Technical Progress Report

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for

DIAGNOSTICS OF A GLOW DISCHARGE USED TO PRODUCE AMORPHOUS SILICON FILMS

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Construction of the basic apparatus has been completed during this period, and many apparatus checks have been completed. Almost complete SiH_4 dissociation has been obtained in $\sim 950^\circ\text{C}$ ovens between the turbo and rough pumps, so that reliable, long-term operation is achieved. A base vacuum of $\sim 10^{-7}$ Torr is achieved in the discharge chamber in a few hours, and $\sim 10^{-8}$ overnight, so that gas-phase impurity levels as low as 10^{-7} are readily achievable. The SiH_4 inlet lines are entirely bakeable stainless steel and permanently closed to air, to maintain the tank purity of SiH_4 . A distillation procedure to further clean the tank SiH_4 is under study. Thus we should be able to study the effects of very small, controlled levels of impurities.

The discharge system has been tested using dc, dc-proximity, and rf discharges, and the mass spectrometer has been tested as a neutral and ion detector. The discharge configurations studied so far are shown in Figs. 1-3. Most of these tests have been performed on Ar, in order to

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compare to known discharge theories and characteristics, and to avoid the effects of a-Si:H surface films on the discharge and the mass spectrometer. Preliminary ion spectra have been obtained from these three types of discharges in pure SiH_4 . The ratios of Si_xH_n^+ fluxes for three types of discharges are shown in Fig. 4. Interpretation of these and additional ion spectra in terms of available models will be included in our next report.

Hydrogenated silicon films have been made for a variety of discharge conditions, but so far only on room-temperature substrates. We have noticed that substantial coatings appear on the anode, as well as on the cathode and walls of a dc discharge. Since no ions reach the anode and the density of negative ions is expected to be very small, this demonstrates that a substantial portion of the film growth is from neutral (radical) deposition. We have also noted that an rf discharge operated in the same SiH_4 pressure and at the same power levels as a dc discharge is visually equivalent to a reversing dc discharge; i.e. equivalent cathode "dark spaces" appear at both (symmetric) rf electrodes and at the cathode of the dc discharge. However, the ion spectrum emitted from the rf discharge electrode is quite different from that obtained from the dc discharge. Discharge and chemical-kinetics models, for use in interpreting these observations, are currently being developed.

rf & dc DISCHARGE, CATHODE DEPOSITION

Fig. 1

dc - PROXIMITY DISCHARGE

Fig. 2

rf & dc DISCHARGES-SIDE WALL DEPOSITION

Fig. 3

Fig. 4. Ratios of $\text{Si}_x \text{H}_y^+$ ion fluxes from three types of low-power discharges in silane.