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RADIATION EFFECTS ON SILICON SOLAR CELLS

Fourth Monthly Progress Report Covering the Period
April 1 - 30, 1962

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Contract No. NAS7-91

May 8, 1962

INTRODUCTION

This report covers the fifth month of research on Contract NAS7-91, Radiation Effects on Silicon Solar Cells. During this month the following accomplishments were.

1. An analysis of recombination phenomena in semiconductors has been performed emphasizing the relation between semiconductor parameters and our experimental observables. The results of this analysis have been incorporated into an informal General Atomic report which will be attached to the next quarterly progress report under this contract.
2. Irradiations have been performed of silicon with high-energy electrons to make measurements of conductivity and Hall coefficient.
3. Irradiations have been performed of silicon with high-energy electrons to make measurements of recombination rates as a function of temperature and radiation.
4. No further infrared measurements were made during this period due to hospitalization of one of our investigators. However, in his absence the measurements will be resumed under the supervision of other staff members.
5. The electron spin resonance equipment is being assembled and a cryostat for performing measurements on irradiated silicon at low temperatures is being constructed.

Some of these results will now be described in more detail.

IRRADIATION EXPERIMENTS

Experimental measurements of recombination times in silicon at low temperatures have exhibited some queer behavior. During one of the recent linear accelerator experiments particular emphasis was made on two points - (1) finding the sources of rf noise which interfered with low level measurements, and (2) finding the cause of apparent non-exponential conductivity decays.

It was established that the minimum rf interference noise was observed in the signal leads when a good ground point was placed directly on the sample. Grounding one of the voltage leads was shown not to be adequate, apparently because the voltage contact may be partially rectifying.

Grounding a thermocouple which was attached securely to one end of the sample appeared to be most effective. Other sources of noise were associated with the dc power supply which supplied current to the sample. Appropriate filtering near the sample decreased these noise sources.

On occasion, particularly at low temperatures where some of the contacts may become partially rectifying, we have observed anomalous appearing conductivity decays. These have now been explained in terms of contact rectification and circuit capacitance. During the next experiment, a revised circuit which is designed to minimize these effects will be tested and, if it is successful, the problem and the technique which has been used to solve it will be described in detail in the next quarterly report.

In spite of these difficulties, some measurements on lifetime as a function of temperature have been made in irradiated silicon, and these are being analyzed at present.

The conductivity and Hall coefficient were monitored for n-type silicon as a function of 15-Mev electron irradiation at 300°K on samples with two different initial carrier concentrations, $1 \times 10^{16} \text{ cm}^{-3}$ and $8 \times 10^{16} \text{ cm}^{-3}$. The carrier removal rates observed were respectively 0.3 cm^{-1} and 0.8 cm^{-1} . Measurements of conductivity and Hall effect were made also as a function of temperature at various times throughout the irradiation. The A center will influence these measurements for it will be occupied or unoccupied depending on where the Fermi level is located. The number of A centers can then be determined by the carrier concentrations before and after the Fermi level passes through the level associated with the A center which is 0.16 ev below the conduction band. Preliminary results indicate that the number of A centers observed is proportional to the amount of irradiation the sample receives.

FUTURE PLANS

Plans for the immediate future include the following:

1. Completion of the electron spin resonance apparatus.
2. Irradiation of a sample for infrared spectroscopy to measure concentrations of A centers both by the vibrational oxygen absorption and by the electronic photoconductive transition.

3. The refined lifetime measuring technique will be used to measure the lifetime changes in phosphorus-doped pulled silicon to evaluate its consistency with the A center model.
4. Further experiments will be performed on floating zone refined silicon and possibly started on p-type silicon to explore other important recombination centers.

PERSONNEL

The following personnel have worked on this program during the past month: V. A. J. van Lint, D. M. J. Compton, E. G. Wikner, J. H. Harrity, H. Horiye, and M. E. Wyatt.