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PREPARATION AND CHARACTERIZATION OF HYDROGENATED AMORPHOUS
SILICON THIN FILMS AND THIN FILM SOLAR CELLS PRODUCED BY
ION PLATING TECHNIQUES

FIRST QUARTERLY PROGRESS REPORT

FOR THE PERIOD

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FRANKLIN H. COCKS, PHILLIP L. JONES

AND LOUIS J. DIMMEY

DUKE UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING
AND MATERIALS SCIENCE
DURHAM, N.C. 27706

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Introduction

Ion plating is a deposition process in which evaporation of a metal or semiconductor into a plasma glow discharge about a negatively biased substrate is used to affect both the character and the surface bonding of the resulting thin film deposit. Ion plating has also been carried out by direct ion beam methods but can still be distinguished from ion implantation by the use of the low ion energies typical of glow discharges. The energy level of the evaporated metal or semiconductor is increased through their interaction with the glow discharge. It is the increased energy state of the depositing material that affects both the nature and adherence of the deposited thin films.

The term ion plating was itself introduced in 1964 by Mattox (Mattox, 1964). To date, the method of ion plating has been used primarily for the coating of substrate materials, including non-conductors such as plastics, with metals. This is so because an immediately recognized advantage of this method was the drastically improved adhesion of ion plated films versus vacuum deposited films (Davis, 1963). This increase in adhesion is due to the controllable arrival energy of the incident metal vapor flux. Both the glow discharge voltage and evaporation rate can be separately controlled (Aisenberg and Chabot, 1973).

Recently, the related method of ionized cluster beam deposition has been used to produce epitaxial semiconductor films of silicon on substrates of single crystal silicon, amorphous carbon, and cleaved NaCl (Takagi, et. al., 1978, Takagi, et. al., 1976). In their experiments the ionizing vapor was composed of thermionically generated electrons rather than the more usual use of evaporation into a glow discharge. It is to be expected that, with low

substrate temperatures, high glow voltages and relatively small cluster sizes, that amorphous silicon films can be readily produced since, in normal glow discharge methods amorphous silicon films can be made on substrates whose temperatures are over 500°K (Loveland, et. al., 1973). To date, however, only one parenthetical report involving amorphous silicon films and ion plating appears to have been presented in the literature (Itoh, 1977). Itoh, however, devoted most of his experimental effort to producing single crystal epitaxial silicon films on the (111) and (110) planes of single crystal silicon substrates.

This program has as its primary goal the development of methods for the preparation of efficient, low cost amorphous thin film solar cells involving the direct use of the ion plating technique.

Experimental

Our First quarterly effort has been primarily concerned with the construction of our ion-plating apparatus. Currently two oil-pumped vacuum systems are being modified to produce a-Si thin films by the combined glow discharge decomposition of silane and ion plating techniques. Both vacuum systems are capable of being pumped to 10^{-7} torr by using liquid nitrogen baffles to eliminate backstreaming.

The glow discharge system is being modified to include an electromagnet that can be used to produce magnetic fields perpendicular to the substrate surface ranging from 0 to 0.12 tesla (1200 gauss). This system will initially be used to determine the effect of applying various magnetic field intensities to constrict and enhance the glow on the resulting deposition rates and film properties of a-Si:H produced by glow discharge decomposition of silane.

When completed, our ion-plating apparatus will be used to produce a-Si:H thin films. In this system a silicon charge will be evaporated by using an RF heating coil. The evaporating silicon will then be allowed to expand adiabatically

into the glow. Using various mixtures of silane and argon as feed gas, base-line ion-plating parameters will first be established.

Future Plans

During the next quarterly period we plan to compute the modifications on both the glow discharge and the ion-plating deposition systems. The glow discharge system will be used to examine the effect of magnetic field confinement of the glow on deposition rates and film properties. In addition, it will provide base-line film data to compare with the properties of our ion-plated films. Initially ion-plated a-Si:H films will be deposited using a wide range of feed gas mixtures in order to establish base-line ion-plating deposition parameters.

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