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Fabrication and Properties of a-Si:H Photoreceptor, and its Application to Laser Beam Printer

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Introduction Amorphous silicon (a-Si:H) films prepared by plasma decomposition of SiH_4 have prominent properties such as high photoconductivity, high surface hardness and good thermal stability for electrophotographic applications.[1,2] The authors have obtained a-Si:H films, dihydride rich, appropriate for electrophotographic photoreceptors by doping with B_2H_6 and a small quantity of oxygen using a RF inductively coupled system.[3,4] This technique, however, suffers from low rate of deposition and is not suitable for mass-production. In order to improve the deposition rate, we have developed a RF diode system and succeeded in the fabrication of excellent electrophotographic photoreceptor drums (a-Si drum) at high deposition rates.

Fabrication Figure 1 shows the RF diode system for preparing a-Si drums. An Al-drum substrate (grounded) was in the center of the reactor. RF power (13.56 MHz) was applied to two electrodes EL_1 and EL_2. The gas mixture (SiH_4 and B_2H_6) and oxygen are introduced separately in to the reactor from perforated tubes attached to the electrode, EL_1, and are exhausted from a tube attached to the electrode, EL_2. The plasma conditions were optimized by monitoring the plasma emission spectra from the top of the reactor during the deposition. The parameters typically used are listed in Table I. Figure 2 shows the deposition rate v.s. SiH_4 concentration where RF power is varied as a parameter. The broken line indicates parameters required to obtain excellent electrophotographic characteristics.

Properties Drift mobility in a-Si:H films deposited at high rate (6 μm/h) for various doping gas ratios (B_2H_6/SiH_4 or PH_3/SiH_4) is shown in Fig.3. These films contained about 0.01 wt% of oxygen. The mobility was measured by the conventional time-of-flight method. Electron mobility decreases when doped with B_2H_6 and becomes almost the same as hole mobility at 10^{-4} of B_2H_6/SiH_4. This a-Si:H film is intrinsic and has bipolar properties. Figure 4 shows the spectral sensitivity of an a-Si drum prepared by this method. The photosensitivity, E_{50}, is defined as the reciprocal of the light energy required to reduce the surface potential to one half of its initial value. For both positive and negative charges, the drum has high photosensitivity over the full visible spectrum with a peak at 650 nm. Though photosensitivity decreases at longer wavelength, diode lasers in the neighborhood of 800 nm can be used as a light source. The dependences of photosensitivity and charge acceptance (V/μm) on oxygen content in a-Si:H films are shown in Fig.5. At oxygen contents higher than 0.02 wt%, the photosensitivity decreases rapidly, while the charge acceptance increases for both surface charge polarities. Practical oxygen content is 0.005 to 0.03 wt%.

Application We developed a laser beam printer, based on Carlson's process, using an a-Si drum (130 mm^{ϕ} x 280 mm^{h}) and a diode laser (λ=770 nm, 5mW). A print sample is shown in Fig.6.

A laser beam with 100 μm spot size and 1 $\mu J/cm^2$ energy density was scanned at 340 m/sec speed on the drum rotated at 120 mm/sec circumference-speed.

Conclusion Using a RF diode system, a-Si drums were fabricated at high deposition rate of 6 μm/h. It was found that thus prepared drums are appropriate for laser beam printer and intelligent copier application.

References

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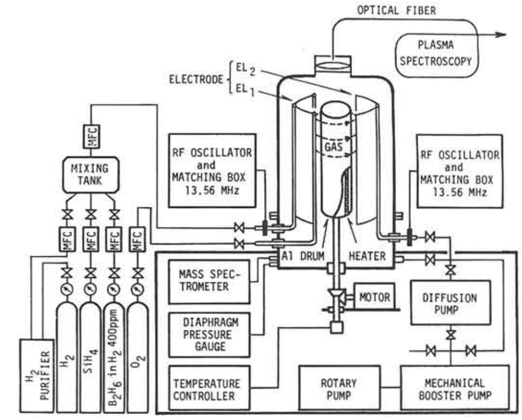

Fig.1. Schematic diagram of RF diode system for fablicating a-Si drums.

Table I. DEPOSITION PARAMETERS OF a-Si DRUM

PARAMETER	RANGE
RF power (13.56 MHz)	0.5 - 1.0 kW
Pressure	
(base)	5 x 10^{-6} Torr
(gas)	1.0 - 2.0 Torr
Mixing ratio	
B_2H_6/SiH_4	10^{-4}
O_2/SiH_4	10^{-2} - 10^{-1}
Total gas flow rate	200 - 500 sccm
Deposition rate	1.0 - 8.0 μm/h
Substrate temperature	200 - 250 °C
Film thickness	10 - 50 μm
Substrate material	Aluminum drum

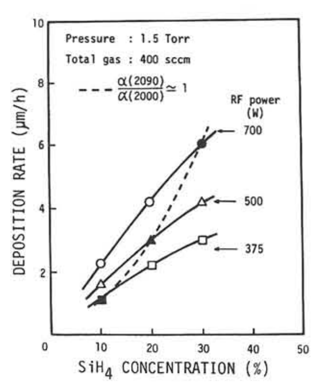

Fig.2. Deposition rate as a function of SiH_4 concentration.

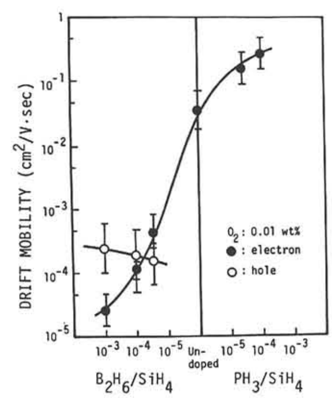

Fig.3. Drift mobilities of a-Si:H films for various doping gas ratios.

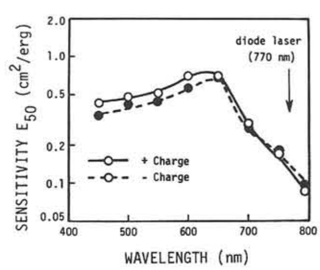

Fig.4. Spectral sensitivity curves for a-Si drum.

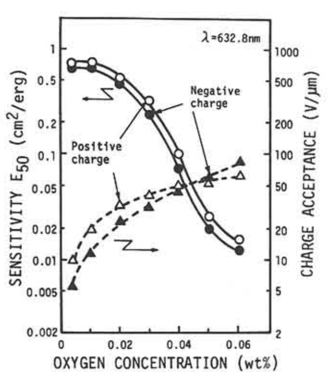

Fig.5. Sensitivity and charge acceptance as a function of oxygen concentration.

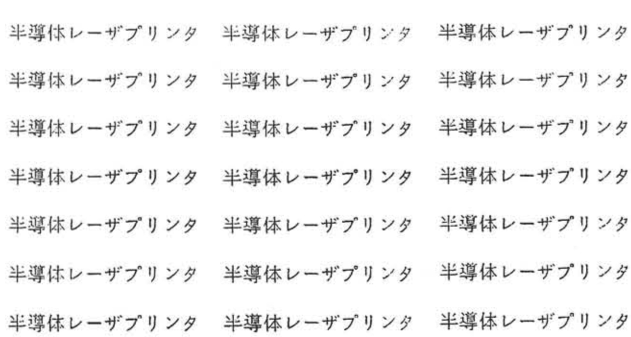

Fig.6. An example of image made by a laser beam printer with a diode laser (770 nm).