SEMI-ANNUAL STATUS REPORT #3
For the Period
1 July 1967 to 31 December 1967

DEFECT PRODUCTION IN SINGLE CRYSTAL RESULTING FROM ION BOMBARDMENT

by

Lawrence B. Shaffer

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Lewis Research Center

Cleveland, Ohio

31 January 1968

GRANT NGR 36-019-001

X RAY PHYSICS LABORATORY
Hiram College
Hiram, Ohio 44234

I. INTRODUCTION AND SUMMARY

Contained in this report is a summary of the progress made during the period of time from July through December, 1967 on work supported through the Lewis Research Center of the National Aeronautics and Space Administration. Initiated in June, 1966 this research program includes two tasks: the first is a study of the damage produced on the surface of metal single crystals during ion bombardment using x ray methods and the second is a determination of certain thermodynamic properties of cesium gas using x-ray methods.

II. SINGLE CRYSTAL DAMAGE STUDIES

Special Vacuum System

After many delays since the original shipping date of April 21 Varian Associates of Palo Alto finally delivered the system on August 19. On September 11 the Varian Service Engineer arrived to install system and do the final check-out at Hiram. During the check-out it was determined that the special rotary feedthrough device did not meet the specifications for either angular resettability or for axial alignment. In addition during the field check-out of the feedthrough, the beryllium window on the vacuum chamber was accidently broken. Then a complete redesign of the feedthrough plus replacement of the window was necessary. In view of the repeated shipping delays, some of which were due to the redesign of the feedthrough, I had written Varian on June 15 to ask in more detail what work Varian had accomplished under

the Special Design Contract. This Design Contract was let before Varian bid on the system so that they could determine the design parameters for the feedthrough device. No satisfactory answer to this letter has yet been received.

After another redesign of the feedthrough and the replacement of the beryllium window the chamber was received at Hiram January 17. The Varian Service Engineer arrived January 23 and is still here. Tests on the rotary feedthrough device at Varian Associates before shipment indicate that the specifications have been met. No tests are planned at Hiram until we can use the x-ray beam on the spectrometer. However now a few modifications are necessary in the vacuum pumping for the system. The check out should be completed within the week.

A preliminary test of the ion gun furnished by John Ferrante of Lewis Research Center indicated that its operation will probably be satisfactory. The beam current could not be determined as we had no isolated target in the vacuum system but the argon discharge was obtained. A vacuum leak has since been discovered in one of the electrical feedthroughs and will probably limit the pressure to approximately 2×10^{-10} Torr.

Double Crystal X-ray spectrometer

With the help of Professor E. L. Jossem, Chairman of the Physics Department at The Ohio State University, the spectrometer has been reassembled. The two spindle axes were made parallel mechanically using a spirit level to less than 10 sec. of arc, the crystal faces were made parallel to the spindle axes to

within a few seconds of arc using a gauss eyepiece telescope, and each crystal face was made to contain the spindle axis to within 0.001 inch using a microscope. The appropriate crystal adjustments for the above motions are provided in the crystal holder design. Using two quartz crystals, the x-ray beam has been reflected through the spectrometer. The final alignment using the x-ray beam will be done next.

Two additional items are being added to the spectrometer: first, a stepping motor is being installed to speed up the data taking process and second, a new 50KV, 50MA power supply is being constructed, mostly from surplus parts, to allow simultaneous running of both x-ray machines.[1]

A complete report on the mechanical details and final configuration of the system (both vacuum and x ray) will be provided, hopefully in the next report.

Theoretical studies

A theoretical evaluation of the ion-surface interaction was begun as well as a study of the interpretation of the x-ray data to be obtained. These studies will be reported when preliminary data are presented.

III. CESIUM GAS SCATTERING STUDIES

One of the two main problems of last summer has been solved: that of reducing the thickness of the lucalox tube walls. Grinding techniques have been successful in reducing the wall thickness from 40 to 15 mils. The other problem of the molybdenum

target is still under consideration. An attempt was made to heat shrink a cylindrical piece of molybdenum 10 mil thick over the present 4" O.D. copper anode but soon after installation, the molybdenum piece fell off inside the vacuum chamber. The failure of this technique is probably due to the heating of the molybdenum piece by the electron bombardment from the x-ray filament and the water cooling of the copper anode resulting in an "unheat-shrinking" process. This technique was a trial possibility before attempting plating of molybdenum on the copper anode by sputtering or evaporation. An evaporation attempt has been made unsuccessfully at Hiram. Work will continue on this problem.

A high temperature oven has been constructed to hold the lucalox tube and also to fit inside the 10 cm scattering chamber.[2] A Foxboro Controller[3] is used to control the temperature. Operation in air to 800°C has been successful. Tests are now underway to determine the uniformity of temperature inside the oven since the entrance and exit windows for the x-rays may affect the temperature distribution. These tests are being run in the 10 cm scattering chamber under vacuum conditions. A copper sleeve will be used around the lucalox tube to help ensure uniform temperature along the tube.

IV. RESULTS, RECOMMENDATIONS, AND PROBLEMS

These last six months have been slow due primarily to equipment shipping delays. Within the next month, if all goes well, the ion damage studies should be underway. Due to the nine month shipping delay by Varian the project is now behind schedule so at this point it is difficult to make an evaluation.

References

1. L. B. Shaffer, "Defect Production in Single Crystals Resulting from Ion Bombardment" Semi-Annual Status Report #2, NASA Grant NGR 36-019-001

2. Ibid.

3. Foxboro Potentiometer Controller, Model No. 4043-40, Foxboro Company, Boston, Mass.