ELECTRICAL ENGINEERING RESEARCH LABORATORY
ENGINEERING EXPERIMENT STATION
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

STATUS REPORT
ON
RESEARCH ON THE ELECTRICAL PROPERTIES
OF
SEMI-CONDUCTORS

Project No. NR 072 169
N6-ori-07138 Report No. 7

Date:
15 July 1954

Period:

1 March 1954

to

31 May 1954

Approved by:

T. A. Murrell
Associate Professor

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1. INTRODUCTION

1.1 Purpose

This is the seventh status report on the Lead-Telluride investigation being carried out under ONR sponsorship at the University of Illinois. This report covers the period 1 March 1954 to 31 May 1954. The purpose of the investigation is to study the semi-conducting properties of PbTe single crystals of various compositions.

1.2 Personnel

Mr. Sirrine and Mr. Golubjatnikov devoted half time to the project. Professor Murrell was carrying a full teaching load during the spring semester, and none of his salary was charged to the contract during this report period.

1.3 Summary

The test series designed to locate possible sources of contamination was completed. The results indicated that the electrical measurements were characteristic of the lead-telluride system and not due to uncontrolled impurities.

An all N-type crystal was grown by increasing the excess lead from 0.2 to 0.5 weight percent.

The possibility of controlling the conductivity type by rate growing the crystal appears favorable and will be investigated.

P-N junctions were cleaved and cut out of the crystal. The characteristics of these junctions will be investigated.

2. EQUIPMENT AND FACILITIES

2.1 Oscillator-Power Amplifier

The oscillator-power amplifier which will drive the crystal lowering motor was completed and works satisfactorily. Rate-grown crystals will be grown in the very near future.

3. SUMMARY OF ACTIVITIES

3.1 Crystal Growing

The first few crystals grown for this investigation established that P-type crystals were obtained even though the melt contained a small amount of excess lead. A series of crystals were grown in an effort to establish whether the P-type crystal was due to contamination or was characteristic of the lead-telluride system. For this test series, the starting constituents and dropping rate were held constant and the other steps in the process were investigated one by one. There was very little variation in the crystals grown for this test series; therefore, it will now be assumed that the observed electrical characteristics are those due to the lead-telluride system and not due to he introduction of uncontrolled impurities.

A spectrographically pure carbon boat was inserted in the quartz seal-off tube as a step in the investigation of the reaction between lead-telluride and the quartz tube. A perfect single crystal was produced in this run. This technique was used in four successive runs. Perfect single crystals resulted each time. This technique will be used in the future.

The amount of excess lead was varied while holding the dropping rate and the other steps in the process constant. Figure 1 indicates the resistivity patterns obtained. The resistivity measurements were obtained by grinding a flat surface along the length of the crystal and using the 4-probe resistivity measuring technique. This method will not give accurate results in regions of rapidly varying resistivity such as occur near P-N junctions. For example, the junction region in Run #27 probably has a much higher resistivity than is shown in Fig. 1.

Earlier tests indicated that similar curves could be obtained by holding the amount of excess lead constant and varying the dropping rate. On the basis of these earlier results, an oscillator-power amplifier was constructed to drive the synchronous motor used in the dropping mechanism. The next crystal will be grown at a variable dropping rate in an attempt to produce a reasonably long region of material of near stoichiometric proportion.

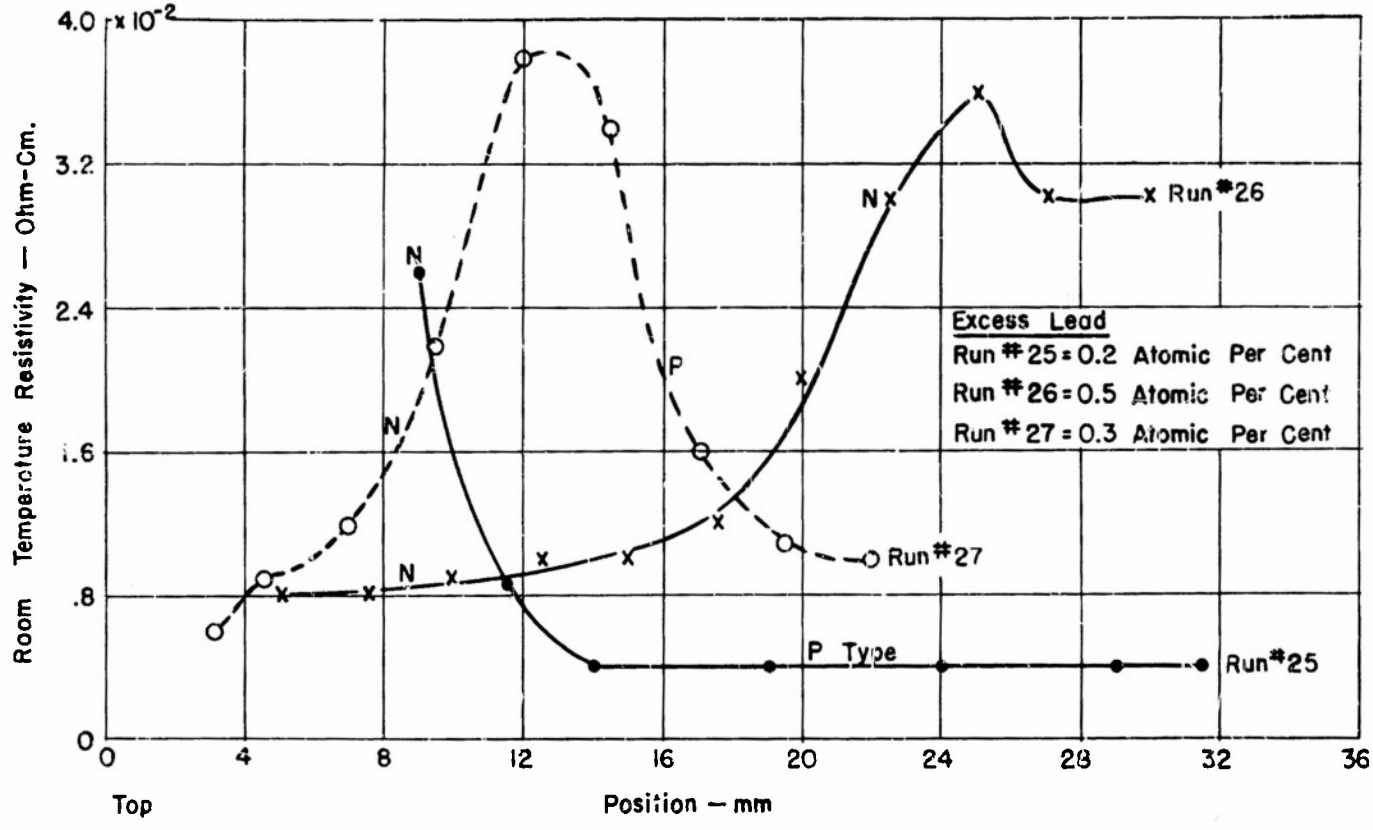

FIGURE 1 RESISTIVITY VERSUS LENGTH

3.2 P-N Junction Measurement

Most of the crystals grown contain a P-N junction. However, it is difficult to cleave out a section containing the junction because the junction and cleavage plane seldom coincide. A junction was successfully cleaved out of Run #24. Current versus voltage measurements were made at room and liquid nitrogen temperatures. Very little rectification was observed at room temperature. The I vs E curve at liquid nitrogen temperature is shown in Fig. 2.

Four junctions were cut out of Run #25 crystal using a diamond saw. The rectification ratio at liquid nitrogen temperature was considerably less for these junctions than for the one cleaved out. The junctions cut out need to be etched but so far a suitable etch has not been found.

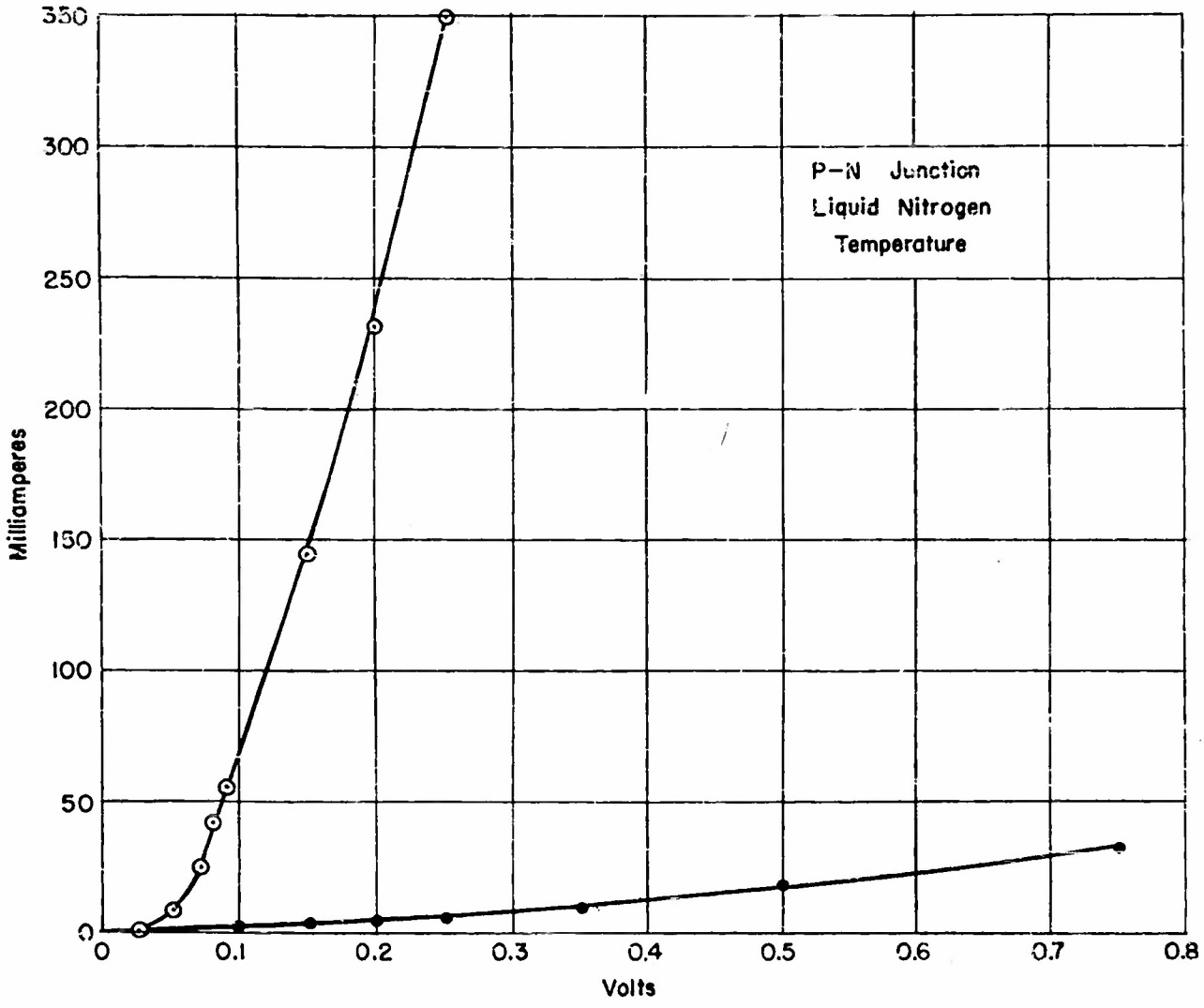

FIGURE 2 CURRENT VS. VOLTAGE CHARACTERISTIC

4. PLANS FOR THE NEXT INTERVAL

The variable dropping rate technique will be investigated as a means of producing material of near stoichiometric composition. If the results are unsatisfactory, diffusion in controlled tellurium vapor pressure will be investigated.