B－4－7 Electrophotographic Properties of RF Discharge-Produced Amorphous Si:H Film

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Up to now, there have been used, for electrophotographic photoreceptor, evaporated films of amorphous Se or its alloys, CdS and ZnO-resin layers, and PVCz-TNF organic photoconductor films.[1] However, with these photoreceptors, many should be improved are remained unsolved in sensitivity, life and reliability. Recently, there appeared many reports on electrical and optical properties of amorphous silicon (a-Si:H) film prepared by glow discharge decomposition of SiH_4. Such a-Si:H film has a prominent photoconductive properties in visible spectral range, however, the dark resistivity, 10^9- 10^{10} ohm-cm, is still not enough to use it for electrophotographic application. In this work, We have succeeded, for the first time, to obtain a-Si:H film of such a high resistivity as 10^{13}- 10^{14}ohm-cm with suitable doping by B_2H_6 and a slight content of oxygen.[2]

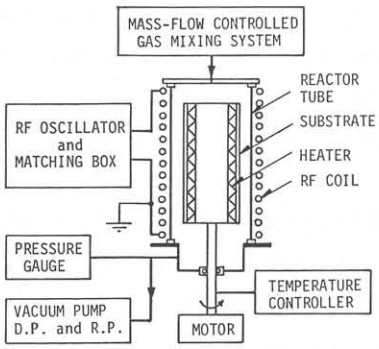

Fig. 1. Inductive coupled RF glow discharge a-Si:H deposition system.

Figure 1 shows our a-Si:H deposition system of inductive coupled RF glow discharge. Substrate, Al plate or drum, heated at 200°C is centraly placed in a pylex plasma reactor tube of 200 mmφ and 800 mm hight. The substrate is made of meticulously cleaned, uniformly oxidized aluminum. For homogeneous deposition, the substrate can be rotated at the rate of 50- 100 rpm during deposition. Typical parameter of deposition is shown in Table 1 and several drums and plates are shown in fig. 2. The largest drum is 20 inches long and 5 inches in diameter.

Table 1. DEPOSITION PARAMETERS

PARAMETER		RANGE
RF Power		300 W, 4 MHz
Pressure	(Back)	5 x 10^{-6} Torr
	(Gas)	0.5 - 2.0 Torr
Gas	(SiH_4)	10 % in H_2
	(B_2H_6, PH_3)	20 ppm in H_2
Flow Rate		50 - 300 sccm
Deposition Rate		15 - 1000 A / min
Substrate Temperature		R.T. - 400 °C
Thickness		10 - 20 μm

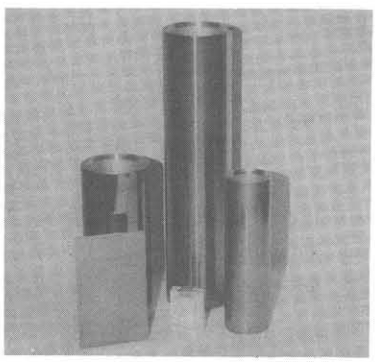

Fig. 2. Photograph of amorphous silicon deposited drums and plates.

Dark- and photo-conductivity at 632.8 nm illumination for various doping gas ratios (B_2H_6/SiH_4 or PH_3/SiH_4) is shown in fig. 3. These doped a-Si:H film are found to contain about 0.2 at% oxygen by Auger analysis. Even for non-doped sample, the dark resistivity reached 10^{12}ohm-cm and doping of B_2H_6/SiH_4 of 10^{-3} marked 10^{14}ohm-cm. For this sample, light to dark conductivity ratio about 10^4 at 200 $\mu W/cm^2$ illumination is obtained.

Figure 4 shows the typical electrophotographic

decay characteristics of the positive surface potential for amorphous silicon plate (sample B of fig. 3) at different illumination wavelengths. The spectral sensitivity of amorphous silicon plate (samples A and B of fig. 3) in 400- 800 nm range is shown in fig. 5, where the sensitivity, E_{50}, is the reciprocal of photo-energy during the half decay. Both samples can be bi-chargable and have maximum sensitivity in 600- 650 nm wavelength range.

Figure 6 shows the spectral sensitivity of several photoelectric materials for electrophotography. The sensitivity decreases rapidly for longer wavelength, however, the sensitivity of our amorphous silicon plate is higher than other photoelectric materials, especially near 650 nm.

Figure 7 shows an example of reproduced images with positively charged amorphous silicon drum developed with negatively charged two components toner (Posi-Posi images). Because our amorphous silicon drum is bi-chargable, we can easily obtain a negative image only by reversing the polarity of corona discharge potential (Nega-Posi images).

In conclusion, amorphous silicon film deposited at the condition of 10^{-4} B_2H_6/SiH_4 ratio and a slight content of oxygen has the highest dark resistivity and high photosensitivity never has been reported. By using such amorphous silicon film, high surface hardness, very long life and bi-chargable photoreceptor for various applications can be constructed.

References 1) R. Schaffert, "Electrophotography", The Focal Press, N. Y. (1975).
2) T. Kawamura et al., Symposium S-34 in annual Meeting of I. E. E. of Japan (Mar. 29, 1980).

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Fig. 7. Posi-posi reproduced images by amorphous silicon deposited drum.

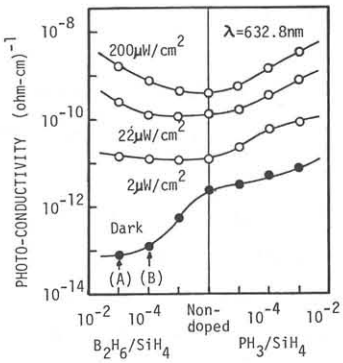

Fig.3. Dark- and photo-conductivity of various doping ratios.

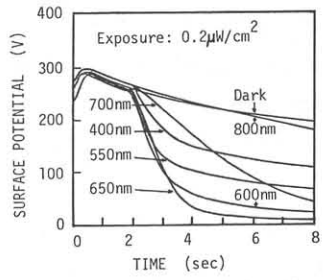

Fig. 4. Typical electrophotographic decay characteristics.

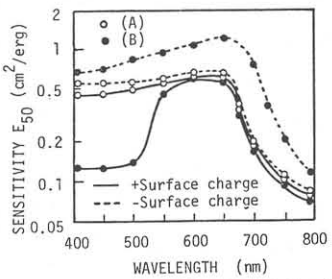

Fig. 5. Spectral sensitivity of doped amorphous silicon plate.

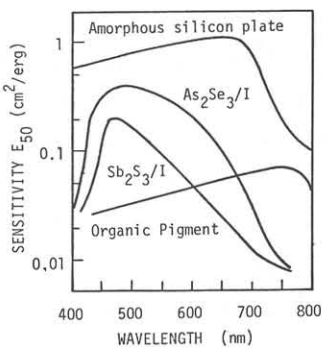

Fig. 6. Spectral sensitivity of some photoelectric materials.