C — 3 — 3 Single-tube Color Imager using Hydrogenated Amorphous Silicon

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Hydrogenated amorphous silicon (a-Si:H) has attracted much attention, and its application to electron devices has been actively studied. Imaging devices have recently become a promising application of a-Si:H[1) 2)], since this material has high photoconductivity, high dark resistivity and can be deposited on almost any substrate material.

We proposed a vidicon-type imaging tube using a-Si:H for the first time[3)], and reported the following advantages over conventional imaging tubes and solid state imagers: high photosensitivity, high resolution, no blooming or burning and stability up to 200°C, or more.

However some problems were left unsolved. First, it was necessary to reduce the large decay lag in the a-Si:H vidicon. Second, reduction of operating voltage and suppression of dark current were simultaneously required. We have developed an improved a-Si:H target and overcome these problems. Application of our new a-Si:H films in a color-filter-integrated single-tube camera is also reported in this paper.

For application in photoconductive targets, the following characteristics of a-Si:H are required: (1) resistivity high enough to store image signals and get high resolution, (2) spectral photosensitivity that covers the whole visible range and extends very little into the infrared region. We prepared highly resistive a-Si:H films by RF reactive sputtering of silicon in a mixed atmosphere of H_2 and Ar. The substrate temperature was about 250°C. Total pressure of the mixed gas was $1 \sim 5 \times 10^{-3}$ Torr, and the selected H_2 ratio had to be 40% or more. A-Si:H films deposited under such condition have an E_g of 1.9～2.0 eV and a resistivity of about $10^{13} \Omega$ cm, thus satisfying (1) and (2) above.

Fig.1 shows the schematic structure of our a-Si:H photoconductive target. On the optically flat surface of glass face plate 18 mm in diameter, a layer of tin oxide was deposited as a transparent electrode. An additional layer was inserted between the electrode and the photoconductor in order to block hole injection from the electrode without affecting signal current flow. Very thin SiO_2 was found to be effective for our purpose, and the thickness of the SiO_2 was selected to be around 200 A. The blocking layer and the a-Si:H photoconductor were successively deposited by sputtering.

Experiments with the infrared transmission spectra showed the a-Si:H vidicon

target to be better only when the a-Si:H showed a di-hydride configuration, that is, when only one peak, at 2100 cm^{-1}, was observed about the stretching mode. This phenomenon is quite different from results with a-Si:H for solar cell use.

Photo- and dark current-voltage characteristics of the target are shown in Fig.2. The dark current was suppressed to less than 1 nA up to 3×10^5 V/cm by the SiO_2 blocking layer. The photocurrent increased with target voltage, until, at voltage V_s, it reached the saturation level, which is estimated to be at almost $\eta=1$. Photo-electric properties were enormously improved by lightly doping impurities into the a-Si:H films. In the case of the undoped a-Si:H target, the saturation voltage was at least 30 V, and the decay lag was about 15 % at 50 msec after turning off the light signal corresponding to an intensity of 0,2 μA. On the other hand, V_s for a doped a-Si:H target was less than 10 V, and the decay lag was drastically reduced to 3.5 %, without affecting the horizontal resolution, which was more than 600 TV lines.

Using a color-filter-integrated substrate as the face plate for our improved a-Si:H vidicon target, we have successfully fabricated a single-tube color image camera. The color image reproduced by this camera is shown in Fig.3.

In summary, we have enormously improved a-Si:H vidicon characteristics, and have confirmed the possibility of its commercial use.

References

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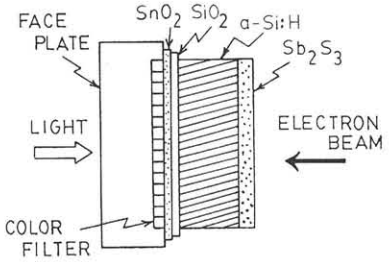

Fig. 1 Schematic structure of a-Si:H photoconductive target.

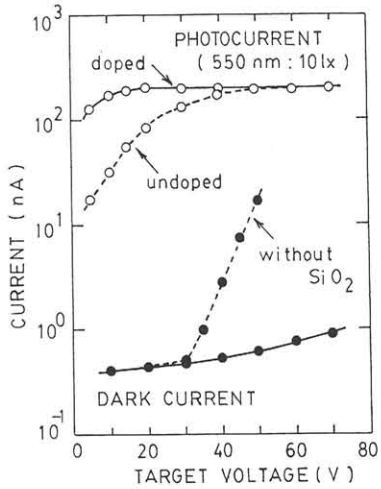

Fig. 2 Current-voltage characteristics of a-Si:H target.

Fig. 3 Color image reproduced by a-Si:H single-tube vidicon.