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Photovoltaic Characteristics of Photo Cells by Ionized-Cluster Beam Deposition Technique

T.Takagi, I.Yamada, A.Sasaki, S.Itoh, H.Mori, and H.Morimoto

Department of Electronics, Kyoto University
Sakyo, Kyoto, Japan

The ionized-cluster beam deposition technique developed by authors has been investigated earlier as the cluster formation, size, and ionization characteristics (1) In addition, the following characteristics of the deposited film has been studied previously: the crystalline state of the deposited films using electron microscope; the profile of an interfacial layer using the ion backschattering technique; the observation of sputtering effects on a substrate surface using the electron microscope; and the implantation effect using nutron activation analysis. From the studies, it was proved that the ionized-cluster beam deposition technique has the potential application in epitaxial deposition, interconnecting on IC substrates, and a wide range of coating and deposition applications.

In this paper, some important characteristics of the ionized-cluster beam deposition which are seemed to give remarkable effects for the epitaxial glowth and the characteristics of the junction diode fabricated by the deposition of n-type Si on p-type Si substrate are reported.

The vapourized-metal cluster ion source[(2)] as described in previous work has been used as the ion source for this deposition. The illustration of an example of this cluster ion source is shown in Fig.1. The kinetic energy of accelerated cluster ion is converted to thermal energy, sputtering energy, ion implantation energy, and etc. In addition to these energies, the migration effect of depositing particles gives much influence to the nucleation, growth and crystalline state of the deposits. This phenomenon is one of the majour characteristics of the ionized-cluster beam deposition technique.

An initial deposition state has been obserbed to investigate the migration effects by the conventional vacuum deposition and the ionized-cluster beam deposi-

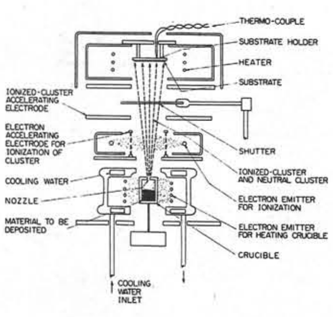

Fig.1 Schematic diagram of the vapourized-cluster ion source.

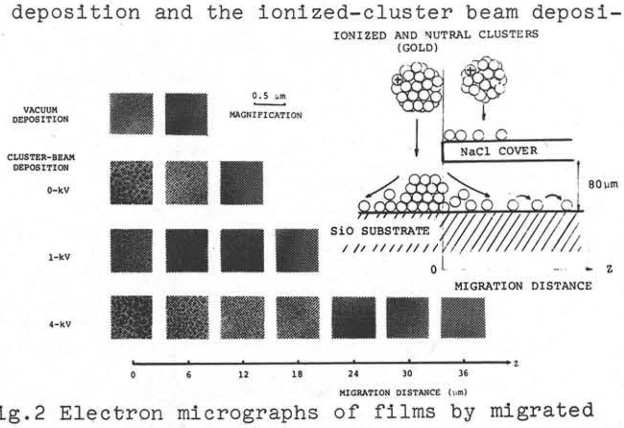

Fig.2 Electron micrographs of films by migrated deposits.

tion under the different acceleration voltage conditions. Figure 2 shows the electron micrographs of the island patterns of the diffused Au on the SiO surface covered by NaCl shadow plate with 80μm gap. Figure 3 shows reflection diffraction patterns of Si films deposited on Si substrates which show better crystalline state with the increasing of acceleration voltage. No substantial improvement was observed in the case of amorphous carbon substrates as shown in Fig. 4. From these results, migration, thermal, and sputtering effects converted from kinetic energy seem to be effective for the epitaxial deposition under the conditions of low substrate temperature (under 800°C) and conventional vacuum region (10^{-7}-10^{-5}Torr.).

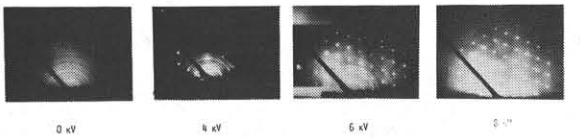

Fig.3 Diffraction patterns of Si films deposited onto single Si substrates.

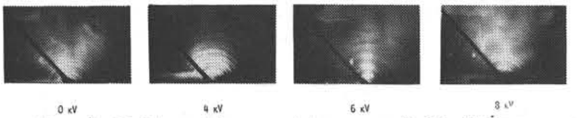

Fig.4 Diffraction patterns of Si films deposited onto amorphous carbon substrates.

A junction diode has been made by depositing an n-type Si layer onto a p-type Si substrate. The spectrum sensitivity of a photovoltaic diode are shown in Fig. 5 (a) and (b) for different deposited layer thickness and for comparison with that of a commercially available solar cell, respectively. The limitation of sensitivity (cut-off wave length) and half-value of the max. sensitivity at an uv region versus the film thickness are shown in Fig.5 (c) which indicate an increase in the sensitivities for reductions in the thickness of a deposited n-layer Si film. The spectrum sensitivity of various crystalline states are shown in Fig.5 (d) where the highest sensitivity is obtained in a single crystal layer.

(1) T.Takagi, I.Yamada and A.Sasaki, J. Vac. Sci. Technol., 12, 1975, p.1128.
(2) T.Takagi, I.Yamada, M.Kunori, and S.Kobiyama, Proc. of the 2nd International Conf. on Ion Source, 1972, p.790, and Proc. of the 2nd Symp. on Ion Sources and Formation of Ion Beam, 1974, p.7-4-1.

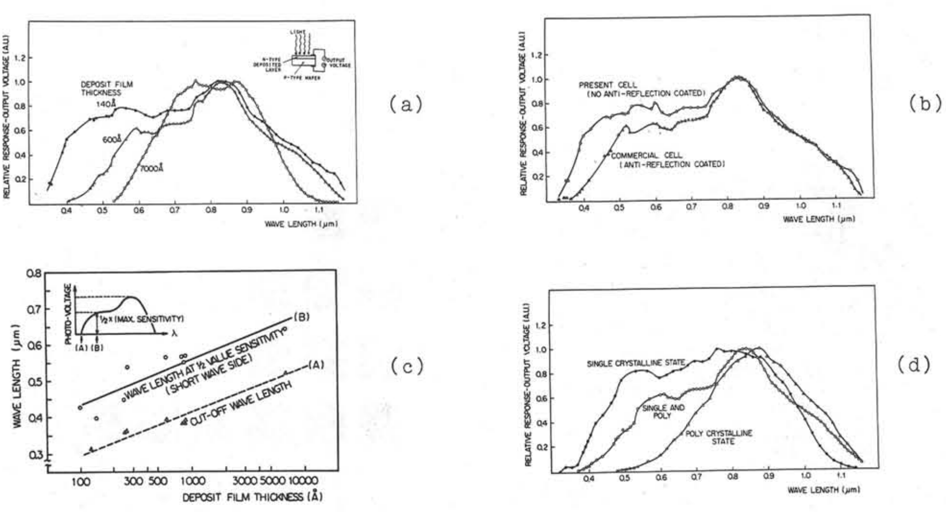

Fig.5 Spectral sensitivities of the photovoltaic diodes.