by interfacing some hardware to the control unit to generate the command to turn on the filament sufficiently early to allow it to equilibrate.

With these modifications to the OMA II system, we now believe that the detection system works in a reproducible and predictable manner. With a pair of 1200 groove/mm gratings, we now have a spectral window of about 200 cm^{-1} and a resolution of approximately .5 to 1 cm^{-1}.

The other component of the system which was targeted for improvement was the Nd:YAG laser. Initially it put out pulses with a 25 to 30 percent fluctuation in energy, and it tended to damage the mode locking cell window after a few hours of operation. Thus, improvement of the YAG laser was aimed at reducing the pulse-to-pulse fluctuations in the output energy and increasing the mean time to failure of the mode locking cell.

The fluctuations in output energy appear to be due to the statistical nature of the build-up of laser radiation from noise. These fluctuations were greatly improved by the addition of an acousto-optic mode locker to the laser cavity earlier this year. Output energy fluctuations have now been reduced to about 10%.

Increasing the reliability of the mode locking cell, however, has proved to be a much more difficult problem to solve. A systematic program of modifications to the laser cavity and the flowing dye cell was undertaken to find a solution to this problem. An intracavity telescope was added to the laser in an attempt to reduce the energy density in the dye cell, but this did not prevent damage. This indicated either deterioration or contamination of the dye. Various cell modifications were undertaken to improve flow in the dye cell, eliminate bubbles in the flow system and eliminate dye/solvent contact with any material other than stainless steel, glass, or teflon to avoid contamination. We have also increased the dye cell thickness to 1.5 mm in order to lower the dye concentration. This last, and most recent, step seems to have helped a great deal in increasing the reliability of the mode locking dye cell. We have run the laser in this configuration for several hours now, with no indication so far of any damage occurring.

2. Initial Experimental Results

The goal of the initial experiments was to determine whether or not we could observe the Raman spectrum produced from picosecond laser pulses incident on silicon samples and determine what directions we should pursue with future experiments.

The first experiment performed was to observe the Raman spectrum from a full Q-switched train of 532 nm, 30 picosecond pulses from the YAG laser incident on a silicon sample. The spectrum obtained from such an experiment, shown in Fig. 1, reveals several things. First, we can in fact see the Raman signal produced by picosecond pulses in a reasonable integration time. The width of the peak is approximately 20 cm^{-1} -- about five times the tabulated room temperature value and indicative of quite high temperatures. This could therefore indicate local heating by the laser pulses. Although the incident energy density (J/cm^2) was below the single pulse damage threshold, the sample was found to be damaged after several shots. This definitely indicates local heating of the sample, confirming our

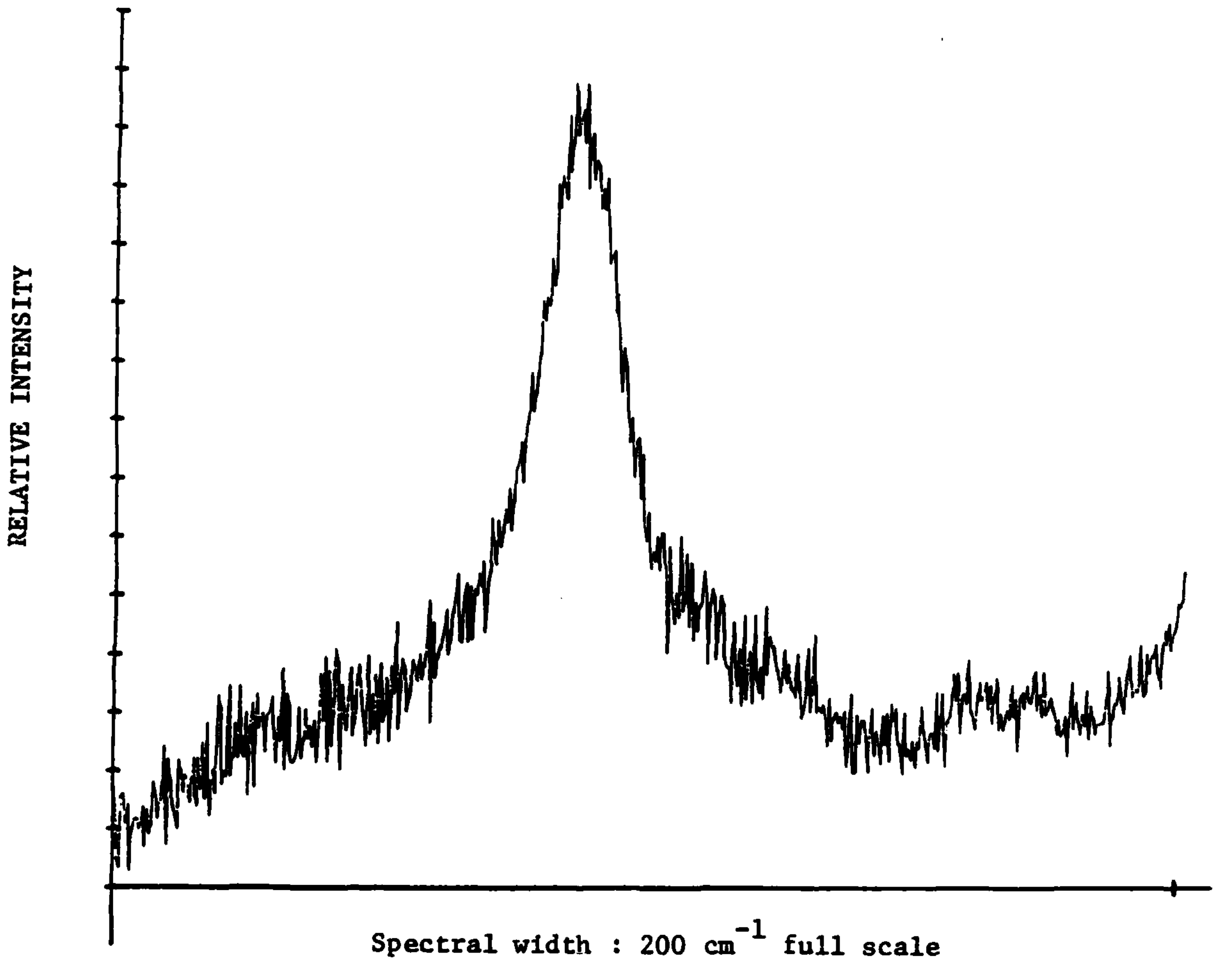

FIGURE 1

523 cm^{-1} Si Raman Line
(Stokes peak)

hypothesis for the broadened Raman line. This observation, combined with the results obtained by P. M. Fauchet [2] of our group on multiple pulse effects in various solids, indicates the need to present a fresh sample area to each incident laser pulse.

One of the first experiments planned after a series of initial experiments was completed was the measurement of lattice temperature in silicon under illumination by intense picosecond pulses. The work of Lo and Compaan [3] suggested using the ratio of Stokes to anti-Stokes peak heights to determine the lattice temperature. The next preliminary experiment was performed in order to determine whether we could observe the anti-Stokes peak (frequency up-shifted from the laser due to absorption of a phonon) as well as the Stokes peak (frequency down-shifted from the laser due to emission of a phonon).

Temporary use of a cw argon laser allowed us to examine both the Stokes and anti-Stokes components of the scattered light -- the cw laser was used because it produces greater Raman signal and is thus easier to use. An easily detectable signal from this experiment would indicate that we should also be able to observe both peaks with picosecond pulses from the YAG laser.

Typical spectra obtained from illuminating silicon samples with approximately 120 mW, 514.5 nm cw Ar laser radiation are shown in Figs. 2 and 3. Figure 2 is the silicon Stokes peak at 523 cm^{-1}, while Fig. 3 is the silicon anti-Stokes peak at 523 cm^{-1}. Both of these spectra were recorded over an approximately 30 second integration time. Thus we can easily detect both the Stokes and anti-Stokes signals; however with the high resolution gratings we are unable to observe both peaks simultaneously. Using the Boltzmann ratio and the correction factors relating the peak height ratio to the temperature [3], we obtain a sample temperature of approximately

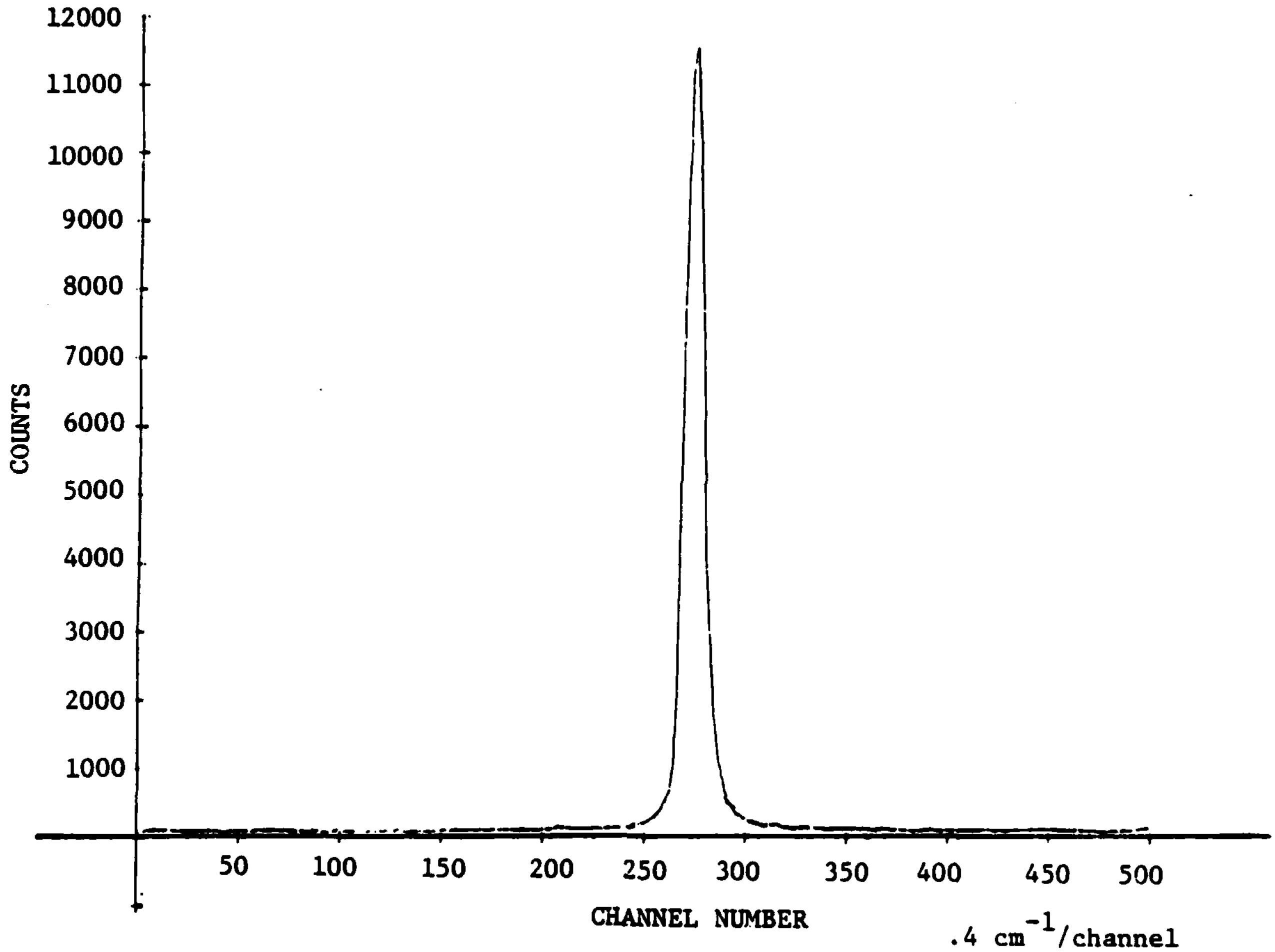

FIGURE 2

523 cm^{-1} Si Raman Line
(Stokes peak)

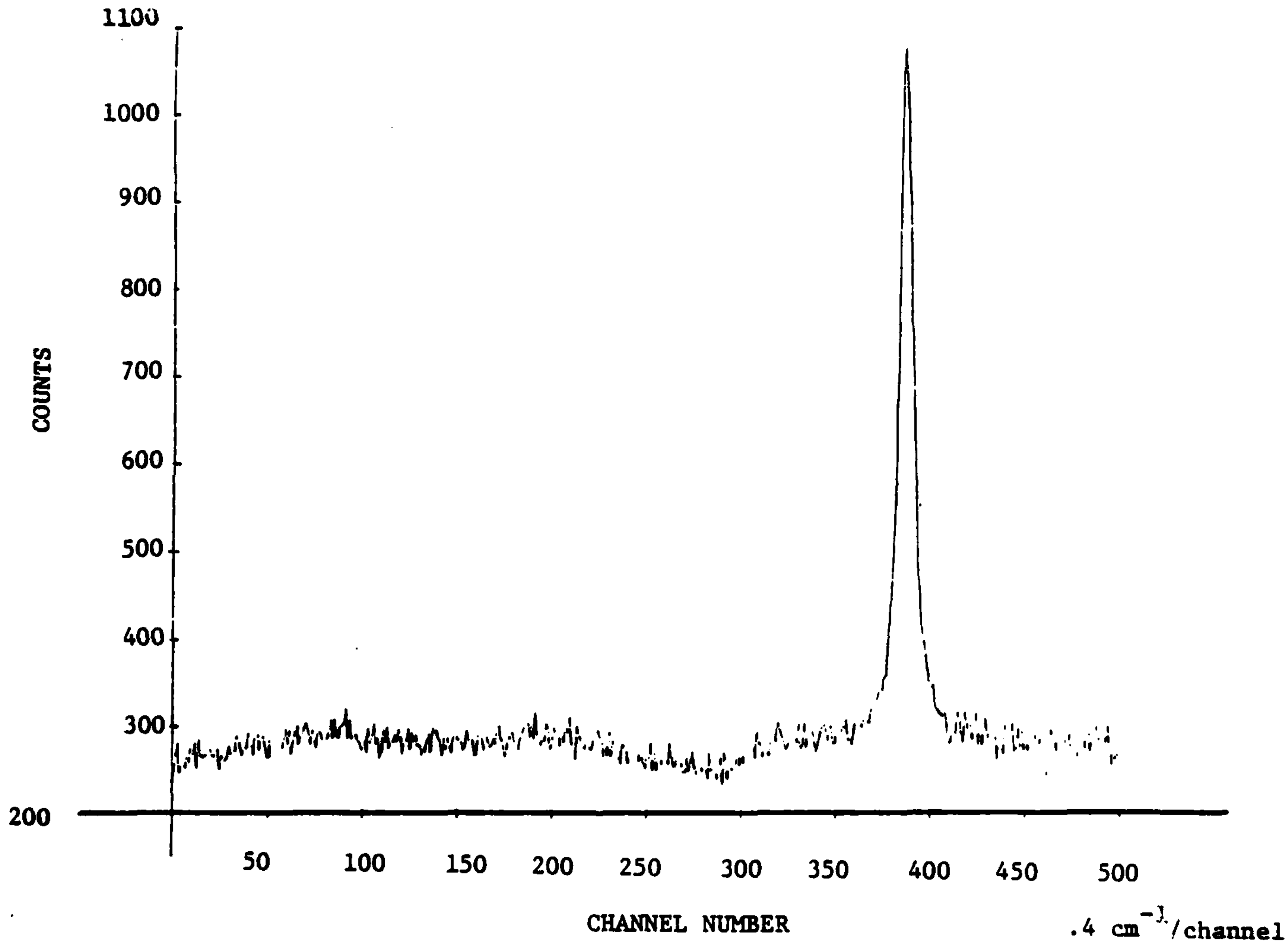

FIGURE 3
523 cm^{-1} Si Raman Line
(anti-Stokes peak)

280 K -- this is near room temperature and reasonable considering the fact that we were unable to observe both lines simultaneously. This indicated that if we were to use the peak height ratio to measure the temperature of the lattice, we would need to use much coarser gratings in the spectrometer in order to cover a range of about 550 cm^{-1} on either side of the laser frequency. This also poses the problem of eliminating, or at least greatly reducing the scattered light entering the spectrometer at the laser wavelength. An attempt to observe the Raman signal from silicon under illumination by 532 nm, 30 picosecond pulses from the YAG laser using a pair of 300 groove/mm gratings in the spectrometer to give a wider spectral window, failed to produce a detectable Raman spectrum due to scattered light at the laser wavelength.

3. Work in Progress

Work by Hart, Aggarwal, and Lax [4] and, more recently, by Tsu and Hernandez [5], indicates that at high temperatures, i.e., near melting, the change in linewidth and frequency shift are much better indicators of lattice temperature than the peak height ratio used by Lo and Compaan [3]. Consequently, we have shifted our emphasis toward using the change in Raman frequency shift as a measure of lattice temperature. This necessitates finding good Raman frequency standards in the 400 to 600 cm^{-1} region with which to calibrate our spectrometer and detector. We are presently searching the literature to locate at least one good reference material for this spectral range. We are also presently designing and constructing a motor-driven translation stage to move fresh sample into the laser beam for each pulse. Also currently under design and construction is a fiber optic link to allow us to use a nearby argon laser. This will allow us to check and maintain the spectrometer throughput when gratings are being changed, as well as giving us permanent cw-Raman capability. This last feature will be most important for some experiments under consideration.

C. FUTURE OBJECTIVES

We plan to continue the silicon Raman experiments into the immediate future. We expect to be able to detect large temperature rises with increasing 532 nm, 30 psec pulse energy incident on crystalline silicon samples. The next step in these experiments will be to heat the sample with a 1.06 μm pulse and then probe the heated region with a variable delay 532 nm pulse. Similar experiments can be performed on amorphous silicon -- these are anti-annealing experiments. In such experiments we would heat the sample with a laser pulse with the intention of producing a region of crystalline silicon and look for the crystalline silicon Raman signal appearing in the broad background signal from the amorphous silicon. Finally, an experiment which could easily be performed with the cw argon laser capability we will have would be to examine multiple, below-threshold pulse effects in crystalline silicon and other solids by examining changes in the cw Raman spectrum of the material as a function of the number of picosecond laser pulses incident on the material.

D. REFERENCES

1. G. Hayward, W. Carlsen, A. E. Siegman, and L. Stryer, "The Retinal Chromophore in Rhodopsin Photo Isomerizes Within Picoseconds," Science 211, 942 (1981).
2. P. M. Fauchet, "Gradual Surface Transitions on Semiconductors Induced by Multiple Picosecond Laser Pulses," Phys. Lett. 93A, 155 (1983).

3. H. W. Lo and A. Compaan, "Raman Measurement of Lattice Temperature During Pulsed Laser Heating of Silicon," Phys. Rev. Lett. 44, 1604 (1980).

4. T. R. Hart, R. L. Aggarwal, and B. Lax, "Temperature Dependence of Raman Scattering in Silicon," Phys. Rev. B 1, 638 (1970).

5. R. Tsu and J. G. Hernandez, "Temperature Dependence of Silicon Raman Lines," Appl. Phys. Lett. 41, 1016 (1982).

SECTION IV

PUBLICATIONS CITING JSEP SPONSORSHIP

G.L. No.	Title	Contract/Grant
3262	M.R. Beasley and C.J. Kircher, "Josephson Junction Electronics: Materials Issues and Fabrication Techniques," Preprint (May 1981). Also: Published in Superconductor Materials Science, eds. Simon Foner and Brian B. Schwartz (Plenum Press Corporation, 1981).	N00014-75-C-0632
3279	R.B. van Dover, A. de Lozanne, and M.R. Beasley, "S-N-S" Microbridges: Fabrication, Electrical Behavior and Modeling," Preprint (June 1981). Also: Published in Journal of Applied Physics, 52, No. 12, 7327 (December 1981).	N00014-75-C-0632
3291	B.A. Auld, S. Ayter, M. Tan, and D. Hauden, "Filter Detection of Phase-Modulated Laser Probe Signals," Preprint (July 1981). Also: Published in Electronics Letters, 17, No. 18, 661 (3 September 1981).	N00014-79-C-0222 and N00014-75-C-0632
3309	B.A. Auld and M.M. Fejer, "Elastic Non-linearity and Domain Wall Motion in Ferroelastic Crystals," Preprint (August 1981).	N00014-75-C-0632
3338	R. Trebino, J.P. Roller, and A.E. Siegman, "A Comparison of the Casegrain and Other Beam Expanders in High-Power Pulsed Dye Lasers," Preparint (October 1981). Also: Published in IEEE Journal of Quantum Electronics, QE-18, No. 8, 1208 (August 1982).	AFOSR-80-0145 and N00014-75-C-0632

G.L. No.	Title	Contract/Grant
3367	R.A. Bergh, M.J.F. Digonnet, H.C. Lefevre, S.A. Newton, and H.J. Shaw, "Single Mode Fiber Optic Components," Preprint (December 1981). Also; Published in SPIE Vol. 326, Fiber Optics--Technology '82, p.137 (1982).	N00014-75-C-0632 and Atlantic Richfield Co.
3402	J.B. Green and G.S. Kino, "SAW Convolvers Using Focused Interdigital Transducers," Preprint (March 1982). Also: Published in IEEE Transactions on Sonics and Ultrasonics, 30, No. 1, 43 (January 1983).	N00014-75-C-0632
3411	Staff, "Annual Progress Report and Report of Significant Accomplishments," for the period 1 April 1981 through 31 March 1982 (April 1982).	N00014-75-C-0632
3438	J.B. Green, G.S. Kino, J.T. Walker, and J.D. Shott, "Novel Programmable High-Speed Analog Transversal Filter," Preprint (June 1982).	N00014-75-C-0632
3453	A. de Lozanne, "High Critical Temperature SNS Josephson Microbridges," Internal Memorandum (June 1982).	N00014-75-C-0632
3468	P. Toledano, M.M. Fejer, and B.A. Auld, "Nonlinear Elasticity in Proper Ferroelastics," Preprint (August 1982). Also: Published in Physical Review B 27, No. 9, 5717 (1 May 1983).	N00014-75-C-0632
3486	M.R. Beasley, "Materials Science of Josephson Junctions," Preprint (December 1982). Also: Published in International Electron Devices Meeting, IDEM 82, 758 (December 1982).	N00014-75-C-0632

G.L. No.	Title	Contract/Grant
3487	J.B. Green, G.S. Kino, J.T. Walker, and J.D. Shott, "TheSAW/FET: A New Programmable SAW Transversal Filter," Preprint (October 1982). Also: Published in the IEEE Ultrasonics Symposium Proceedings, 436-441 (1982).	N00014-75-C-0632 and N00014-76-C-0129
3489	J.E. Bowers, R.L. Jungerman, and B.T. Khuri-Yakub, "Noncontacting Sensors for Acoustic Waves," Preprint (October 1982).	Ames SC-81-009; Litton Systems; N00014-76-C-0129; N00014-75-C-0632
3509	D.A. Rudman, "A15 Niobium-Tin: Fabrication and Superconductive Tunneling Spectroscopy," Internal Memorandum (October 1982).	N00014-75-C-0632
3517	J.B. Green, "Surface Acoustic Wave Signal Processing Devices: New Concepts for Monolithic Designs," Internal Memorandum (November 1982).	N00014-75-C-0632 and N00014-76-C-0129
3531	J.B. Green, G.S. Kino, J.T. Walker, and J.D. Shott, "Integrated Surface Acoustic Wave/Field-Effect Transistor High-Speed Analog," Preprint (January 1983). Also: Published in Applied Physics Letters, 42, No. 12, 1015 (15 June 1983).	N00014-75-C-0632 and N00014-76-C-0129
3532	A. de Lozanne, M.S. DiIorio, and M.R. Beasley, "Fabrication and Josephson Behavior of High-T_c Superconductor-Normal-Superconductor Microbridges," Preprint (January 1983). Also: Published in Applied Physics Letters, 42, No. 6, 541 (15 March 1983).	N00014-75-C-0632
3583	S.W. Meeks, B.A. Auld, P. Maccagno, and A. Miller, "Interaction of Acoustic Waves and Ferroelastic Domain Walls," Preprint (June 1983). Presented at the 1983 IEEE International Symposium on Applications of Ferroelectrics (ISAF).	N00014-75-C-0632 and NSF-MRL Program

SECTION V

REPORTS AND PUBLICATIONS

EDWARD L. GINZTON LABORATORY FACULTY AND STAFF

G.L. No.	Title	Contract/Grant
3244	B.T. Khuri-Yakub, J.G. Smits, and T. Barbee, "Reactive Magnetron Sputtering of ZnO," Preprint (April 1981). Also: Published in Journal of Applied Physics, 52, No. 7, 4772-4774 (July 1981).	N00014-78-C-0129
3245	J. Heiserman, "Cryogenic Acoustic Microscopy," Reprint from Scanned Image Microscopy (Academic Press, 1980), pp. 71-95.	N00014-77-C-0412
3246	Staff, "Nondestructive Evaluation of Structural Ceramics," Six-Month Progress Report for the period October 1, 1980 to February 28, 1981 (March 1981).	AMES SC-81-009
3247	Se-Jung Oh and S. Doniach, "Fluorescent Electron Emission--A Prediction for Resonant Photoemission Spectra," Reprint from Physics Letters, 81A, No 8, 483-487 (18 February 1981).	NSF DMR79-13102
3248	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 53rd Report for the period 1 February to 31 March 1981 (April 1981).	EPRI RP609-1
3249	Staff, "Acoustic Microscopy for Non-destructive Evaluation of Materials," R & D Status Report for the period 1 February to 30 April 1981 (April 1981).	F49620-78-C-0098
3250	A.E. Siegman, "Passive Mode Locking Using an Antiresonant Ring Laser Cavity," Preprint (April 1981). Also: Published in Optics Letters, 6, No. 7, 334-335 (July 1981).	AFOSR-80-0145

G.L. No.	Title	Contract/Grant
3251	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 27th Monthly Report for the period 1 March to 1 April 1981 (April 1981).	EPRI RP 1395-3
3252	M.D. Wright, D.M. O'Brien, J.F. Young, and S.E. Harris, "Laser Induced Charge Transfer Collisions of Calcium Ions with Strontium Atoms," Preprint (April 1981). Also: Published in Physical Review A, 24, No. 4, 1750-1755 (October 1981).	F49620-80-C-0023
3253	N.W. Carlson, A.J. Taylor, K.M. Jones, A.L. Schawlow, "Two-Step Polarization Labeling Spectroscopy of Excited States of Na_2," Preprint (April 1981). Also: Published in Physical Review A, 24, No. 2, 822-834 (August 1981).	NSF PHY80-10689
3254	G.A. Zdasiuk, "Atomic Pair Processes and Laser Application," Internal Memorandum (April 1981).	F49620-80-C-0023
3255	R.L. Byer, Y.K. Park, R.S. Feigelson, and E.L. Kway, "Efficient Second Harmonic Generation of Nd:YAG Laser Radiation using Warm Phasematching $LiNbO_3$," Preprint (April 1981). Also: Published in Applied Physics Letters, 39, No. 1, 17-19 (1 July 1981).	LLL 3488009
3256	Staff, "Measurement of Surface Defects in Ceramics," End of Year Report - 1980 (April 1981).	N00014-78-C-0283
3257	H. Park, M. Chodorow, and R. Kompfner, "High Resolution Optical Ranging System," Preprint (June 1981). Also: Published in Applied Optics, 20, No. 14, 2389-2394 (15 July 1981).	-----

G.L. No.	Title	Contract/Grant
3258	Staff, "Application of CARS Spectroscopy to Turbulence Measurements," Final Report (April 1981).	NASA/Ames NSG 2289
3259	R.B. King, G. Herrmann, and G.S. Kino, "Use of Stress Measurements with Ultrasonics for Nondestructive Evaluation of the J Integral," Preprint (April 1981). Also: Published in Engineering Fracture Mechanics, 15, No. 1-2, 77-86 (1981).	F49620-79-C-0217 and EPRI RP609-1
3260	J.E. Bowers, "Broadband Monolithic Sezawa Wave Storage Correlators and Convolvers," Internal Memorandum (May 1981).	N00014-76-C-0129
3261	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 28th Monthly Report for the period 1 April to 1 May 1981 (May 1981).	EPRI RP1395-3
3262	M.R. Beasley and C.J. Kircher, "Josephson Junction Electronics: Materials Issues and Fabrication Techniques," Preprint (May 1981). Also: Published in Superconductor Materials Science, eds. Simon Foner and Brian B. Schwartz (Plenum Publishing Corporation, 1981).	N00014-75-C-0632
3263	W.A. Harrison, "New Tight-Binding Parameters for Covalent Solids Obtained using Louie Peripheral States," Preprint (May 1981). Also: Published in Physical Review B, 24, No. 10, 5835-5843 (15 November 1981).	NSF DMR80-22365
3264	Staff, "Film Synthesis and New Superconductors," Interim Technical Report for the period 1 October 1980 to 31 March 1981 (May 1981).	F49620-78-C-0009

G.L. No.	Title	Contract/Grant
3265	J. Kwo, T.P. Orlando, and M.R. Beasley "The Microscopic Superconducting Parameters of Nb_3Al: How Important is the Band Density of States?", Preprint (June 1981). Also: Published in Physical Review B, 24, No. 5, 2506-2514 (1 September 1981).	DOE DE-AT03-76ER71043 and F49620-78-C-0009
3266	Staff, "Laser Physics and Laser Techniques," Interim Scientific Report for the period 1 January 1980 to 31 January 1981.	AFOSR-80-0145
3267	T.P. Orlando and M.R. Beasley, "Pauli Limiting and Possibility of Spin Fluctuations in the A15 Superconductors," Preprint (June 1981). Also: Published in Physical Review Letters, 46, No. 24, 1598-1601 (15 June 1981).	DOE DE-AT03-76ER71043
3268	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 29th Monthly Report for the period 1 May to 1 June 1981 (June 1981).	EPRI RP1395-3
3269	G.A. Pavlath and H.J. Shaw, "Birefringence and Polarization Effects in Fiber Gyroscopes," Preprint (June 1981). Also: Published in Applied Optics, 21, No. 10, 1752-1757 (15 May 1982).	F49620-80-C-0040
3270	J.E. Bowers and G.S. Kino, "Adaptive Noise Cancellation with a SAW Storage Correlator," Preprint (June 1981). Also: Published in Electronics Letters, 17, No. 13, 460-461 (25 June 1981).	N00014-76-C-0129

G.L. No.	Title	Contract/Grant
3271	W.L. Carter, S.J. Poon, G.W. Hull, Jr., and T.H. Geballe, "Enhanced Critical Field Curves of Metastable Superconductors," Preprint (June 1981). Also: Published in Solid State Communications, 39, 41-45 (1981).	F49620-78-C-0009
3272	R. King, G. Herrmann, and G. Kino, "Acoustic Nondestructive Evaluation of Energy Release Rates in Plane Cracked Solids," Preprint (June 1981).	EPRI RP609-1 and NSF-MRL (CMR)
3273	J.J.W. Tien, B.T. Khuri-Yakub, G.S. Kino, A.G. Evans, and D. Marshall, "Surface Acoustic Wave Measurements of Surface Cracks in Ceramics," Preprint (June 1981).	N00014-78-C-0283
3274	B.T. Khuri-Yakub, C.H. Chou, K. Liang, and G.S. Kino, "NDE for Bulk Defects in Ceramics," Preprint (June 1981).	F49620-79-C-0217
3275	S.D. Bennett, D. Husson, and G.S. Kino, "Focused Acoustic Beams for Accurate Phase Measurements," Preprint (June 1981). Also: Published in Acoustical Imaging, Vol. 11, pp. 583-596 (1982).	EPRI RP609-1 and F49620-79-C-0217
3276	N. Grayeli, F. Stanke, G.S. Kino, and J.C. Shyne, "Effect of Grain Size and Preferred Crystal Texture on Acoustic Properties of 304 Stainless Steel," Preprint (June 1981).	F49620-79-C-0217
3277	S. Bennett, D.K. Peterson, D. Corl, and G.S. Kino, "A Real-time Synthetic Aperture Digital Acoustic Imaging System," Preprint (June 1981). Also: Published in Acoustical Imaging, Vol. 10, pp. 669-692.	F49620-79-C-0217
3278	G.S. Kino, "Fundamentals of Scanning Systems," Preprint (June 1981).	F49620-79-C-0217

G.L. No.	Title	Contract/Grant
3279	R.B. van Dover, A. de Lozanne, and M.R. Beasley, "S-N-S Microbridges: Fabrication, Electrical Behavior and Modeling," Preprint (June 1981). Also: Published in Journal of Applied Physics, 52, No. 12, 7327-7343 (December 1981).	N00014-75-C-0632
3280	W.P. Lowe, T.W. Barbee, Jr., T.H. Geballe, and D.B. McWhan, "X-Ray Scattering from Multilayers of NbCu," Preprint (June 1981). Also: Published in Physical Review B, 24, No. 9, 5063-5070 (15 November 1981).	F49620-78-C-0009
3281	R.D. Feldman, "Growth of A15 Nb-Si by Epitaxy and Composition Grading," Preprint (June 1981). Also Published in Thin Solid Films, 87 243-258 (1982).	F49620-78-C-0009
3282	K.E. Kihlstrom and T.H. Geballe, "Tunneling $\alpha^2F(\omega)$ as a Function of Composition in A15 NbGe," Preprint (June 1981). Also: Published in Physical Review B, 24, No. 7, 4101-4104 (1 October 1981).	F49620-78-C-0009
3283	K. Liang, B.T. Khuri-Yakub, C.H. Chou, G.S. Kino, K. Peterson, and S. Bennett, "A 50 MHz Synthetic Focus System," Preprint (June 1981).	F49620-79-C-0217 and Ames SC-81-009
3284	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 54th Monthly Report for the period 1 April to 31 May 1981 (June 1981).	EPRI RP609-1
3285	Robert L. Thornton, "Schottky Barrier Elevation by Ion Implantation and Implant Segregation," Preprint (June 1981). Also: Published in Electronics Letters, 17, No. 14, 485-486 (9 July 1981).	N00014-76-C-0129

G.L. No.	Title	Contract/Grant
3286	A.J. Taylor, K.M. Jones, and A.L. Schawlow, "A Study of Excited $^1\Sigma_g^+$ States in Na_2," Preprint (July 1981). Also: Published in Optics Communications, 39. No. 1,2, 47-50 (15 September 1981).	NSF PHY80-10689
3287	H.-R. Xia, G.-Y. Yan, and A.L. Schawlow, "Two-Photon Line Shapes with Near-Resonant Enhancement," Preprint (June 1981). Also: Published in Optics Communications, 39, No. 3, 153-158 (1 October 1981).	NSF PHY80-10689
3288	Ph. Dabiewicz and T.W. Hänsch. "Polarization Intermodulated Excitation (POLINEX) Spectroscopy of the CuI 578.2 nm Transition," Preprint (June 1981). Also: Published in Optics Communications, 38, No. 5,6, 351-356 (1 September 1981).	NSF PHY80-10689
3289	S.E. Harris, R.W. Falcone, M. Gross, R. Normandin, K.D. Pedrotti, J.E. Rothenberg, J.C. Wang, J.R. Willison, and J.F. Young, "Anti-Stokes Scattering as an XUV Radiation Source," Preprint (July 1981).	N00014-78-C-0403, F49620-80-C-0023, NASA NAG 2-44
3290	R.A. Bergh, H.C. Lefevre, and H.J. Shaw, All-Single-Mode Fiber-Optic Gyroscope with Long Term Stability," Preprint (July 1981). Also: Published in Optics Letters, 6, No. 10, 502-504 (October 1981).	Atlantic Richfield Co.
3291	B.A. Auld, S. Ayter, M. Tan, and D. Hauden, "Filter Detection of Phase-Modulated Laser Probe Signals," Preprint (July 1981). Also: Published in Electronics Letters, 17, No. 18, 661-662 (3 September 1981).	N00014-79-C-0222 and N00014-75-C-0632

G.L. No.	Title	Contract/Grant
3292	Staff, "Research Studies on Radiative Collisional Processes," Semi-Annual Report for the period 2 January to 30 June 1981 (July 1981).	F49620-80-C-0023
3293	B. Burgoyne, J. Pavkovich, and G.S. Kino "Digital Filtering of Acoustic Images," Preprint (August 1981).	---------
3294	M.R. Beasley, "New Perspectives on the Physics of High-Field Superconductors," Preprint (July 1981). To be published Advances in Cryogenic Engineering (Materials), Vol. 28, 345-360.	DOE DE-AT03-76ER71043
3295	Staff, "Acoustic Microscopy for Nondestructive Evaluation of Materials," Annual Report for the period 1 July 1980 to 30 June 1981 (July 1981).	F49620-78-C-0098
3296	J.-M. Heritier, J.E. Fouquet, and A.E. Siegman, "Photoacoustic Cell Using Elliptical Focusing," Preprint (September 1981). Also: Published in Applied Optics, 21, No. 1, 90-93 (January 1982).	AFOSR-80-0145 and NASA NAG 2-44
3297	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 30th Monthly Report for the period 1 June to 1 July 1981 (July 1981).	EPRI RP1395-3
3298	Staff, "Laser Physics and Laser Spectroscopy," Final Technical Report for the period 15 February 1980 to 14 February 1981 (July 1981).	AFOSR-80-0144
3299	Walter A. Harrison, "Electronic Structure and Properties of Nonmetals under Pressure," Preprint (August 1981). Also: Published in Physics of Solids Under Pressure (North-Holland Publishing Co., 1981), pp. 57-65.	NSF DMR80-22365

G.L. No.	Title	Contract/Grant
3300	S. Doniach and C. Sommers, "The Use of Local Density Functional Theory for Spin Polarized Relativistic Band Structure Calculations," Reprint from Valence Fluctuations in Solids, (1981).	--------
3301	M. Chodorow, "Nonlinear Generation of Sound in the Scanning Acoutic Microscope," Final Report for the period 15 July 1977 to 28 February 1981.	NSF ENG77-01119
3302	J.E. Heiserman, "Cryogenic Acoustic Microscopy: The Search for Ultrahigh Resolution Using Cryogenic Liquids," Preprint (August 1981). Also: Published in Physica, 109 & 110B (1982), pp. 1978-1989.	N00014-77-C-0412
3303	H. Vanherzeele, J.L. Van Eck, and A.E. Siegman, "Mode-Locked Laser Oscillation Using Self-Pumped Phase Conjugate Reflection," Preprint (September 1981). Also: Published in Optics Letters, 6, No. 10, 467-469 (October 1981).	AFOSR-80-0145
3304	Staff, "Acoustically Scanned Optical Imaging Devices," Semiannual Report No. 12, for the period 1 January to 30 June 1981 (August 1981).	N00014-76-C-0129
3305	H. Vanherzeele, J.L. Van Eck, and A.E. Siegman, "Colliding Pulse Mode-Locking of a Nd:YAG Laser with an Antiresonant Ring Structure," Preprint (September 1981). Also: Published in Applied Optics, 20, No. 20, 3484-3486 (15 October 1981).	AFOSR-80-0145
3306	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 55th Report for the period 1 June to 31 July 1981 (August 1981).	EPRI RP609-1

G.L. No.	Title	Contract/Grant
3307	A. Arbel and J. Bowers, "Active Matching Circuits for SAW Devices," Preprint (August 1981).	DE-AM03-76SF00326 and N00014-76-C-0129
3308	M.R. Beasley, T.H. Geballe, and H.A. Schwettman, "To Study the RF Properties of Superconducting A15 Compounds," Final Technical Report (July 1981).	N00019-79-C-0618
3309	B.A. Auld and M.M. Fejer, "Elastic Non-linearity and Domain Wall motion in Ferroelastic Crystals," Preprint (August 1981).	N00014-75-C-0632
3310	B.A. Auld and H.A. Kunkel, "Laser Probe Measurements of Material Properties and Elastic Vibration Distributions in Counterpoled Ceramics," Preprint (September 1981). Also: Published in Ferroelectrics, 38, 971-974 (1981).	N00014-79-C-0222
3311	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 31st Monthly Report for the period 1 July to 1 August 1981 (August 1981).	EPRI RP1395-3
3312	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 32nd Monthly Report for the period 1 August to 1 September 1981 (September 1981).	EPRI RP1395-3
3313	Staff, "Studies on Lasers and Laser Devices," Semiannual Status Report for the period 1 April to 30 September 1981 (September 1981).	NASA NAG 2-44
3314	Staff, "Elastic Domain Wall Waves in Ferroelectric Ceramics and Single Crystals," Annual Progress Report for the period 1 February 1980 to 31 January 1981 (September 1981).	N00014-79-C-0222
3315	Staff, "Annual Progress Report and Report of Significant Accomplishments," for the period 1 April 1980 through 31 March 1981.	N00014-75-C-0632

G.L. No.	Title	Contract/Grant
3316	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," Annual Report (September 1981).	EPRI RP609-1
3317	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," Summary Report for the period 1 October 1980 to 1 October 1981), (October 1981).	EPRI RP1395-3
3318	S.D. Bennett, "Approximate Materials Characterization by Coherent Acoustic Microscopy," Preprint (September 1981).	F49620-79-C-0217
3319	M. Digonnet and H.J. Shaw, "Analysis of a Tunable Single Mode Optical Fiber Coupler," Preprint (September 1981). Also: Published in IEEE Journal of Quantum Electronics, QE-18, No. 4, 746-754 (April 1982).	Atlantic Richfield Co.
3320	Staff, "Elastic Domain Wall Waves in Ferroelectric Ceramics and Single Crystals," End of Year Letter (October 1981).	N00014-79-C-0222
3321	J. Heiserman, "Thermal Grounding of a Transmission Line in a Dilution Refrigerator," Preprint (September 1981). Also: Published in Cryogenics, 243-244 (May 1982).	N00014-77-C-0412
3322	B.A. Auld and D.K. Winslow, "Microwave Eddy-Current Experiments with Ferro-magnetic Resonance Probes," Reprint from Journal of Special Technical Publication, Vol. 733, American Society for Testing and Materials, 332-347 (1981).	-------
3323	R.L. Byer and M. Endemann, "Remote Measurements of Trace Species in the Troposphere," Prepint (September 1981). Also: Published in AIAA Journal, 20, No. 3, 395-403 (March 1982).	DAAG29-77-G-0181

G.L. No.	Title	Contract/Grant
3324	D.A. Brown and S. Doniach, "Vortex Pinning and the Decay of Persistent Currents in Unsaturated Superfluid Helium Films," Preprint (September 1981). Also: Published in Physical Review B, 24, No. 1, 136-150 (January 1982).	NSF DMR80-07934
3325	J.M. Eggleston, G. Giuliani, and R.L. Byer, "Radial Intensity Filters Using Radial Birefringent Elements," Preprint (September 1981). Also: Published in Journal of the Optical Society of America, 71, No. 10, 1264-1272 (October 1981).	AFOSR-80-0144
3326	S. Doniach, "Quantum Fluctuations in Two-Dimensional Superconductors," Preprint (August 1981). Also: Published in Physical Review B, 24, No. 9, 5063-5070 (1 November 1981).	NSF DMR80-07934
3327	S. Froyen and C. Herring, "Distribution of Interatomic Spacings in Random Alloys," Reprint from Journal of Applied Physics, 52, No. 12, 7165-7173 (December 1981).	NSF DMR77-21384
3328	R.W. Falcone and K.D. Pedrotti, "Pulsed Hollow Cathode Discharge for XUV Lasers and Radiation Sources," Preprint (September 1981). Also: Published in Optics Letters, 7, No. 2, 74-76 (February 1982).	N00014-78-C-0403
3329	Staff, "Film Synthesis and New Superconductors," Interim Technical Report for the period 1 April to 30 September 1981 (October 1981).	F49620-78-C-0009
3330	M.D. Wright, "Laser Induced Charge Transfer Collisions," Internal Memorandum (September 1981).	F49620-80-C-0023

G.L. No.	Title	Contract/Grant
3331	Staff, "Tunable Optical Sources," Progress Report for the period 2 February to 30 June 1981 (September 1981).	DAAG29-81-K-0038
3332	L.-S. Lee and A.L. Schawlow, "A Multiple-Wedge Wavemeter for Pulsed Lasers," Preprint (October 1981). Also: Published in Optics Letters, 6, No. 12, 610-612 (December 1981).	NSF PHY78-23532
3333	Staff, "To Study the RF Properties of Superconducting A15 Compounds," Quarterly Progress Report for the period April to June 1981 (September 1981).	N00019-81-C-0131
3334	W.A. Harrison and J.M. Wills, "Interionic Interactions in Simple Metals," Preprint (October 1981). Also: Published in Physical Review B, 25, No. 8, 5007-5017 (15 April 1982).	NSF DMR80-22365
3335	J.R. Willison, R.W. Falcone, J.F. Young, and S.E. Harris, "Laser Spectroscopy of Metastable XUV Levels in Lithium Atoms and ions," Preprint (October 1981). Also: Published in Physical Review Letters, 47, No. 25, 1827-1829 (21 December 1981).	N00014-78-C-0403
3336	Staff, "Acoustic Microscopy at Cryogenic Temperatures," Status Report for the period 1 January to 1 July 1981 (September 1981).	N00014-77-C-0412
3337	A.F. Arbel and J.E. Bowers, "Active Matching of Interdigital Transducers," Preprint (October 1981). Also: Published in the 1981 Ultrasonics Symposium Proceedings, pp. 69-73.	N00014-76-C-0129

G.L. No.	Title	Contract/Grant
3338	R. Trebino, J.P. Roller, and A.E. Siegman, "A Comparison of the Casegrain and Other Beam Expanders in High-Power Pulsed Dye Lasers," Preprint (October 1981). Also; Published in IEEE Journal of Quantum Electronics, QE-18, No. 8, 1208-1213 (August 1982).	AFOSR-80-0145 and N00014-75-C-0632
3339	Staff, "Quantiative Modeling of Flaw Responses in Eddy Current Testing," 33rd Monthly Report for the period 1 September to 1 October 1981 (October 1981).	EPRI RP1395-3
3340	Staff, "PVF_2 Transducers for Non-destructive Evaluation of Ceramics and Brittle Materials," Final Report (October 1981).	AFOSR-77-3386
3341	Staff, "New Approach to Optical Systems for Inertial Rotation Sensing," Interim Scientific Report (December 1981).	F49620-80-C-0040
3342	H.A. Kunkel and B.A. Auld, "Laser Probe Investigation of Guided Acoustic Interface Waves in Differentially Poled Ceramics," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 438-443.	N00014-79-C-0222
3343	S.D. Bennett, D. Husson, and G.S. Kino, "Measurement of Three-Dimensional Stress Variation," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 964-968.	EPRI RP609-1

G.L. No.	Title	Contract/Grant
3344	A.R. Selfridge, R. Baer, B.T. Khuri-Yakub, and G.S. Kino, "Computer-Optimized Design of Quarter-Wave Acoustic Matching and Electrical Matching Networks for Acoustic Transducers," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 644-648.	NSF ECS-7728528, DOE DE-AM03-76SF00326 (DE-AT03-76ER71043)
3345	D.V. Nelson and B.A. Auld, "Crack Opening Displacement as a Fracture Mechanics Parameter in Eddy Current NDE," Preprint (October 1981). Presented at the Review of Progress in Quantitative NDE at Boulder, CO.	Ames SC-81-011 and NSF DMR77-24222 (Stanford Materials Lab.)
3346	J.J. Tien, K. Liang, B.T. Khuri-Yakub, G.S. Kino, D. Marshall, and A.G. Evans, "Long Wavelength Measurement of Surface Cracks in Silicon Nitride," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 844-848.	N00014-78-C-0283
3347	K. Liang, B.T. Khuri-Yakub, and G.S. Kino, "Reflection Tomography at 50 and 300 MHz," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 925-929.	Ames SC-81-009 and F49620-79-C-0217
3348	D.K. Peterson, S.D. Bennett, and G.S. Kino, "Real-Time Digital Imaging," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 919-924.	F49620-79-C-0217

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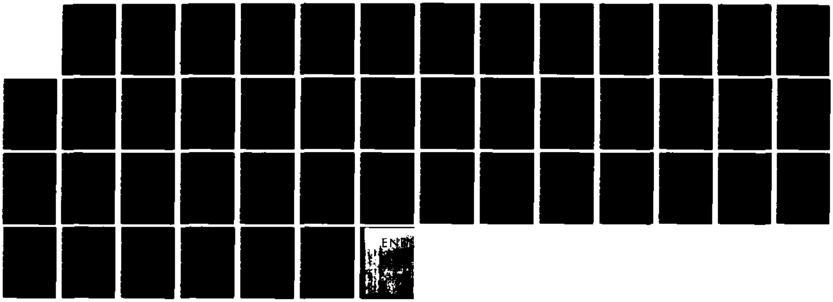

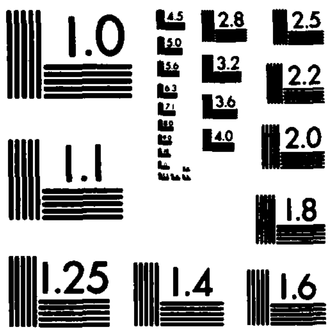

MICROCOPY RESOLUTION TEST CHART
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G.L. No.	Title	Contract/Grant
3349	R.L. Baer, A.R. Selfridge, B.T. Khuri-Yakub, G.S. Kino, and J. Souquet, "Contacting Transducers and Transducer Arrays for NDE," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 969-973.	F49620-79-C-0217 and DE-AT03-76ER71043
3350	R.L. Thornton, J.E. Bowers, and J.B. Green, "Recent Developments in the ZnO on Si Storage Correlator," Preprint (October 1981). Also: Published in 1981 Ultrasonics Symposium Proceedings, pp. 774-779.	N00014-76-C-0129
3351	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 55th Report for the period 1 August to 30 September 1981 (October 1981).	EPRI RP609-1
3352	S. Ayter, B.A. Auld, and M. Tan, "Optical Probing of Resonant Ultrasonic Scattering from Machined Flaws in Plates," Preprint (October 1981).	Ames SC-81-011 and NSF ENG79-14623
3353	B.A. Auld, F. Muennemann, M. Riaziat, and D.K. Winslow, "Analytical Methods in Eddy Current NDE," Preprint (October 1981).	Ames SC-81-011, EPRI RP1395-3, NSF DMR77-24222, and B-96062-B-K.
3354	R.L. Jungerman, J.E. Bowers, J.B. Green, and G.S. Kino, "Fiber Optic Laser Probe for Acoustic Wave Measurements," Preprint (November 1981). Also: Published in Applied Physics Letters, 40, No. 4, 313-315 (15 February 1982).	F49620-79-C-0217
3355	Staff, "Piezoelectric PVF_2 Polymer Films and Devices," Final Report (November 1981).	N00014-77-C-0582

G.L. No.	Title	Contract/Grant
3356	A.L. Schawlow, "Simplifying Spectra by Laser Level Labeling," Preprint (November 1981). Also: Published in Physica Scripta, 25, 333-337 (1982).	NSF PHY80-10689 and N00014-78-C-0403
3357	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 34th Monthly Report for the period 1 October to 1 November 1981 (November 1981).	EPRI RP1395-3
3358	G.P. Morgan, H.-R. Xia, and A.L. Schawlow, "Spectral Structure of CW Two-Photon Transitions in Na_2," Preprint (November 1981). Also: Published in the Journal of the Optical Society of America, 72, No. 3, 315-320 (March 1982).	NSF PHY80-10689 and N00014-78-C-0403
3359	A.E. Siegman, "Developments in Mode-Locked Lasers and their Applications," Preprint (December 1981). Also: Published in SPIE, 322, pp. 60-67 (1982).	AFOSR-80-0145 and NASA NAG 2-44
3360	J.J. Tien, B.T. Khuri-Yakub, G.S. Kino, A.G. Evans, and D. Marshall, "Long Wavelength Measurements of Surface Cracks in Silicon Nitride," Preprint (December 1981). To be published in Review of Progress in Quantitative Nondestructive Evaluation, Vol. 1, pp. 577-580.	N00014-78-C-0283
3361	D.K. Peterson, R. Baer, K. Liang, S.D. Bennett, B.T. Khuri-Yakub, and G.S. Kino, "Quantitative Evaluation of Real-Time Synthetic Aperture Acoustic Images," Preprint (December 1981). To be published in Review of Progress in Quantitative Nondestructive Evaluation, Volume 1, pp. 777-786.	F49620-79-C-0217

G.L. No.	Title	Contract/Grant
3362	B.T. Khuri-Yakub, G.S. Kino, K. Liang, J. Tien, C.H. Chou, A.G. Evans, and D. Marshall, "Nondestructive Evaluation of Ceramics," Preprint (December 1981).	Ames SC-81-009 and N00014-78-C-0283
3363	Staff, "Research on Nondestructive Testing," Year End Report for the period 1 September 1980 through 31 August 1981 (November 1981).	F49620-79-C-0217
3364	R.L. Byer, "Nd:YAG Pumped Tunable Sources and Applications," Internal Memorandum (November 1981).	--------
3365	Staff, "Acoustic Microscopy for Nondestructive Evaluation of Materials," Final Technical Report for the period 1 July 1978 through 31 December 1981 (December 1981).	F49620-78-C-0098
3366	S.A. Newton, J.E. Bowers, and H.J. Shaw, "Single Mode Fiber Recirculating Delay Line," Preprint (December 1981). Also: Published in SPIE, 326, pp. 108-115 (1982).	F49620-80-C-0040
3367	R.A. Bergh, M.J.F. Digonnet, H.C. Lefevre, S.A. Newton, and H.J. Shaw, "Single Mode Fiber Optic Components," Preprint (December 1981). Also: Published in SPIE, 326, pp 137-142 (1982).	N00014-75-C-0632 and Atlantic Richfield Co.
3368	Staff, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," 35th Monthly Report for the period 1 November to 1 December 1981 (December 1981).	EPRI RP1395-3
3369	Staff, "Acoustic Microscopy at Cryogenic Temperature," Annual Summary Report for the period 1 July 1980 through 30 June 1981 (November 1981).	N00014-77-C-0412

G.L. No.	Title	Contract/Grant
3370	D. Rugar, "Cryogenic Acoustic Microscopy," Internal Memorandum (December 1981).	N00014-77-C-0412
3371	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 57th Report for the period 1 October to 30 November 1981 (December 1981).	EPRI RP609-1
3372	H. Gerhardt and T.W. Hänsch, "Color Center Laser and Electron Impact Excitation: Doppler-Free Spectroscopy in Excited Helium States," Preprint (December 1981). Also: Published in Optics Communications, 41, No. 1, 17-20 (1 March 1982).	NSF PHY80-10689 and N00014-78-C-0403
3373	D.K. Peterson, S.D. Bennett, and G.S. Kino, "Real-Time NDE of Flaws Using a Digital Acoustic Imaging System," Preprint (January 1982).	F49620-79-C-0217
3374	D.C. Wolfe, Jr. and R.L. Byer, "Model Studies of Laser Absorption Computed Tomography for Remote Air Pollution Measurement," Preprint (December 1981). Also: Published in Applied Optics, 12, No. 7, 1165-1178 (1 April 1982).	NASA NSG 2289 and F49620-77-C-0092
3375	Staff, "Research to Define Algorithms Appropriate to a High Data Rate Laser Wavelength Measurement Instrument," Final Report (December 1981).	LLL 3488009
3376	B.A. Auld and M. Riaziat, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," Final Report December 1981).	EPRI RP 1395-3
3377	Staff, "Acoustically Scanned Optical Imaging Devices," Management Report for the period 1 October to 31 December 1981 (January 1982).	N00014-76-C-0129
3378	Staff, "Acoustically Scanning of Optical Images," Semiannual Technical Report No. 13 for the period 1 July through 31 December 1981 (January 1982).	N00014-76-C-0129

G.L. No.	Title	Contract/Grant
3379	Staff, Research Studies on Radiative Collisional Processes," Annual Technical Report for the period 1 October 1980 through 30 September 1981 (January 1982).	F49620-80-C-0023
3380	Staff, "Reseach Studies on Radiative Collisional Processes," Semiannual Progress Report for the period 1 July through 31 December 1981 (January 1982).	F49620-80-C-0023
3381	Staff, "Elastic Domain Wall Waves in Ferroelectric Ceramics and Single Crystals," Annual Progress Report for the period 1 February 1981 to 31 January 1982 (January 1982).	N00014-79-C-0222
3382	J.E. Bowers, S.A. Newton, W.V. Sorin, and H.J. Shaw, "Filter Response of Single Mode Fiber Recirculating Delay Lines," Preprint (January 1982). Also: Published in Electronics Letters, 18, No. 3, 110-111 (4 February 1982).	ARCO Ventures
3383	Staff, "Tunable Optical Sources," Progress Report for the period 30 June through 31 December 1981 (January 1982).	DAAG29-81-K-0038
3384	D. Husson and G.S. Kino, "A Perturbation Theory for Acoustoelastic Effects," Preprint (March 1982). Also: Published in Journal of Applied Physics 53, No. 11, 7250-7258 (1 August 1982).	EPRI RP609-1
3385	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 58th Report for the period 1 December 1981 through 31 January 1982 (February 1982).	EPRI RP609-1

G.L. No.	Title	Contract/Grant
3386	J.E. Bowers, "All-Fiber Sensor for Surface Acoustic Waves," Preprint (March 1982). Also: Published in Applied Physics Letters, 41, No. 3, 231-233 (1 August 1982).	ARCO Ventures
3387	J.F. Young, S.E. Harris, P.J.K. Wisoff, and A.J. Mendelsohn, "Microwave Excitation of Excimer Lasers," Preprint (February 1982). Also; Published in Laser Focus, 63-67 (April 1982).	F49620-80-C-0023
3388	Staff, "Acoustic Microscopy at Cryogenic Tempeatures," Status Report for the period 1 July 1981 to 1 January 1982 (January 1982).	N00014-77-C-0412
3389	B.A. Auld, A. Renard, and J. Henaff, "STW Resonances on Corrugated Plates of Finite Thickness," Preprint (January 1982). Also: Published in Electronics Letters, 18, No. 3, 183-184 (18 February 1982).	---------
3390	Staff, "Film Synthesis and New Superconductors," Interim Technical Report for the period 1 October 1981 through March 1982 (March 1982).	F49620-78-C-0009
3391	P.M. Fauchet and A.E. Siegman, "Surface Ripples on Silicon and Gallium Arsenide Under Picosecond Laser Illumination," Preprint (February 1982). Also: Published in Applied Physics Letters, 40, No. 9, 824-826 (1 May 1982).	AFOSR-80-0145

G.L. No.	Title	Contract/Grant
3392	J.A. Hildebrand, D. Rugar, and C.F. Quate, "Biological Acoustic Microscopy Living Cells at 37°C and Fixed Cells in Cryogenic Liquids," Preprint (March 1982). To appear in the EMSA Also: Published in 40th Annual Proceedings Electron Microscopy Society of America pp. 174-177 (1982).	NIH 5 R01 GM-25826-04
3393	M.J.F. Digonnet and H.J. Shaw, "Single Mode Fiber Optic Wavelength Multiplexer," Preprint (February 1982). To be presented at the 1982 Topical Meeting on Optical Fiber Communication at Phoenix, Arizona, April 12-14, 1982.	ARCO Ventures
3394	M.R. Beasley, "Small-Scale Superconductive Devices M320/0968," Preprint (February 1982). Submitted to the Encyclopaedia of Material Science and Engineering.	-----
3395	G.A. Pavlath and H.J. Shaw, "Re-Entrant Fiber Optic Rotation Sensors," Preprint (February 1982). Presented at the International Conference on Fiber-optic Rotation Sensors, held in November 1981 at MIT.	F49620-80-C-0040
3396	R.D. Feldman and B.E. Jacobson, "Growth Morphology of Superconducting Nb-Si: The Effects of Oxygen and Substrate Temperature," Preprint (February 1982). Also: Published in Journal of Low Temperature Physics, 48, Nos. 5/6, 477-494 (1982).	F49620-78-C-0009
3397	W.A. Harrison, "Theoretical Alchemy, Fresh Insight into Chemical Bonding can be Obtained by Conceptually Transmuting One Nucleus into Another," Preprint (February 1982). Submitted to the American Journal of Physics.	NSF DMR77-22365

G.L. No.	Title	Contract/Grant
3398	H.J. Arditty and H.C. Lefevre, "Theoretical Basis of Sagnac Effect in Fiber Gyroscopes," Preprint (February 1982). Presented at the International Conference on Fiber-optics Rotation Sensors held in November 1981 at MIT.	ARCO Ventures
3399	L.A. Bloomfield, B. Couillaud, Ph. Dabkiewicz, H. Gerhardt, and T.W. Hansch, "Hyperfine Structure of the $2^3S - S^3P$ Transition in ^3He by High Resolution UV-Laser Spectroscopy," Preprint (March 1982). Also: Published in Physical Review A, 26, No. 1, 713-716 (July 1982).	NSF PHY80-10689 and N00014-78-C-0403
3400	R.A. Bergh, H.C. Lefevre, and H.J. Shaw, "Compensation of the Optical Kerr Effect in Fiber Optic Gyroscopes," Preprint (March 1982). Also: Published in Optics Letters, 7, No. 6, 282-284 (June 1982).	ARCO Ventures
3401	T.H. Geballe, "This Golden Age of Solid State Physics," Preprint (March 1982). Submitted for inclusion in the 50th Anniversary Issue of Physics Today.	-----
3402	J.B. Green and G.S. Kino, "SAW Convolvers Using Focused Interdigital Transducers," Preprint (March 1982). Submitted to IEEE Transactions on Sonics and Ultrasonics.	N00014-75-C-0632
3403	Staff, "Probe-Flaw Interactions and Inversion Processes," Interim Report for the period 1 October 1981 through 31 March 1982 (March 1982).	Ames SC-81-011

G.L. No.	Title	Contract/Grant
3404	S.E. Harris, J.F. Young, R.W. Falcone Joshua E. Rothenberg, J.R. Willison, and J.C. Wang, "Anti-Stokes Scattering as an XUV Radiation Source and Flashlamp," Preprint (April 1982). Presented at the OSA Topical Meeting on Laser Techniques for XUV Spectroscopy, Boulder, CO, 1982.	N00014-78-C-0403 and F49620-80-C-0023
3405	R.W. Falcone, D.E. Holgrem, and K.D. Pedrotti, "Hollow-Cathode Discharge for XUV Lasers and Radiation Sources," Preprint (April 1982). Presented at the OSA Topical Meeting on Laser Techniques for XUV Spectroscopy, Boulder, CO, 1982.	N00014-78-C-0403
3406	Staff, "Measurement of Surface Defects in Ceramics," End-of-Year Report for 1981 (April 1982).	N00014-78-C-0283
3407	Staff, "Reciprocity Relation Approach to Scattering from Rough Surfaces and Cracks," Interim Report for the period 1 October 1981 - 31 March 1982 (April 1982).	Ames SC-81-011
3408	T. Garel and S. Doniach, "Phase Transitions with Spontaneous Modulation—the Dipolar Ising Ferromagnet," Reprint from Physical Review B, 26, No. 1, 325 (1 July 1982).	NSF DMR 80-07934 and NIH 5 R01 GM2517
3409	L.F. Stokes, M. Chodorow, and H.J. Shaw, "An All Single Mode Fiber Resonator," Preprint (April 1982). Also: Published in Optics Letters, 7, No. 6, 288 (June 1982).	ARCO Ventures
3410	S.-J. Oh and S. Doniach, "Line Shapes in Resonant Photoemission Spectra," Reprint from Physical Review B, 26, No. 4, 1859 (15 August 1982).	NSF DMR 79-13102

G.L. No.	Title	Contract/Grant
3411	Staff, "Annual Progress Report and Report of Significant Accomplishments," for the period 1 April 1981 through 31 March 1982 (April 1982).	N00014-75-C-0632
3412	C.H. Chou, B.T. Khuri-Yakub, and G.S. Kino, "Exact and Ray Tracing Theories for Scattering of Acoustic Waves from a Void in a Solid," Preprint (April 1982).	Ames SC-81-009
3413	Staff, "Nondestructive Evaluation of Structural Ceramics," Six-Month Progress Report for the period October 1981 - March 1982 (May 1982).	Ames SC-81-009
3414	Staff, "Studies on Lasers and Laser Devices," Semiannual Status Report for the period 1 October 1981 - 31 March 1982 (April 1982).	NASA NAG 2-44
3415	S.E. Harris, R.W. Falcone, and D.M. O'Brien, "Proposal for High Power Radiative Collisional Lasers," Preprint (April 1982). Also: Published in Optics Letters, 7, No. 9, 397 (September 1982).	F49620-80-C-0023
3416	W.A. Harrison, "Total Energies in Transition Metals," Preprint (April 1982). To appear in the Proceedings of the 12th International Symposium on the Electronic Structure of Metals and Alloys, Gaussig, Germany.	NSF DMR 77-21384
3417	S.C. Rand, L.-S. Lee, and A.L. Schawlow, "Ultraviolet Sum-Frequency Generation Utilizing Optical Pair Interactions in Solids," Preprint (April 1982). Also: Published in Optics Communications, 42, No. 3, 179 (1982).	N00014-78-C-0403
3418	Staff, "Acoustical Scanning of Optical Images," Management Report for the period 1 January - 31 March 1982 (April 1982).	N00014-76-C-0129

G.L. No.	Title	Contract/Grant
3419	D. Husson, S.D. Bennett, and G.S. Kino, "Remote Temperature Measurement Using an Acoustic Probe," Preprint (June 1982). Also: Published in Applied Physics Letters, 41, No. 10, 915 (15 November 1982).	F49620-79-C-0217
3420	J.E. Bowers, R.L. Thornton, B.T. Khuri-Yakub, R.L. Jungerman, and G.S. Kino, "The Effect of Nonuniform Piezoelectric Films on Monolithic SAW Devices," Preprint (June 1982). Also: Published in Applied Physics Letters, 41, No. 9, 805 (1 November 1982).	N00014-76-C-0129
3421	S.-J. Oh and S. Doniach, "Screening Effects in the Core-Level Spectra of Mixed-Valence Compounds," Reprint from Physical Review B, 26, No. 4, 2085 (15 August 1982).	NSF DMR 79-13102
3422	S. Ruggiero, T.W. Barbee, Jr., and M.R. Beasley, "Superconducting Properties of Nb/Ge Metal Semiconductor Multilayers," Preprint (May 1982). Also: Published in Physical Review B, 26, No. 9, 4984 (1 September 1982).	NSF DMR 81-09583
3423	Staff, "Laser Physics and Laser Techniques," Interim Scientific Report for the period 1 January 1981 - 31 January 1982 (May 1982).	AFOSR-80-0145
3424	K.P. Jackson, J.E. Bowers, S.A. Newton, and C.C. Cutler, "Microbend Optical Fiber Tapped Delay Line for Gigahertz Signal Processing," Preprint (May 1982). Also: Published in Applied Physics Letters, 41, No. 2, 139 (15 July 1982).	ARCO Ventures

G.L. No.	Title	Contract/Grant
3425	B. Couillaud, Ph. Dabkiewicz, L.A. Bloomfield, and T.W. Hansch, "Generation of Continuous-Wave Ultraviolet Radiation by Sum-Frequency Mixing in an External Ring Cavity," Reprint from Optics Letters, 7, No. 6, 265 (June 1982).	N00014-78-C-0403
3426	L.A. Bloomfield, H. Gerhardt, T.W. Hansch, and S.C. Rand, "Nonlinear UV-Laser Spectroscopy of the 2^3S-5^3P Transition in ^3He and ^4He," Preprint (May 1982).	NSF PHY 80-10689 and N00014-78-C-0403
	Also: Published in Optics Communication, 42, No. 4, 247 (15 July 1982).	
3427	M.R. Beasley and B.A. Huberman, "Chaos in Josephson Junctions," Preprint (May 1982).	NSF DMR 81-09583
	Also: Published in Comments Solid State Physics, 10, No. 5, 155 (1982).	
3428	M. Endemann and R.L. Byer, "Simultaneous Remote Measurements of Atmospheric Temperature and Humidity Using a Continuously Tunable IR Lidar," Reprint from Applied Optics, 20, No. 18, 3211 (15 September 1981).	DAAG-77-G-0221
3429	D. D'Humieres, M.R. Beasley, B.A. Huberman, and A. Libchaber, "Chaotic States and Routes to Chaos in the Forced Pendulum," Preprint (May 1982).	NSF DMR 81-09583
	Also: Published in Physical Review A, 26, No. 6, 3483 (December 1982).	
3430	S.E. Harris, J.F. Young, R.W. Falcone, Joshua E. Rothenberg, and J.R. Willison, "Laser Techniques for Spectroscopy of Core-Excited Atomic Levels," Preprint (May 1982). To be presented at the CNRS International Colloquium on Atomic and Molecular Physics Near Ionization Thresholds in High Fields, France (June 1982).	N00014-78-C-0403; F49620-80-C-0023; and NASA NAG 2-44

G.L. No.	Title	Contract/Grant
3431	A.L. Schawlow, "Spectroscopy in a New Light," Preprint (June 1982). Also: Published in Science, 217, No. 4554, 9 (2 July 1982).	NSP PHY 80-10689
3432	H.C. Lefevre, R.A. Bergh, and H.J. Shaw, "All-Fiber Gyroscope with Inertial Navigation Short-Term Sensitivity," Preprint (May 1982). Also: Published in Optics Letters, 7, No. 9, 454 (September 1982).	ARCO Ventures
3433	D.R. Lyons, "Doppler-Free Radiofrequency Optogalvanic Spectroscopy Using Polarization Intermodulated Excitation," Internal Memorandum (June 1982).	NSF PHY 80-10689
3434	J.R. Willison, "Spontaneous and Laser-Induced XUV Radiation from Core-Excited Lithium Atoms and Ions," Internal Memorandum (May 1982).	N00014-78-C-0403
3435	Staff, "Acoustic Microscopy at Cryogenic Temperatures," Summary Report for the period July 1977 to June 1982 (June 1982).	N00014-77-C-0412
3436	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 60th Report for the period 1 April - 31 May 1982 (June 1982).	EPRI T107-5-5
3437	R.A. Bergh, B. Culshaw, C.C. Cutler, H.C. Lefevre, and H.J. Shaw, "Source Statistics and the Kerr Effect in Fiber Optic Gyroscopes," Preprint (June 1982). Also: Published in Optics Letters, 7, No. 11, 563 (November 1982).	Litton Systems, Inc.
3438	J.B. Green, G.S. Kino, J.T. Walker, and J.D. Shott, "Novel Programmable High-Speed Analog Transversal Filter," Preprint (June 1982).	N00014-75-C-0632

G.L. No.	Title	Contract/Grant
3439	Zhou Guosheng, P.M. Fauchet, and A.E. Siegman, "Growth of Spontaneous Periodic Surface Structures on Solids During Laser Illumination," Preprint (June 1982). Also: Published in Physical Review B, 26, No. 10, 5366 (15 November 1982).	F49620-82-K-0015
3440	Yao Jian-quan, Zhou Guosheng, and A.E. Siegman, "Large Scale Results for Degenerate Four-Wave Mixing and Phase Conjugate Resonators," Preprint (June 1982). Also: Published in Applied Physics B, 30, 11 (1983).	F49620-82-K-0015
3441	S.A. Trugman and S. Doniach, "Vortex Dynamics in Inhomogeneous Superconducting Films," Reprint from Physical Review B, 26, No. 7, 3682 (1 October 1982).	NSF DMR 80-07934
3442	R.G. Caro, J.C. Wang, R.W. Falcone, J.F. Young, and S.E. Harris, "Soft X-Ray Pumping of Metastable Levels of Li^+," Preprint (July 1982). Also: Published in Applied Physics Letters, 42, No. 1, 9 (1 January 1983).	N00014-78-C-0403
3443	P.J.K. Wisoff, A.J. Mendelsohn, S.E. Harris, and J.F. Young, "Improved Performance of the Microwave-Pumped XeCℓ Laser," Preprint (July 1982). Also: Published in IEEE Journal of Quantum Electronics, QE-18, No. 11. 1839 (November 1982).	F49620-80-C-0023
3444	P.D. Corl, "A Real-Time Synthetic-Aperture Digital Acoustic Imaging System," Internal Memorandum (June 1982).	F49620-79-C-0217

G.L. No.	Title	Contract/Grant
3445	A.J. Taylor, "Two-Step Polarization Labeling Spectroscopy of Excited States of Diatomic Sodium," Internal Memorandum (August 1982).	NSF PHY 80-10689
3446	M. Tur, J.W. Goldman, B. Moslehi, J.E. Bowers, and H.J. Shaw, "Fiber-Optic Signal Processor with Applications to Matrix-Vector Multiplication and Lattice Filtering," Preprint (July 1982). Also: Published in Optics Letters, 7, No. 9, 463 (September 1982).	Litton Systems, Inc.
3447	A.L. Schawlow, "Spectroscopy: Present Achievement and Future Prospects," Reprint from Phil. Trans. R. Soc. Lond., A307, 685 (1982).	NSF PHY 80-10689
3448	Y.L. Sun and R.L. Byer, "A Sub-Megahertz Frequency Stabilized Nd:YAG Oscillator," Preprint (July 1982). Also: Published in Optics Letters, 7, No. 9, 408 (September 1982).	DAAG29-81-K-0038; NASA NAG 1-182; and GM R&D Labs.
3449	E.K. Gustafson, J.C. McDaniel, and R.L. Byer, "High Resolution CW CARS Spectroscopy in a Supersonic Jet," Preprint (July 1982). Also: Published in Optics Letters, 7, No. 9, 434 (September 1982).	NASA NCC 2-50 and NSF ECS 79-12673
3450	J.M. Eggleston, T.J. Kane, J. Unternahrer, and R.L. Byer, "Slab-Geometry Nd:Glass Laser Performance Studies," Reprint from Optics Letters, 7, No. 9, 405 September 1982).	DAAG29-81-K-0038; LLL3818309; and NASA NAG 1-182
3451	S. Doniach, "Synchrotron Radiation: A Tool for Chemistry and Biology," Reprint from Physica Scripta T1, 11 (1982).	N00014-81-K-0469 and NIH 5R01 GM25217

G.L. No.	Title	Contract/Grant
3452	Staff, "Research Studies on Radiative Collisional Processes," Semiannual Progress Report for the period 1 January - 30 June 1982 (July 1982).	F49620-80-C-0023
3453	A. de Lozanne, "High Critical Temperature SNS Josephson Microbridges," Internal Memorandum (June 1982).	N00014-75-C-0632
3454	K. Liang, S.D. Bennett, B.T. Khuri-Yakub, and G.S. Kino, "Precision Measurement of Rayleigh Wave Velocity Perturbation," Preprint (August 1982). Also: Published in Applied Physics Letters, 41, No. 12, 1124 (15 December 1982).	F49620-79-C-0217
3455	R.L. Baer and G.S. Kino, "A Shear Wave Transducer Array for Real-Time Imaging," Preprint (August 1982).	DOE DE-AT03-81ER10865
3456	L.A. Bloomfield, H. Gerhardt, and T.W. Hansch, "Singlet-Triplet Mixing in the 13d-Rydberg State of ^{3}He Observed with Stepwise Laser Excitation," Preprint (August 1982). Also: Published in Physical Review A, 26, No. 6, 3716 (December 1982).	NSF PHY 80-10689 and N00014-78-C-0403
3457	L.F. Stokes, M. Chodorow, and H.J. Shaw, "All-Fiber Stimulated Brillouin Ring Laser with Sub-milliwatt Pump Threshold," Preprint (July 1982). Also: Published in Optics Letters, 7, No. 10, 509 (October 1982).	Litton Systems, Inc.
3458	Staff, "Ultra High Resolution Molecular Beam CARS Spectroscopy with Application to Planetary Atmospheric Molecules," Final Technical Report covering the period 1 January 1980 - 30 June 1982 (July 1982).	NASA NCC 2-50

G.L. No.	Title	Contract/Grant
3459	M. Digonnet and H.J. Shaw, "Wavelength Multiplexing in Single Mode Fiber Couplers," Preprint (August 1982). Also: Published in Applied Optics, 22, No. 3, 484 (1 February 1983).	Litton Systems, Inc.
3460	R.L. Jungerman, J.E. Bowers, B.T. Khuri-Yakub, and G.S. Kino, "Non-contacting Measurement of Surface Acoustic Waves," Preprint (August 1982). Presented at the DARPA/AF Review of Progress in Quantitative NDE.	Ames SC-81-009
3461	G.S. Kino, D. Husson, and S.D. Bennett, "Measurement of Stress," Preprint (August 1982). Presented at the German-American Workshop on Research and Development of New Procedures in NDT.	EPRI T107-5-5 and CMR
3462	B.T. Khuri-Yakub, "Acoustic Characterization of Structural Ceramics," Preprint (August 1982). Presented at the Advances in Materials Characterization Conference.	Ames SC-81-009 and N00014-78-C-0283
3463	C.H. Chou, K. Liang, B.T. Khuri-Yakub, and G.S. Kino, "Bulk Defect Characterization Using Short Wavelength Measurements," Preprint (August 1982). Presented at the German-American Workshop on Research and Development of New Procedures in NDT.	Ames SC-81-009
3464	J.J. Tien, K. Liang, B.T. Khuri-Yakub, G.S. Kino, D.B. Marshall, and A.G. Evans, "Surface Cracks: Size and Failure Prediction Using Long Wavelength Measurements," Preprint (August 1982). Presented at the German-American Workshop on Research and Development of the New Procedures in NDT.	Ames SC-81-009 and N00014-78-C-0283

G.L. No.	Title	Contract/Grant
3465	G.S. Kino, D.K. Peterson, and S.D. Bennett, "Acoustic Imaging," Preprint (August 1982). Presented at the German-American Workshop on Research and Development of New Procedures in NDT.	F49620-79-C-0217
3466	W.A. Harrison, "Pseudopotential Methods in Physics," Progress Report (August 1982).	NSF DMR 80-22365
3467	K.E. Kihlstrom, "Synthesis and Superconducting Properties of Niobium Germanium," Internal Memorandum (August 1982).	F49620-78-C-0009
3468	P. Toledano, M.M. Fejer, and B.A. Auld, "Nonlinear Elasticity in Proper Ferroelastics," Preprint (August 1982). To appear in Physical Review B.	N00014-75-C-0632
3469	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 61st Report covering the period 1 June - 31 July 1982 (August 1982).	EPRI T107-5-5
3470	K. Liang, S.D. Bennett, and G.S. Kino, "Precision Measurement of Rayleigh Wave Velocity Perturbation," Preprint (August 1982). Presented at the DARPA/AF Review of Progress in Quantitative NDE.	F49620-79-C-0217
3471	D.K. Peterson, S.D. Bennett, and G.S. Kino, "Determination of Flaw Depth Profiles from Acoustic Images," Preprint (August 1982). Presented at the DARPA/AF Review of Progress in Quantitative NDE.	F49620-79-C-0217
3472	Staff, "Improved Solid State Laser Sources," Final Technical Report for the period 2 June 1981 through 1 June 1982 (August 1982).	LLL 3818301
3473	Staff, "Acoustical Scanning of Optical Images," Management Report for the period 1 April - 30 June 1982 (August 1982).	N00014-76-C-0129

G.L. No.	Title	Contract/Grant
3474	K.E. Kihlstrom, R.H. Hammond, J. Talvacchio, T.H. Geballe, A.K. Green, and Victor Rehn, "Preparation, Tunneling, Resistivity, and Critical Current Measurements on Homogeneous High-T_c A15 Nb_3Ge Thin Films," Preprint (August 1982). Also: Published in the Journal of Applied Physics, 53, No. 12, 8907 (December 1982).	F49620-78-C-0009
3475	G.S. Kino, D.M. Barnett, H.J. Shaw, S.D. Bennett, K. Fesler, D. Husson, K.C. Jackson, and L. Zitelli, "Acoustic Techniques for Measuring Stress Regions in Materials," Year-End Report (August 1982).	EPRI T107-5-5
3476	R.L. Jungerman, B.T. Khuri-Yakub, and G.S. Kino, "Optical Probing of Acoustic Waves on Rough Surfaces," Preprint (August 1982).	Ames SC-81-009
3477	S. Ayter and B.A. Auld, "Elastic Wave Scattering from Rough Surfaces and Cracks," Preprint (September 1982). Presented at the Review of Progress in Quantitative NDE.	Ames SC-81-011
3478	Staff, "Acoustical Scanning of Optical Images," Semiannual Technical Report for the period 1 January - 30 June 1982 (August 1982).	N00014-76-C-0129
3479	F. Muennemann, B.A. Auld, C.M. Fortunko, and S.A. Padget, "Inversion of Eddy Current Signals in a Nonuniform Probe Field," Preprint (September 1982). Presented at the DARPA/AF Review of Progress in Quantitative NDE.	Ames SC-81-011 and NBS NB82NAHA3015
3480	K.E. Kihlstrom and T.H. Geballe, "Response to "Comment on 'Tunneling $\alpha^2F(\omega)$ as a Function of Composition in A15 NbGe'" by B.R. Sood," Reprint from Physical Review B, 27, No. 5, 3082 (1 March 1983).	F49620-78-C-0009

G.L. No.	Title	Contract/Grant
3481	Staff, "Acoustic Microscopy at Cryogenic Temperatures," Annual Summary Report for the period 1 July 1981 - 30 June 1982 (August 1982).	N00014-77-C-0412
3482	D. Rugar, J.S. Foster, and J. Heiserman, "Acoustic Microscopy at Temperatures Less than 0.2°K," Preprint (September 1982). Also: Published in Acoustical Imaging (Plenum Publishing Corp., 1982), vol. 12.	N00014-77-C-0412
3483	N. Shaikh, C. Steele, and G.S. Kino, "Acoustoelasticity: Scanning with Shear Waves," Preprint (September 1982). Presented at the DARPA/AF Review of Progress in Quantitative NDE.	CMR sponsored
3484	S.D. Bennett, "IC Applications for Acoustic Microscopy," Preprint (September 1982). Presented at the International Conference on the Quality of Electronic Devices: Strategy for the Next Years, University of Bordaux, France.	F49620-79-C-0217
3485	R.G. Stearns, G.S. Kino, and B.T. Khuri-Yakub, "A New Type of Laser Probe," Preprint (October 1982).	N00014-78-C-0283 and NSF-CMR
3486	M.R. Beasley, "Materials Science of Josephson Junctions," Preprint (December 1982). Also: Published in International Electron Devices Meeting, IDEM 82, 758 (December 1982).	N00014-75-C-0632

G.L. No.	Title	Contract/Grant
3487	J.B. Green, G.S. Kino, J.T. Walker, and J.D. Shott, "The SAW/FET: A New Programmable SAW Transversal Filter," Preprint (October 1982). Also: Published in the IEEE Ultrasonics Symposium Proceedings, 436-441 (1982).	N00014-75-C-0632 and N00014-78-C-0129
3488	R.L. Baer and G.S. Kino, "A Traveling Wave Ultrasonic Transducer," Preprint (October 1982). Also: Published in the IEEE Ultrasonics Symposium Proceedings, 498-501 (1982).	DOE DE-AT03-81ER10865
3489	J.E. Bowers, R.L. Jungerman, and B.T. Khuri-Yakub, "Noncontacting Sensors for Acoustic Waves," Preprint (October 1982). Presented at the 1982 Ultrasonics Symposium.	Ames SC-81-009; Litton Systems; N00014-76-C-0129; N00014-75-C-0632
3490	G.S. Kino, "Recent Research Trends in Quantitative Nondestructive Testing," Preprint (October 1982). Presented at the 30th Anniversary of the Japanese Society for Nondestructive Inspection.	EPRI T107-5-5; Ames SC-81-009; F49620-79-C-0217
3491	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 62nd Report for the period 1 August - 30 September 1982 (October 1982).	EPRI T107-5-5
3492	Unassigned	
3493	M. Riaziat and B.A. Auld, "Eddy Current Probe Design and Matched Filtering for Optimum Flaw Detection," Preprint (October 1982). Presented at DARPA/AF Review of Progress in Quantitative NDE.	Ames SC-81-011; EPRI RP1395-3; Battelle B-96062-B-K

G.L. No.	Title	Contract/Grant
3494	M.A. Henesian, "High Resolution Continuous-Wave Coherent Anti-Stokes Raman Spectroscopy," Internal Memorandum (October 1982).	NSF CHE 79-12673
3495	B.A. Auld, F. Muennemann, and M. Riaziat, "Analytical Methods in Flaw Response Modeling and Inversion for EC Testing," Preprint (October 1982). Presented at the Germany-United States Workshop on Research and Development in NDT.	Ames SC-81-011
3496	P.M. Fauchet, "Gradual Surface Transitions on Semiconductors Induced by Multiple Picosecond Laser Pulses," Preprint (October 1982). Also: Published in Physics Letters, 93A, No. 3, 155 (3 January 1983).	F49620-82-K-0015
3497	J.M. Eggleston, III, "Theoretical and Experimental Studies of Slab Geometry Lasers," Internal Memorandum (October 1982).	DAAG29-81-K-0038 and LLL 3818301
3498	R.L. Baer, B.T. Khuri-Yakub, and G.S. Kino, "A Conical Transducer for Generation of Acoustic Waves in Fluids," Preprint (November 1982). Also: Published in Applied Physics Letters, 42, No. 7, 573 (1 April 1983).	DOE DE-AT03-81ER10865
3499	Staff, "Elastic Domain Wall Waves in Ferroelectric Ceramics and Single Crystals," Progress Report (End-of-Year Letter) (October 1982).	N00014-79-C-0222
3500	R.W. Falcone and J. Bokor, "Dichroic Beamsplitter for Extreme Ultraviolet and Visible Radiation," Preprint (October 1982). Also: Published in Optics Letters, 8, No. 1, 21 (January 1983).	N00014-78-C-0403

G.L. No.	Title	Contract/Grant
3501	S. Ayter and B.A. Auld, "Inverse Scattering from Rough Cracks," Preprint (October 1982). Presented at the 1982 IEEE Ultrasonics Symposium.	Ames SC-81-011
3502	N. Grayeli, F. Stanke, and J.C. Shyne, "Prediction of Grain Size in Copper Using Acoustic Attenuation Measurements," Preprint (October 1982). Also: Published in IEEE Ultrasonics Symposium Proceedings, 595-600 (1982).	F49620-79-C-0217
3503	D. Husson, S.D. Bennett, and G.S. Kino, "Measurement of Surface Stresses Using Rayleigh Waves," Preprint (October 1982). Also: Published in IEEE Ultrasonics Symposium Proceedings, 889-892 (1982).	EPRI T107-5-5
3504	K. Liang, S.D. Bennett, B.T. Khuri-Yakub, and G.S. Kino, "Surface Wave Velocity Measurements at 50 Megahertz," Preprint (October 1982). Presented at the 1982 IEEE Ultrasonics Symposium.	F49620-79-C-0217
3505	R.G. Stearns, B.T. Khuri-Yakub, and G.S. Kino, "Measurements of Thermal-Elastic Interactions with Acoustic Waves," Preprint (October 1982). Also: Published in IEEE Ultrasonics Symposium Proceedings, 595-600 (1982).	N00014-78-C-0283
3506	D.K. Peterson, S.D. Bennett, and G.S. Kino, "Reducing Sidelobe Levels of a Synthetic Aperture Digital Acoustic Digital Imaging System," Preprint (October 1982). Also: Published in IEEE Ultrasonics Symposium Proceedings, 815-820 (1982).	F49620-79-C-0217

G.L. No.	Title	Contract/Grant
3507	Unassigned	
3508	J. Talvacchio, "Inductive Technique for Measuring Critical Current Densities in Thin-Film Superconductors," Reprint from Review of Scientific Instruments, 54, No. 1, 16 (January 1983).	F49620-78-C-0009
3509	D.A. Rudman, "A15 Niobium-Tin: Fabrication and Superconductive Tunneling Spectroscopy," Internal Memorandum (October 1982).	N00014-75-C-0632
3510	P.M. Fauchet, Zhou Guosheng, and A.E. Siegman, "Picosecond Laser-Induced Surface Transformations in Solids," Preprint (October 1982). Also: Published in Mat. Res. Soc. Symp. Proc., (Elsevier Science Publishing Co., Inc., 1983), vol. 13.	F49620-82-K-0015
3511	W.A. Harrison, "Theory of the Two-Center Bond," Preprint (October 1982). Also: Published in Physical Review B, 27, No. 6, 3592 (15 March 1983).	NSF DMR 77-21384
3512	J.E. Bowers, S.A. Newton, and H.J. Shaw, "Fiber-Optic Variable Delay Lines," Preprint (November 1982). Also: Published in Electronics Letters, 18, 999 (11 November 1982).	Litton Systems, Inc.
3513	S.A. Newton, J.E. Bowers, G. Kotler, and H.J. Shaw, "Single-Mode-Fiber 1 x N Directional Coupler," Preprint (October 1982). Also: Published in Optics Letters, 8, No. 1, 60 (January 1983).	Litton Systems, Inc.

G.L. No.	Title	Contract/Grant
3514	L.A. Bloomfield, H. Gerhardt, and T.W. Hansch, "Ultraviolet-Infrared Double Resonance Laser Spectroscopy of nd(n = 12-17) Rydberg States in ^{3}He," Preprint (November 1982). Also: Published in Physical Review A, 27, No. 2, 850 (February 1983).	NSF PHY 80-10689
3515	J.E. Rothenberg, "Spontaneous Raman Scattering as a High Resolution Source in the Extreme Ultraviolet," Internal Memorandum (October 1982).	F49620-80-C-0023 and NASA NAG 2-44
3516	T.W. Hansch, "Precision Laser Spectroscopy of Hydrogen," Preprint (November 1982). Also: Published in Quantum Electrodynamics of Strong Fields (Plenum Press, 1983).	NSF PHY 80-10689 and N00014-78-C-0403
3517	J.B. Green, "Surface Acoustic Wave Signal Processing Devices: New Concepts for Monolithic Designs," Internal Memorandum (November 1982).	N00014-75-C-0632 and N00014-76-C-0129
3518	Staff, "Photoacoustic Imaging," Progress Report for the period 30 June to 1 November 1982 (November 1982).	AFOSR-82-0248
3519	Jean-Marc Heritier, "Electrostrictive Limit and Focusing Effects in Pulsed Photoacoustic Detection," Reprint from Optics Communications, 44, No. 4, 267 (15 January 1983).	NASA NAG 2-44
3520	S.E. Harris and J.F. Young, "Research Studies on Radiative Collisional Processes," Final Technical Report for the period 1 October 1979 to 30 September 1982 (November 1982).	F49620-80-C-0023
3521	A.E. Siegman, "Additional Formulas for Stimulated Atomic Transitions," Preprint (November 1982).	F49620-82-K-0015

G.L. No.	Title	Contract/Grant
3522	K.P. Jackson, S.A. Newton, and H.J. Shaw, "A 1 Gigabit/Sec Code Generator and Matched Filter Using an Optical Fiber Tapped Delay Line," Preprint (December 1982). Also: Published in Applied Physics Letters, 42, No. 7, 556 (1 April 1983).	Litton Systems, Inc.
3523	A.L. Schawlow, "Lasers and Physics: A Pretty Good Hint," Preprint (December 1982). Also: Published in Physics Today, 2-7 (December 1982).	NSF PHY 80-10689
3524	Staff, "Film Synthesis and New Superconductors," Interim Technical Report for the period 1 April to 30 September 1982 (November 1982).	F49620-78-C-0009
3525	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 63rd Report for the period 1 October to 30 November 1982 (December 1982).	EPRI T107-5-5
3526	Jean-Marc Heritier and A.E. Siegman, "Picosecond Measurements Using Photoacoustic Detection," Preprint (December 1982).	NASA NAG 2-44 and F49620-82-K-0015
3527	Staff, "Measurements of Surface Defects in Ceramics," End of the Fiscal Year Letter for the period 1 October 1981 to 30 September 1982 (December 1982).	N00014-78-C-0283
3528	Staff, "Research of Nondestructive Testing," Year End Report for the period 1 September 1981 through 31 August 1982 (November 1982).	NSF ECS 80-10786
3529	J.A. Hildebrand and L.K. Lam, "Directional Acoustic Microscopy for Observation of Elastic Anisotropy," Reprint from Applied Physics Letters, 42, No. 5, 413 (1 March 1983).	NSF ECS 80-10786

G.L. No.	Title	Contract/Grant
3530	S.A. Newton, K.P. Jackson, J.E. Bowers, C.C. Cutler, and H.J. Shaw, "Fiber-Optic Delay Line Devices for Gigahertz Signal Processing," Preprint (January 1983). Also: Published in the Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing, pp. 1204-1207 (April 1983).	Litton Systems, Inc.
3531	J.B. Green, G.S. Kino, J.T. Walker, and J.D. Shott, "An Integrataed Surface Acoustic Wave/Field Effect Transistor High-Speed Analog Memory," Preprint (December 1982). To be published in Applied Physics Letters.	N00014-75-C-0632 and N00014-76-C-0129
3532	A. de Lozanne, M.S. DiIorio, and M.R. Beasley, "Fabrication and Josephson Behavior of High-T_c Superconductor-Normal-Superconductor Microbridges," Preprint (January 1983). Also: Published in Applied Physics Letters, 42, No. 6, 541 (15 March 1983).	N00014-75-C-0632
3533	L.A. Bloomfield, B. Couillaud, E.A. Hildum, and T.W. Hansch, "CW Ultra-violet Saturation Spectroscopy of the $6p^3P_0-9s^3S_1$ Transition in Mercury at 246.5 nm," Preprint (January 1983). Also; Published in Optics Communication, 45, No. 2, 87 (15 March 1983).	NSF PHY 80-10689 and N00014-78-C-0403
3534	G.A. Pavlath and H.J. Shaw, "Multi-mode Fiber Gyroscopes," Reprint from the Proceedings of the First International Conference on Fiber-Optic Rotation Sensors (Springer-Verlag, 1982), 32, 111-114.	F49620-80-C-0040

G.L. No.	Title	Contract/Grant
3535	R.A. Bergh, H.C. Lefevre, and H.J. Shaw, "Geometrical Fiber Configuration for Isolators and Magnetometers," Reprint from Proceedings of the First International Conference on Fiber-Optic Rotation Sensors (Springer-Verlag, 1982), 32, 400-405.	ARCO Ventures
3536	J.A. Hildebrand, "Observations of Cell Motility with the Acoustic Microscope," Preprint (January 1983).	NIH 1R01 GM-25826
3537	R.A. Bergh, M.J.F. Digonnet, H.C. Lefevre, S.A. Newton, and H.J. Shaw, "Single Mode Fiber Optic Components," Reprint from Proceedings of First International Conference on Fiber-Optic Rotation Sensors (Springer-Verlag, 1982), 32, 136-143.	ARCO Ventures
3538	R.A. Bergh, H.C. Lefevre, and H.J. Shaw, "All Single Mode Fiber Optic Gyroscope," Reprint from Proceedings of First International Conference on Fiber-Optic Rotation Sensors (Springer-Verlag, 1982), 32, 252-255.	ARCO Ventures
3539	J.E. Rothenberg, J.F. Young, and S.E. Harris, "Spontaneous Raman Scattering as a High Resolution XUV Radiation Source," Preprint (January 1983).	F49620-80-C-0023 and NASA NAG 2-44
3540	B.A. Auld, F.G. Muennemann, and M. Riaziat, "Quantitative Modeling of Flaw Responses in Eddy Current Testing," Preprint (January 1983).	Ames SC-81-011
3541	Staff, "Acoustic Microscopy at Cryogenic Temperatures," Status Report for the period 1 July 1982 - 1 January 1983 (January 1983).	N00014-77-C-0412
3542	M. Tur and B. Moslehi, "Laser Phase Noise Effects in Fiber-Optic Signal Processors with Recirculating Loops," Reprint from Optics Letters, 8, No. 4, 229 (April 1983).	Litton Systems, Inc.

G.L. No.	Title	Contract/Grant
3543	Staff, "Research Studies on Radiative Collisional Processes," Semiannual Progress Report for the period 1 July - 31 December 1982 (February 1983).	F49620-80-C-0023
3544	Staff, "Elastic Domain Wall Waves in Ferroelectric Ceramics and Single Crystals," Annual Progress Report for the period 1 February 1982 - 31 Janury 1983 (February 1983).	N00014-79-C-0222
3545	B.A. Auld and M. Riaziat, "Spatial Frequency Analysis and Matched Filtering in Electromagnetic Nondestructive Evaluation," Preprint (February 1983). To be published in the Journal of Applied Physics.	EPRI RP1395-3
3546	L.A. Bloomfield, H. Gerhardt, and T.W. Hansch, "Specific Mass Shift in the $1s2s\,^3S$ and $1s5p\,^3P$ States of Helium," Preprint (February 1983). To be published in Physical Review A.	NSF PHY 80-10689 and N00014-78-C-0403
3547	Staff, "Acoustic Techniques for Measuring Stress Regions in Materials," 64th Progress Report for the period 1 December 1982 - 31 January 1983 (February 1983).	EPRI T107-5-5
3548	B.T. Khuri-Yakub, "Detection and Sizing of Fatigue Cracks by Ultrasonic and Optical Methods," Preprint (March 1983).	Ames SC-81-009
3549	Staff, "Acoustical Scanning of Optical Images," Management Report for the period 1 July - 30 September 1982 (October 1982).	N00014-76-C-0129
3550	Staff, "Acoustical Scanning of Optical Images," Management Report for the period 1 October - 31 December 1982 (January 1983).	N00014-76-C-0129
3551	G.A. Pavlath, "Fiber-Optic Rotation Sensors: Alternate Configurations and Modes of Operation," Technical Report (March 1983).	F49620-80-C-0040

G.L. No.	Title	Contract/Grant
3552	Staff, "Research on New Approaches to Optical Systems for Inertial Rotation Sensing," Final Report (March 1983).	F49620-80-C-0040
3553	B. Couillaud, L.A. Bloomfield, and T.W. Hansch, "Generation of Continuous-Wave Radiation Near 243 nm by Sum-Frequency Mixing in an External Ring Cavity," Preprint (March 1983). To appear in Optics Letters.	N00014-78-C-0403
3554	M. Tur, B. Moslehi, J.E. Bowers, S.A. Newton, K.P. Jackson, J.W. Goodman, C.C. Cutler, and H.J. Shaw, "Spectral Structure of Phase-Induced Intensity Noise in Recirculating Delay Lines," Preprint (March 1983).	Litton Systems, Inc.
3555	Staff, "Probe Flaw Interactions and Inversion Processes," Semiannual Technical Report for the period October 1982 - March 1983 (March 1983).	Ames SC-81-011
3556	L.F. Stokes, M. Chodorow, and H.J. Shaw, "Sensitive All-Single-Mode Fiber Resonant Ring Interferometer," Preprint (March 1983). Also: Published in the Journal of Lightwave Technology, LT-1, No. 1, 110 (March 1983).	Litton Systems, Inc.
3557	J.S. Foster and D. Rugar, "High Resolution Acoustic Microscopy in Superfluid Helium," Preprint (March 1983). To be published in Applied Physics Letters.	N00014-77-C-0412 and NSF ECS 80-10786
3558	Staff, "Laser Physics and Laser Techniques," Interim Scientific Report for the period 1 February 1982 - 31 January 1983 (March 1983).	F49620-82-K-0015

SECTION VI

LABORATORY CONTRACT AND GRANT SUPPORT

Edward L. Ginzton Laboratory
W.W. Hansen Laboratories of Physics
STANFORD UNIVERSITY

CONTRACT/GRANT	PRINCIPAL INVESTIGATORS	PROGRAM TITLE	DATE
N00014-83-M-0105	Byer	AgGaS2 and AgGaSe2 Evaluation	06 30 83
N00014-76-C-0129	Kino	Acoustical Scanning of Optical Imaging	11 14 83
N00014-79-C-0222	Auld	Elastic Domain Wall Waves in Ferroelectric Ceramics and Single Crystals	01 31 85
N00014-78-C-0283	Kino	Measurements of Surface Defects in Ceramics	04 30 84
N00019-82-C-0286	Beasley/Schwettman	RF Properties of Superconducting A-15 Compounds	06 14 83
N00014-77-C-0412	Quate	Acoustic Microscopy at Cryogenic Temperatures	06 30 84
N00014-78-C-0403	Schawlow/Harris	Advanced Laser Research	03 31 83*
N00014-75-C-0632	Siegman/GL Faculty	(JSEP) Optical and Acoustic Wave Research	03 31 83*
N00014-81-K-0469	Doniach/Hodgson	Small X-Ray Diffraction of Immunoglobulin Membrane Complexes	04 14 84
F49620-83-C0016	Harris Young	Research Studies on Radiative Collisional Processes	09 30 85
F49620-82-K-0015	Siegman	Laser Physics and Laser Techniques	01 31 84
F19628-83-K-0011	Auld	Temperature Compensation of Surface Transverse Waves for Stable Oscillator Applications	04 30 85
F49620-79-C-0217	Kino	Research on Non-Destructive Evaluation	03 31 84
F49620-83-K-0004	Hanson/Byer	Advanced Instrumentation and Diagnostics for Chemically reacting Flows	09 30 83
F49620-82-C00014	Geballe	Superconducting Thin Films, Composites and Junctions	09 30 84
AFOSR 83-0193	Byer	Laser Physics and Spectroscopy	04 14 84
AFOSR-82-0248	Quate	Photoacoustic Imaging	06 29 83
DAAG29-81-K-0038	Byer	Tunable Optical Sources	02 19 84
DoE DE-AT03-76ER71043	Beasley	Superconducting and Semiconducting Properties of Electron Beam Evaporated Materials	10 31 83
DoE DE-AT03-81-ER10865	Kino	High Frequency Transducers	03 31 84

DoE DE-AS03-83DP40178	Harris/Young	Auger Electron Pumping of Short Wavelength Lasers	09 30 83
DoE DE-AS08-83DP40179	Siegman	Measurement Techniques using Ultrashort Optical Pulses	09 30 83
NAG 1-182	Byer	High Energy Efficient, Solid State Laser Sources	07 31 83*
NAG 5-220	Byer/Feigelson	Growth and Evaluation of Crystals for Infrared Non-linear Applications	01 31 84
NSF ECS 81 11100	Cutler	Nonlinearity & Intermodulation in Microwave Acoustics	02 28 84
NSF DMR 81-09583	Beasley	Two-Dimensional Superconductivity & Layered Superconducting Structures	06 30 84
NSF ECS 80-10786	Quate	Research on Acoustic Microscopy with Superior Resolution	01 31 84
NSF ECS 82-18083	Beasley	High Transition Temperature Superconducting Electron Devices and Circuits	02 29 84
NSF ECS 82-18703	Byer	Laser Plasma X-Ray Lithography and Microscopy	04 30 84
NSF ECS 83-05108	Siegman	High Speed Transient Digitiser Equipment	06 30 84
NSF ECS 83-05652	Harris/Young	High-Power, High-Repetition-Rate, Narrow-Band Tunable Laser System	06 30 84
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20. ABSTRACT (Continue on reverse side if necessary and identify by Block no.)

This report summarizes the research progress and activity on Joint Services Electronics Program Contract No. N00014-75-C-0632 for the period 1 April 1982 through 31 March 1983. Specific Projects are: (82-1) Nonlinear Interactions of Acoustic Waves with Domains in Ferroic Materials (B.A. Auld); (82-2) High-T_c Superconducting Weak-Link Josephson Junctions and Circuits (M.R. Beasley); (82-3) Optical and Nonlinear Optical Studies of Single Crystal Fibers (R.L. Byer); (82-4) Acoustic Surface Wave Scanning of Optical Images (G.S. Kino); and (82-5) Picosecond Raman Studies of Electronic Solids (A.E. Siegman).

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