Quarterly Status Report

to

National Aeronautics and Space Administration
Office of Scientific and Technical Information (Code US)
Washington, D.C. 20546

on

Grant NGR-05-002-100

"SPACE CHARGE EFFECTS IN CURRENT TRANSPORT"

to the

California Institute of Technology
Pasadena, California 91109

December 12, 1969

NASA Cambridge (Dr. J. Hopkins), JPL, Pasadena (Dr. A. Shumka) and OSU, Stillwater (Dr. H. Bilger) each have received one thermostat and an electronic control system. Two more units are in regular use here at Caltech. A paper on the subject has been submitted to the Review of Scientific Instruments, has been accepted and is scheduled for publication in the March issue 1970 (see enclosure). Efforts to find a manufacturer interested in a commercial exploitation of this thermostat should be worthwhile, but will have to be delayed at this end because of the prime investigator's absence on a leave. A revised manuscript for publication as a NASA report has just been completed; it provides full information to laboratories interested in duplicating the thermostat.

The study of gr noise in double injection, performed by P. Worch under H. Bilger's direction at OSU is approaching its conclusion. Mr. Bilger will be in Stillwater early next year to discuss the final phases of this thesis. Upon completion, the analyzer will be returned to Caltech.

Mr. Vu is presently writing a thesis on the fast neutron experiment. Some aspects of the subject are well understood, but others (particularly the effect of irradiation in the ohmic range of the device and the temperature dependence there) are not, probably because the behavior in that range of operation is critically dependent on minute changes in the balance of the free carriers (order of $\sim 10^{10} cm^{-3}$).*

Some thought is presently being given to the subject of sclc as a dosimeter. It appears that the residual conductivity ($\sim$ energy gap) of the material and the breakdown voltage pose two major limitations to such a dosimeter. The subject will be pursued a little further analytically and comparisons should then be drawn with existing detectors to

---

*This experiment is clearly but a first step which should be followed by studies of annealing, different types of radiation (particularly γ-rays) and a range of energies. Not until then will it be clear to what extent sclc is affected irreversibly and how much by what type of radiation.

determine the possible advantages of such dosimeter.

A last effort is being prepared to measure the noise of sclc of thermal carriers. Consideration is being given to new materials, of a wider band gap than Si, in which sclc could be investigated above room temperature. Comparative analytical studies to better understand the relationship between FET and SCLC would also be desirable. To which extent these projects can be pushed depends largely on our ability to get a research fellow's help next year, because the number of Ph.D. students has fallen off sharply last year and new candidates will have to be broken in first.

Early results on the experiment with sclc in π-type silicon, using an ion implanted back contact of Boron and a regularly alloyed front contact of Aluminum, are briefly as follows:

- sclc exhibits "trapping" (that is, the current decays with time when a voltage is suddenly applied to the device). At room temperature, the time constant decreases from 100μs to μs for applied voltages increasing from about 2.V to 30.V. The trapping parameter θ is fairly constant in that range $2 \lesssim \theta^{-1} \lesssim 4$.
- The electrical behavior of the device is symmetrical with respect to inversion of the polarity, although only one of the two contacts has been ion implanted. This is a surprising result. Its implications are not yet understood clearly.
- At 77°K, trapping is much more pronounced ($\theta^{-1} > 100$) and long time constants appear in addition to the short one.
- After annealing at 500°C for about 15 min., trapping almost completely disappears. This is qualitatively in line with the results of Hall effect measurements on ion implanted layers. Whether the details of the two phenomena are consistent with each other is not yet established, however.

These experiments establish that nonannealed ion-implanted B contacts are clearly deficient in their emission efficiency. Preliminary results with Sb and P implanted contacts on ν-type Si indicate that this fact is likely to be true quite generally. These results are obviously closely tied to the general question of the properties of ion implanted interfaces and their electrical behavior. In particular, it would be important to know what the work function of an implanted surface is, or if this concept is breaking down. An independent proposal is being sent to NASA Cambridge to investigate this question. In the meantime, additional experiments and measurements are being prepared to pursue the subject of sclc with implanted emitters. The positive outcome of this experiment uncovers a new aspect of implanted layers.

Pasadena, December 12, 1969

M-A. Nicolet

J. W. Mayer

MAN:ce
cc: J. Hopkins - NASA

A. J. Lindstrom