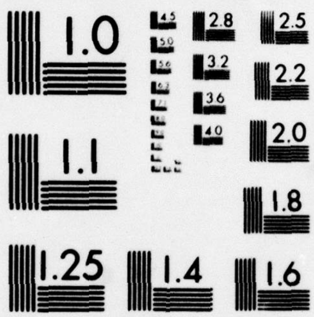
AD-A063 471 NAVAL WEAPONS CENTER CHINA LAKE CALIF F/G 20/6
REDUCTION OF RETICLE REFLECTANCE.(U)
MAR 75 H BLAZEK, R HUNT
UNCLASSIFIED NWC-TM-2514 GIDEP-E095-2133 NL

END
DATE
FILMED
3-79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

95-2133

100413

Ncl

NWC Technical Memorandum 2514

LEVEL II

AD A063471

DDC FILE COPY

REDUCTION OF RETICLE REFLECTANCE

by

Henry Blazek

and

Robert Hunt

Electromechanical Division

Engineering Department

March 1975

Approved for public relase; distribution unlimited. This is not an official report of theNaval Weapons Center and is not to be used as authority for action.

Naval Weapons Center
China Lake, California 93555

78 11 28 166

MAY 25 1978

N/R

GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM

GENERAL DOCUMENT SUMMARY SHEET

Please Type All Information – See Instructions on Reverse

1. ACCESS NUMBER (19) E095-2133	2. COMPONENT/PART NAME PER GIDEP SUBJECT THESAURUS Optical Devices	
3. APPLICATION Engineering	4. MFR NOTIFICATION [ ] NOTIFIED [X] NOT APPLICABLE	5. DOCUMENT ISSUE (Month/Year) (11) March 1975
6. ORIGINATOR'S DOCUMENT TITLE (6) Reduction of Reticle Reflectance		7. DOCUMENT TYPE [X] GEN RPT [ ] NONSTD PART [ ] SPEC
8. ORIGINATOR'S DOCUMENT NUMBER (14) NWC-TM-2514	9. ORIGINATOR'S PART NAME/IDENTIFICATION N/A	
10. DOCUMENT (SUPERSEDES) (SUPPLEMENTS) ACCESS NO. None	11. ENVIRONMENTAL EXPOSURE CODES N/A	
12. MANUFACTURER N/A	13. MANUFACTURER PART NUMBER N/A	14. INDUSTRY/GOVERNMENT STANDARD NUMBER N/A

15. OUTLINE, TABLE OF CONTENTS, SUMMARY, OR EQUIVALENT DESCRIPTION

(12) 13 p. (18) GIDEP

The objective of the effort reported here is to minimize the relative reflectance of reticles used in electro-optic guidance systems. Relative reflectance is defined as the ratio of observed reflectance of a surface to that of a perfectly smooth surface of the same material using near normal incident radiation. There are two mechanisms which can be utilized to reduce the relative reflectance: scattering and absorption. The efforts described here were directed toward the development of a technique which emphasized the scattering mechanism. Scattering is dependent upon surface roughness, and in general one may state that the minimum RMS value of roughness to obtain less than 10% relative reflectance should be one-fifth the wavelength of the incident radiation. The objective is then narrowed to the problem of producing a sufficiently rough reticle pattern on a smooth transmitting substrate.

(10) Henry Blazek Robert Hunt

(9) Technical memo.

78 11 28 166

16. KEY WORDS FOR INDEXING Reticle Reflectance; Electro-Optic Guidance; Reflectance; Scattering; Surface Roughness (Doc Des--P)

17. GIDEP REPRESENTATIVE M. H. Sloan	18. PARTICIPANT ACTIVITY AND CODE Naval Weapons Center, China Lake, CA (X7)

DD FORM 1 OCT 77 2000

13 403 019

FOREWORD

This report describes a process whereby reticles fabricated on sapphire substrates have low reflectivity from both front and back. This work was funded in part by the AIM-9L program. Work was begun in Fiscal Year 1973. Since this report descusses preliminary findings that are subject to modification, it is released at the working level.

M. K. Pladson
Head (Acting), Electromechanical Division
Engineering Department
26 March 1975

NWC TM 2514, published by Code 531, 15 copies.

REDUCTION OF RETICLE REFLECTANCE

OBJECTIVE

The objective of the effort reported here is to minimize the relative reflectance of reticles used in electro-optic guidance systems. Relative reflectance is defined as the ratio of observed reflectance of a surface to that of a perfectly smooth surface of the same material using near normal incident radiation. There are two mechanisms which can be utilized to reduce the relative reflectance: scattering and absorption. The efforts described here were directed toward the development of a technique which emphasized the scattering mechanism. Scattering is dependent upon surface roughness, and in general one may state that the minimum RMS value of roughness to obtain less than 10% relative reflectance should be one-fifth the wavelength of the incident radiation.[1] The objective is then narrowed to the problem of producing a sufficiently rough reticle pattern on a smooth transmitting substrate.

EXPERIMENTAL OBJECTIVES

In the evaluation of each of the proposed scattering techniques, it is necessary to take into consideration the following conditions:

1. Any reduction must extend from the visible out to 4.5 microns.

2. Assuming 4.0 microns as the primary wavelength and extrapolating from reference 1, the surface roughness desired must be 1 micron RMS.

3. Only the opaque portions of the reticle must be roughened.

4. Both the front surface and the interface boundary must be reduced in relative reflectance.

5. Edge resolution of the reticle pattern must be held to 0.25 micron (0.01 mil).

---

[1] H. E. Bennett, *J. Opt. Soc. Amer.*, Vol 53, No. 12 (December 1963), pp. 1389-94.

4

APPROACH

Consider Figure 1 which illustrates two aspects of reflection that are the basis for the need to reduce the reflectance of the reticle pattern. These reflected rays eventually reach the detector, producing optical noise and hence reducing the signal-to-noise ratio of the detection system. The front surface reflections (Ray A) can be dealt with in a straightforward manner. One need only consider those techniques that produce a rough front surface in the opaque reticle areas. The following techniques were evaluated with the experimental objectives as constraints:

1. grinding
2. sandblasting
3. ultrasonic grinding
4. laser blasting
5. chemical frosting
6. diffusion-etching
7. controlled film structure
   a. sputter deposition
   b. heat treatment

The best results were obtained by using sputtered films. The front surface roughness of these films is a function of the sputtering parameters and can be easily reproduced.[2] Figures 2 through 5 show the reduction of relative reflectance for the front surface of various sputtered films.

The second reflection (Ray B in Figure 1), described as the interface reflection since it occurs at the interface of the transmitting substrate and the reflecting film of the reticle pattern is a more difficult case, particularly when those techniques which preroughen the entire substrate are unusable. A solution to the interface reflection was developed when it was found that a reticle pattern photo etched in an aluminum film would produce a rough surface when properly heat-treated. In this technique the aluminum is oxidized to form the transparent aluminum oxide and hence must be recoated with a film to make the roughened areas opaque. Th[e] details of this technique are illustrated in Figures 6 and 7.

---

[2] Naval Weapons Center. Sputter Deposition of Zirconium and Titanium Onto Metal Cubes, by H. Blazek, C. Cutsinger, and G. Turner. China Lake, Calif., NWC, September 1972. (IDP 3391, publication UNCLASSIFIED.)

CONCLUSION

A technique of reticle fabrication which utilizes heat treatment of the aluminum pattern has been developed which significantly reduces the relative reflectance of the opaque portions of the pattern. The relative reflectance of the interface boundary (Figure 7) is reduced from 70% to 10% at 4 microns. This low-reflectance reticle technique should significantly reduce the optical noise in E/O seekers due to reflections from the interface boundary.

There is an indication in the relative reflectance data obtained on certain sputtered materials that absorption in a sputtered film can become a factor in reducing the relative reflectance. It is recommended that this be investigated in greater detail. A combined heat-treated sputter-coated reticle pattern may lead to further reduction of the relative reflectance of reticles.

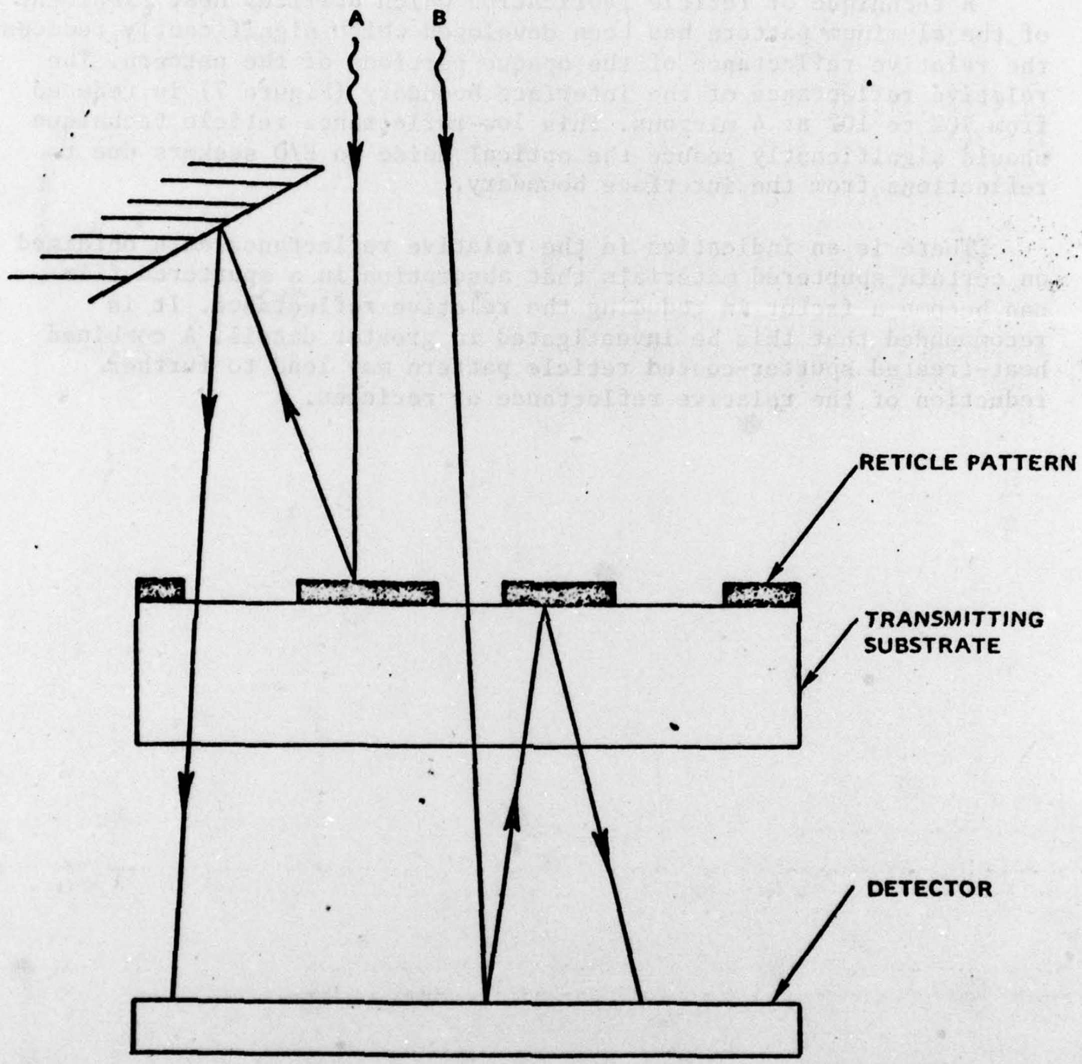


FIGURE 1. Reflections Contributing to Optical Noise.

7

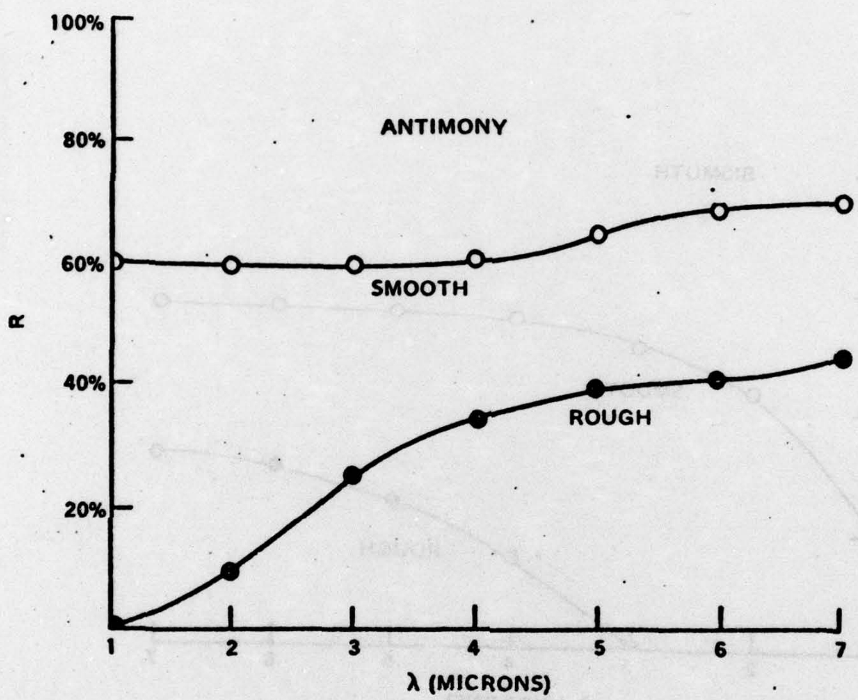


FIGURE 2. Reflectivity of Antimony on Quartz.

8

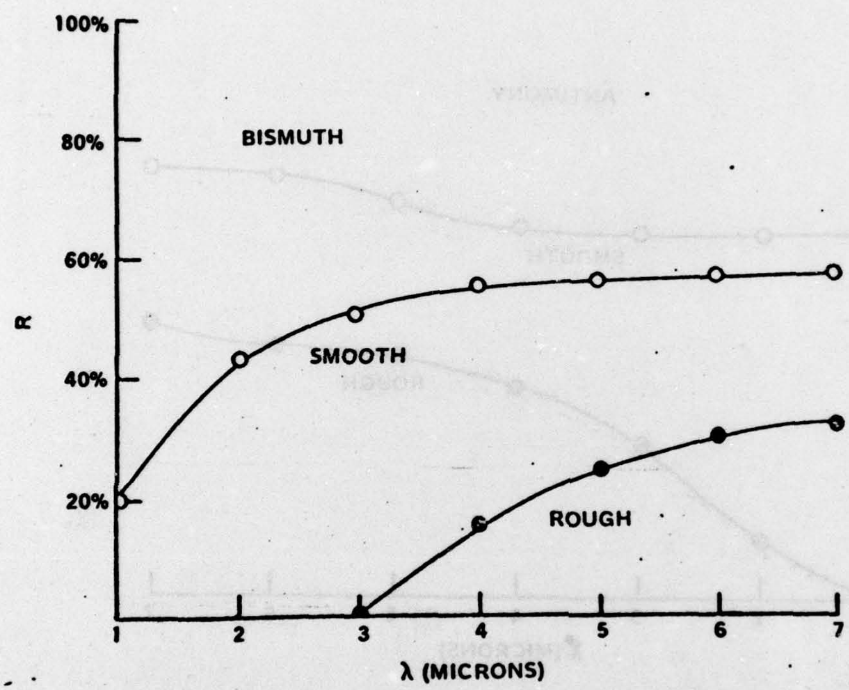


FIGURE 3. Reflectivity of Bismuth on Quartz.

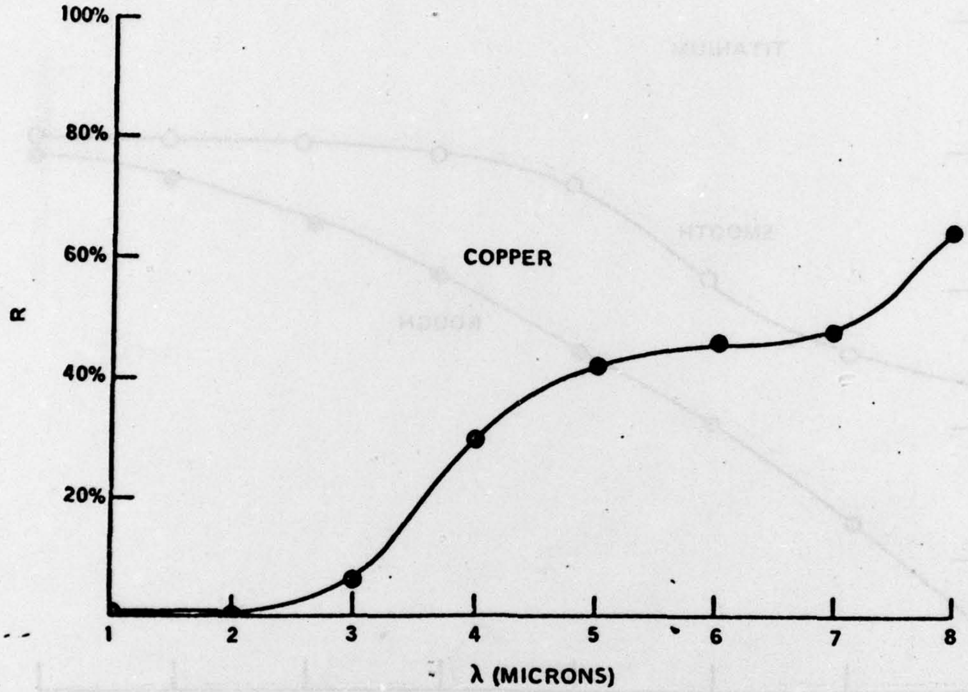


FIGURE 4. Reflectivity of Copper on Quartz.

10

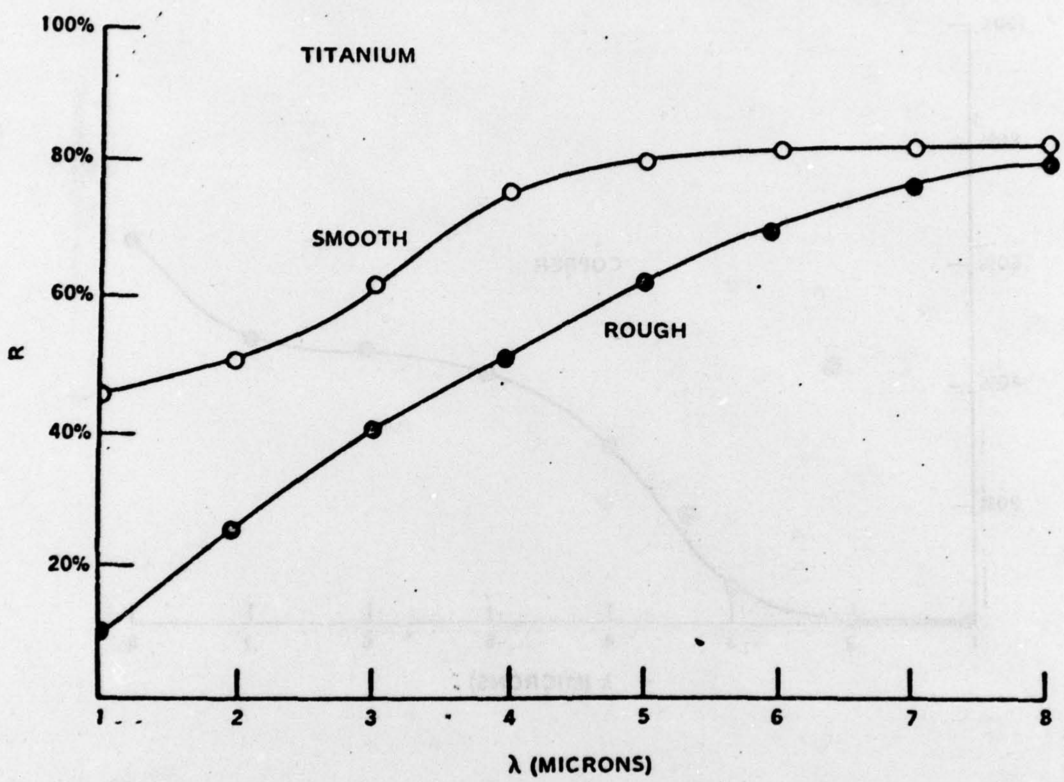


FIGURE 5. Reflectivity of Titanium on Quartz.

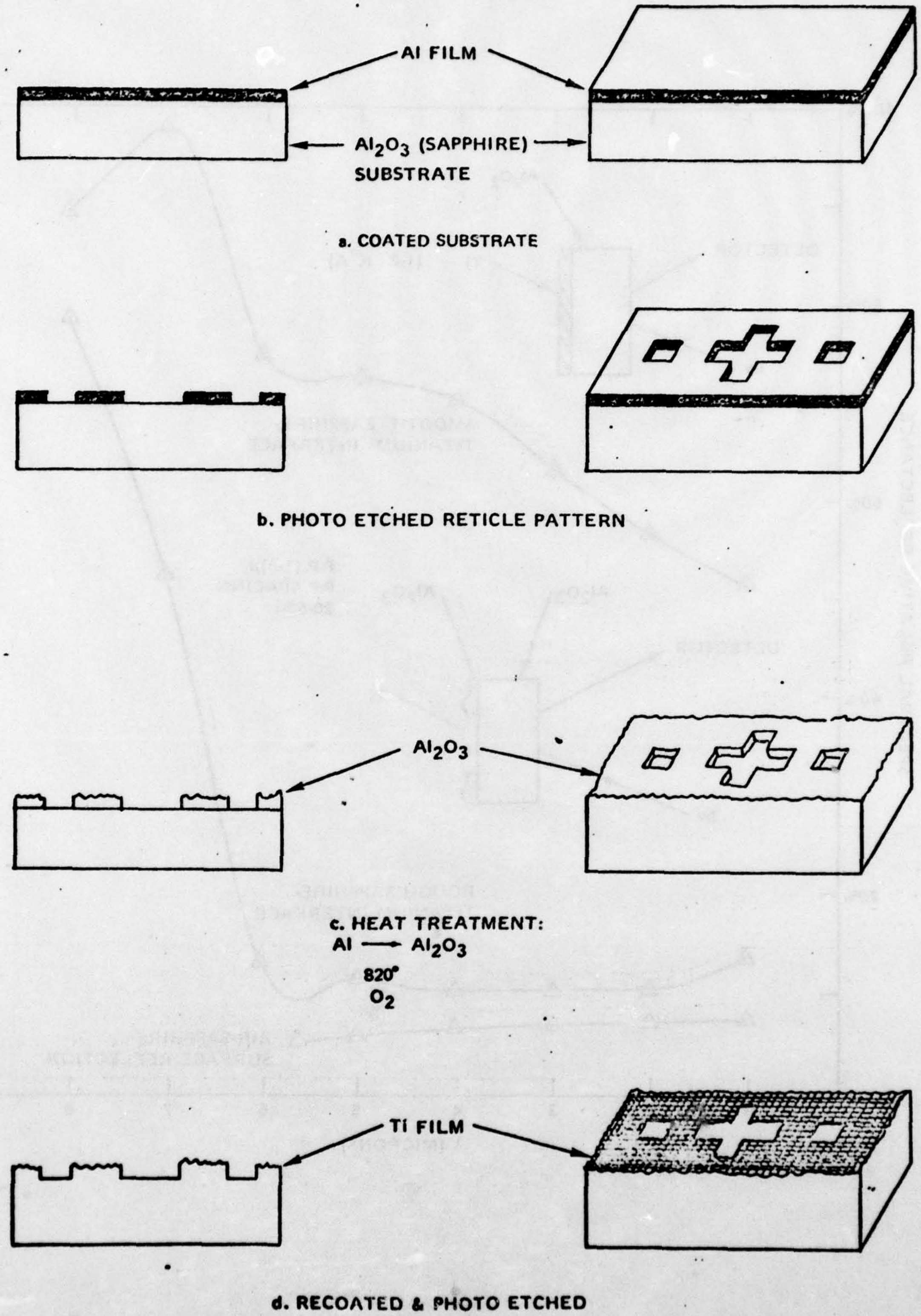


FIGURE 6. Aluminum Heat Treatment Technique.

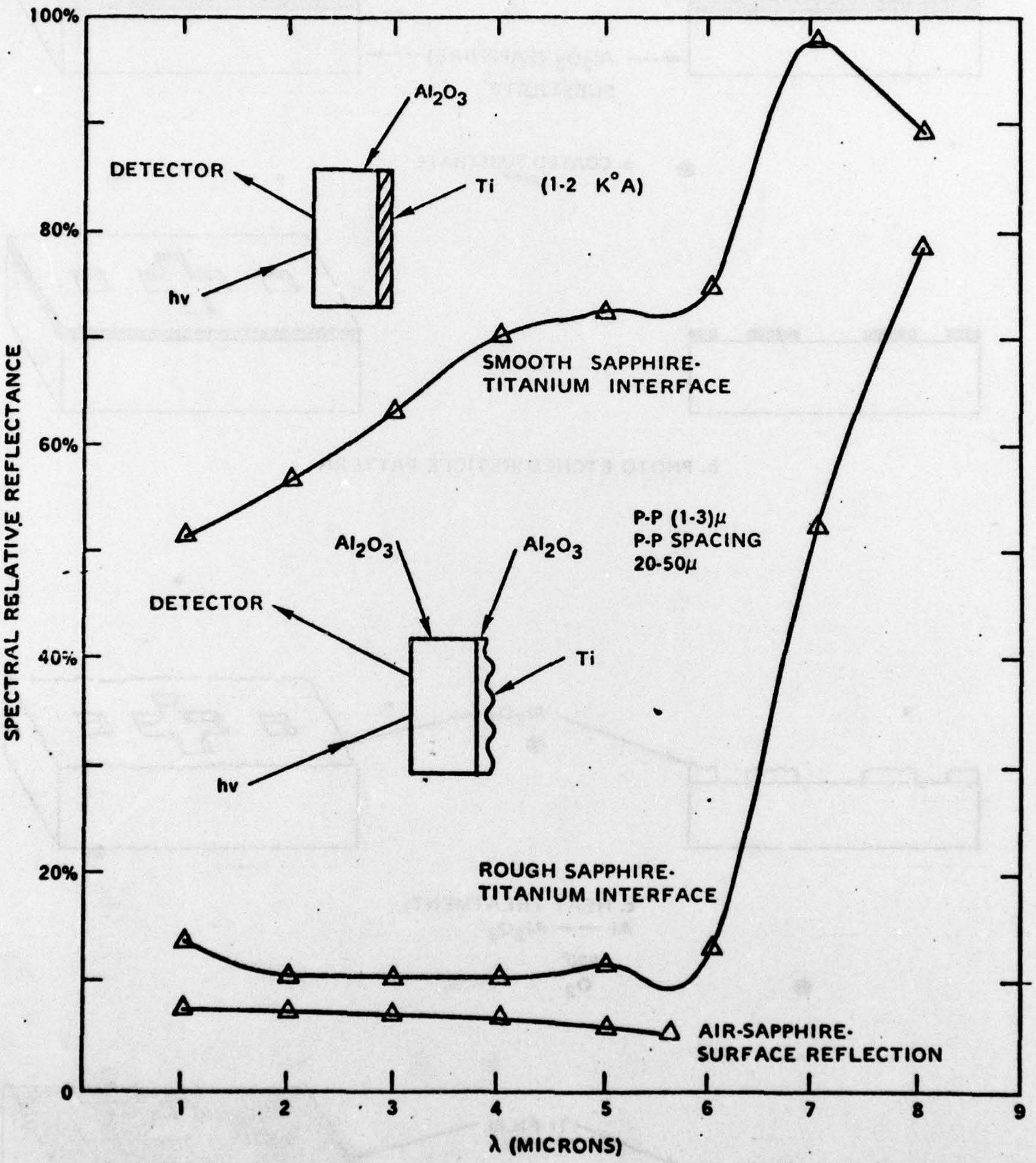


FIGURE 7. Low Reflectance by Diffuse Scattering.