B－4－5 Amorphous Si_xGe_{1-x} for High Performance Solar Cells.

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Amorphous silicon (a-Si) is very interesting material from the point of view for low cost solar cells.[1] a-Ge films have also been investigated.[2,3] A new approach to obtain high efficiency a-Si solar cells has been proposed with tandem structure.[4]

This papaer reports a preliminary study on a glow discharge a-Si_xGe_{1-x} film properties and some types of cell structures using a-Si_xGe_{1-x} films.

Amorphous Si_xGe_{1-x} films were grown by grow discharge plasma using 10% Ar based silane and 5% H_2 based germane in cylindrical reaction tube which have capacitivtively coupled electrodes. Figure 1 shows the wave length dependence of light absorption coefficient for various Ge compositions. As the Ge content increases, the absorption coefficient increases. Figure 2 shows $E_{gopt.}$, photoluminescence peak photon energy and electron and hole mobilities u_n and u_p as a function of Ge content. u_n and u_p were measured by MOS transistor characteristics. u_n and u_p are nearly constant up to 25 mol % Ge and decreases suddenly above this value. Photoluminescence peak energy decreases monotonously with Ge content. Figure 3 shows photoluminescence spectra for three films with different Ge content. The shapes of the spectra have same structures indicating no significant change in band structure by addition of Ge. The content of Ge and Si were measured by AES method.

We fabricated two types of p-i-n type solar cells and a tandem cells as shown in Fig.4. (a) has a-$Si_{0.75}Ge_{0.25}$ i-layer, (b) has double layers of a-Si and a-$Si_{.75}Ge_{.25}$ and (c) has a tandem structure of a-Si and a-Si:Ge pin cells. Figure 5 and Fig. 6 show I-V characteristics and spectral responses of the cells. Open circuit voltage of the tandem cell increased as expected, while current level was reduced considerably by carriers recombination in the tunnel junction. The spectral response in the long wave length region were increased as seen from Fig. 6. with a-$Si_{.75}Ge_{.25}$ film in the active region in the cells. The decreases in the short wave length region may be resulted from the poor film properties of a-$Si_{.75}Ge_{.25}$ film. The improvements in film properties of a-Si_xGe_{1-x} and an optimum design of the cell structure are required to obtain high performance solar cells.

In conclusion, a-Si_xGe_{1-x} film was prepared by glow discharge plasma method and its optical and electrical properties were measured. Various solar cells were fabricated and evaluated their photovoltaic properties. Improvements in solar cell performance were expected from these results.

References: 1)D.E.Carlson and C. Wro nski, J. Electronic Mater. 6 (1977)95.
2)R. C. Chittick, J. non-Cryst. Solids, 3 (1970)255.
3)D. I. Jones, Phil. Mag. B 39 (1977) 147.
4)V. L. Dalal, a-Si Workshop, San Diego, Jan. 1980 and to be published.
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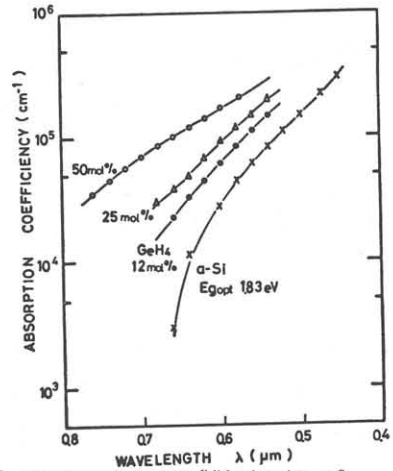

Fig.1 Absorption coefficients of $a\text{-}Si_xGe_{1-x}$ films

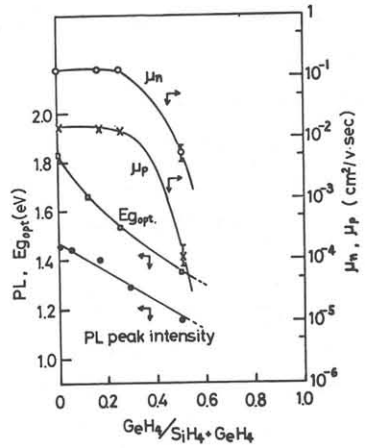

Fig.2 Optical band gap E_{g}opt, photoluminescence peak energy, u_n and u_n vss Ge content in $a\text{-}Si_xGe_{1-x}$ films

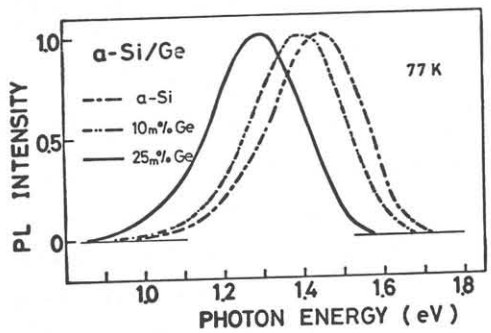

Fig. 3 Photoluminescence spectra for various Ge content in films.

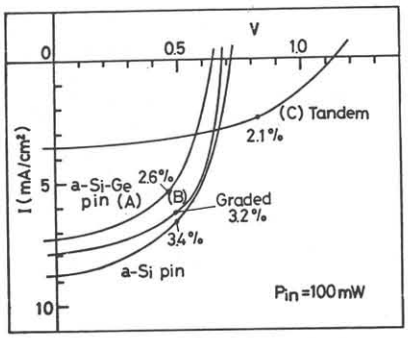

Fig.5 I-V characteristics of the three types of solar cells given in Fig.4.

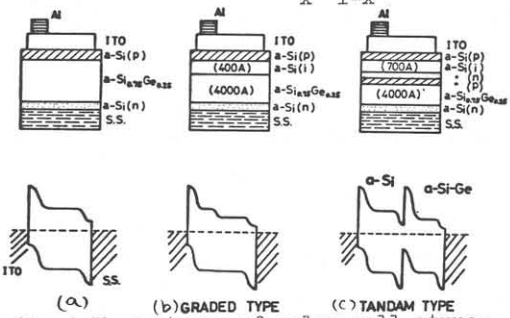

Fig.4 Three types of solar cell structures using $a\text{-}Si_{.75}Ge_{.25}$ film.

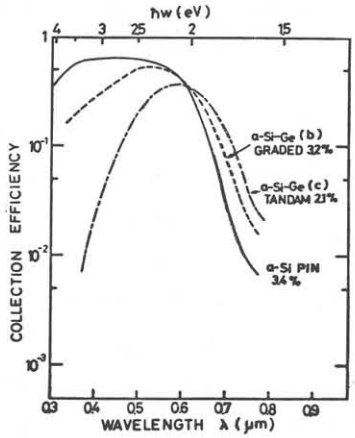

Fig. 6 Spectral responses of the three types of the solar cells given in Fig.4.