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Near Infrared Photoconductivity in a-Si:H(F)/a-SiGe:H(F) Multilayers

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Recently, increasing attention has been paid to photoconductive materials with bandgaps between 1.3 and 1.5eV. Such materials could be employed in photoreceptor for laser printers and tandem-type solar cell application. Amorphous Si based alloys with incorporating Ge are promising candidates. However, lowering of the gap is generally accompanied by a deterioration in the photoresponse; a reduction of photoconductivity and an increase in dark conductivity. In this paper we report an attempt to solve the problem by employing multilayers of a-Si:H(F)/a-SiGe$_x$:H(F) prepared by hydrogen radical assisted chemical vapor deposition[1)]

Multilayers of a-Si:H(F)/a-SiGe$_x$:H(F) were deposited by controlling the flow of GeF_4 sequentially under the steady flow of SiF_4 in RF plasma and hydrogen radical generated by microwave plasma.[2)] Thanks to the large incorporation efficiency of Ge atom in the alloy, small (less than 1vol%) pulse of GeF_4 gas flow makes 40% Ge in the film. Therefore, multilayered structure were prepared continuously by controlling only the flow of GeF_4 without interrupting RF plasma.

In Fig. 1, electrical conductivity in the dark and under light illumination (725nm, 0.2mW/cm^2) measured at room temperature both in the direction parallel and perpendicular to the plane are plotted as a function of the repetition length L . The number in the figure indicates the total number of layer pairs . The total thickness of the films used is about 0.5 μm. Photoconductivities measured in both directions are in almost the same order of magnitude and independent of the L value. The high photoconductivity observed in the samples with many interfaces suggests that there are no additional deep trapping states at the interface. The perpendicular dark-conductivities of the multilayer films are lower than that of a-Si:H(F) and decrease with increasing the L value.

Photo and dark current-voltage characteristics were measured for reverse biased Schottky device with a-Si:H(F) (E_0=1.72ev) / a-SiGe$_x$:H(F) (E_0=1.45ev) multilayered structure (L=80A,N=100) as shown in **Fig. 2**. Highly photoconductive gain (the saturated current normalized by the photon flux) is obtained in the multilayer films at the wavelengths of around 725nm compared with that of a-Si:H(F).

The drift mobility of electrons, evaluated from the time-of-flight measurements, was 10^{-2}-10^{-3} cm^2/Vs, while mobility-lifetime products was 10^{-7}cm^2/V. These results imply that the electron transport in the multilayer films should be ruled by the additional shallow trapping states. The drift mobility of holes, on the other hand, was 10^{-3}cm^2/Vs, which was the similar magnitude to that of a-Si:H(F) suggesting that multilayers didnot affect the valence band.

In conclusion, high photosensitivity was obtained in the near infrared light region, while suppressingdark current, by employing a-Si:H(F)/ a-SiGe$_x$:H(F) multilayers.

1) S. Oda, S. Ishihara, N. Shibata, H. Shirai, A. Miyauchi, K. Fukuda, A. Tanabe, H. Ohtoshi, J. Hanna and I. Shimizu, Jpn. J. Appl. Phys. 25(1986) L188.
2) H. Shirai, A. Tanabe, S. Oda, J. Hanna, T. Nakamura and I. Shimizu, Jpn. J. Appl. Phys, (in press).

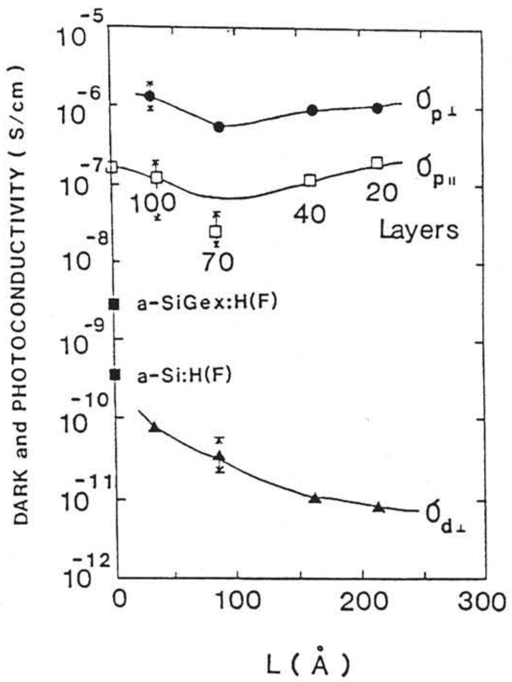

Fig 1

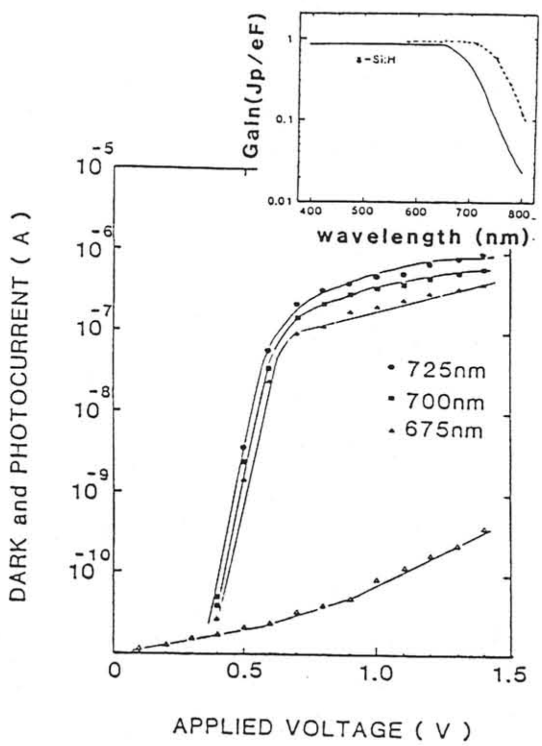

Fig. 2