C — 5 — 3 OPTICAL STABILITY STUDIES OF a-Si:H SOLAR CELLS*

J. J. Hanak and V. Korsun

RCA Laboratories

Princeton, NJ 08540 U.S.A.

Statement of the Problem: Solar cells made of a-Si:H made by rf capacitive glow discharge are subject to large variations in performance depending on the conditions of preparation. This has been found to be true for the case of optical stability (OS) under prolonged illumination; some cells show remarkable stability, while others degrade at different rates and to different degrees. We have made studies designed to identify the causes of optical degradation.

Scope and Method of Approach: Studies of OS have been made on solar cell configurations of glass/ITO/Pt-SiO_2/p i n a-Si:H/metal and a similar structure without the p layer. We made use of graded i-layer thickness and deposition temperature (T_s) to study the dependence of OS on these parameters. We also made tests on cells in which the metal electrode was replaced by ITO to enable illumination from both sides. Another structure was a two-cell stacked cell of a-Si:H to demonstrate stability. Other parameters studied were rf power used in the deposition, dilution of SiH_4 in H_2 and voltage bias applied to the cell. The studies consisted of prolonged illumination of the cell in AM1 sunlight and obtaining IV, QE, before and after, and in some cases SIMS data.

Significant Results: A strong inverse dependence of OS on i-layer thickness has been established both for p i n and i n cells. For a particular i layer used the cells remained stable up to 200 nm thickness with respect to cell efficiency (η). At higher thicknesses η decreased primarily because of a decrease in FF and to a lesser degree in J_{sc} and V_{oc}. The decrease in FF was accompanied by a threefold increase in cell series resistance (Fig. 1), an indication of the Staebler-Wronski effect [1]. The observed OS for thin i layers ($\leq$ 200 nm) is in agreement with prediction by Rose [2] who stated that for thin cells ($\sim$100 nm) density of states as high as $\sim 10^{17}$ can be tolerated before problems with carrier collection arise.

We predicted and confirmed OS of stacked a-Si:H cells based on the small thicknesses normally used in such cells.

We found marked enhancement of OS by the application of increasing reverse bias and a decrease of OS by forward bias applied during light soaking of the samples. The high internal field at reverse bias apparently prevents the population of traps present in the material.

Samples prepared from SiH_4 diluted in H_2 tend to contain more hydrogen than those deposited from undiluted silane and have been found to be less stable than the latter. This indicates that excess hydrogen in the samples might be associated with the traps.

*Research reported herein was supported by Solar Energy Research Institute, under Contract No. XG-0-9372-1, and by RCA Laboratories, Princeton, NJ 08540.

Over a range of 190-290°C of T_S for a-Si:H deposited from SiH_4 and glow discharge rf power density of 30 to 150 mW/cm^2 there were no pronounced variations in OS.

References: 1. D. L. Staebler and C. R. Wronski, Appl. Phys. Lett. 31, 292 (1077).
2. A. Rose, Phys. Status Solidi A56, 11 (1979).

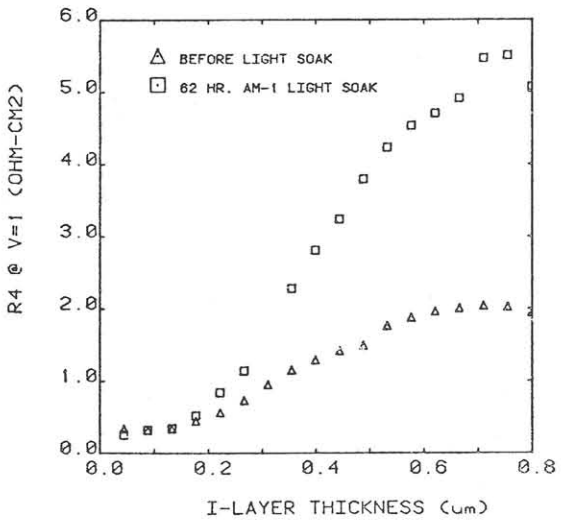

Figure 1. DEPENDENCE OF SERIES RESISTANCE AT 1 VOLT FORWARD BIAS