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Amorphous Silicon Photoconsensor

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The photoconductivity in amorphous silicon films seems to be promising for large scale sensor applications. The photoconductive sensitivities and transient behaviors are investigated in a series of doped and non-doped a-Si specimens. Specimens were prepared by the glow discharge decomposition of silane. Doping was achieved by the addition of controlled amounts of phosphine and diborane during deposition. Experiments were carried out on planar structure specimens with interdigital gap electrodes separated by 0.5mm. The transient properties were measured by a box-car integrator under the illumination of pulsed argon laser (λ =5145A).

Figure 1 shows dark and photoconductivity, σ_d and σ_p as a function of doping levels. The maximum ratio σ_p/σ_d is 5×10^4 when boron is lightly doped.

The photocurrent decay behaviors of non-doped specimens are summarized in Fig.2. The first decay corresponds to the quasi-thermalization between localized tail states and extended states. The second decay represents a striking behavior, where log i_p-log t plot is straight over the wide range. This decay corresponds to the recombination processes between trapped electrons and holes. This is interpreted using a model of diffusion limited bimolecular recombination.(1) The decay gets faster as the illumination intensity increases or the pulse width decreases, which corresponds the line shift as shown with arrows. The addition of dc illumination and the increase of pulse repetition are accompanied by the departure from the straight line. The log i_p-log t plots of rise and decay behaviors are shown in Fig.3 (a) and (b), respectively. It is interesting that phosphorus doping causes fast rise and very slow decay, and that boron doping causes slow rise and slow decay. As shown above transient behaviors of amorphous silicon are not exponential and can.not be characterized by so called rise and decay time. In order to estimate the performance of a-Si films for facsimile photoconsensors, on-off ratio of photocurrent was measured for the modurated laser pulses of 10msec pulse width, 20msec repetition time and 150μW/cm^2 illumination intensity. Figure 4 shows on-off ratio (which are defined as the inserted figure of Fig.4) as a function of doping levels. It is the heighest for non-doped sample and drastically reduced by impurity doping. For application to facsimile photoconsensor the dynamic on-off ratio is more important than dc sensitivity (σ_p/σ_d). Therefore we fabricated 32 bits photoconsensor array of non-doped a-Si. In a interdigital geometry using top surface electrodes 100μm long separated by 10μm gap, photocurrent more than 1μA was obtained under illumination of 100μW/cm^2 and applied voltage of 10V.

The sensitivity and the transient behavior of a-Si photoconductivity are very sensitive to impurities. This infers that the purification or some other impurity doping may improve the sensitivity and the transient behavior.

1) N.Matsumoto, T.Kagawa, G.Motosugi and K.Kumabe; Jpn. J. Appl. Phys. Suppl. 2nd Photovol. Sci. Eng. Conf. Jpn. (1981) 175

2) D.A.Anderson and W.E.Spear; Phil. Mag. 36 (1977) 695

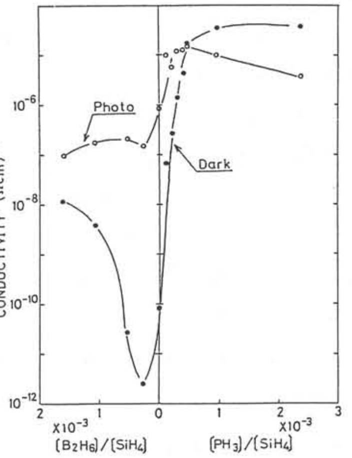

Fig.1 Doping level dependence of dark and photoconductivity. Light intensity is 400μW/cm^2.

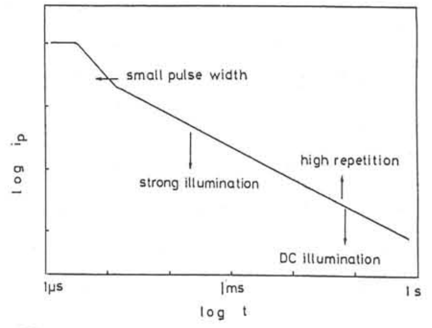

Fig.2 Photocurrent decay behavior of non-doped a-Si

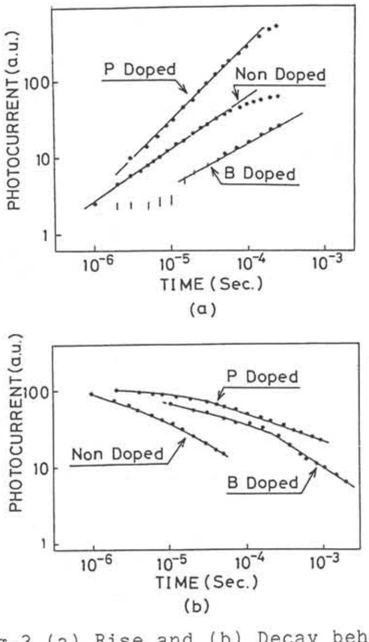

Fig.3 (a) Rise and (b) Decay behavior of doped samples. Light intensity is 6mW/cm^2.
(a) Pulse width T_1=300μsec
Repetition time T_2=300msec
(b) T_1=100μsec T_2=100msec

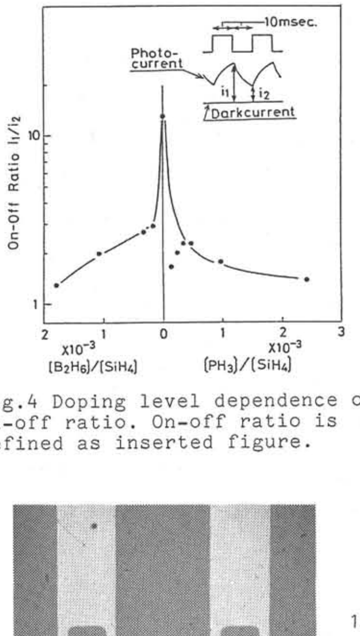

Fig.4 Doping level dependence of on-off ratio. On-off ratio is defined as inserted figure.

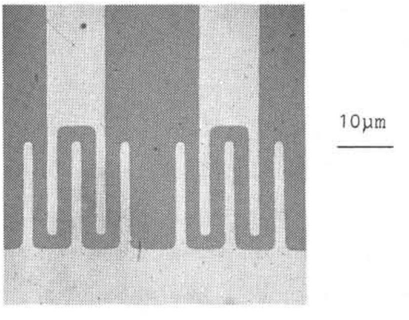

Fig.5 Amorphous silicon photoconsensor array