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Semi-Transparent Organic Photo Detectors Utilizing a Sputter Deposited Indium Tin Oxide for a Top Contact Electrode

Taichiro Morimune, Hirotake Kajii and Yutaka Ohmori

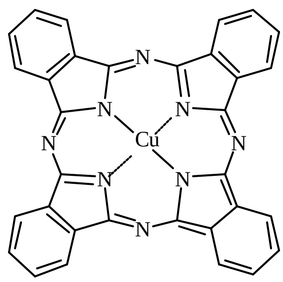
Osaka University, Center for Advanced Science and Innovation (CASI)
2-1 Yamada-oka, Suita 565-0871, Japan
Phone: +81-6-6879-4214, Fax: +81-6-6879-4212 E-mail: morimune@casi.osaka-u.ac.jp

1. Introduction

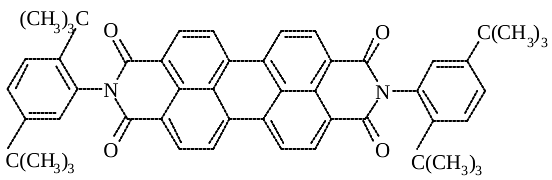
Recently, organic materials have been attracted a great deal of attention to the scientists because of their unique characteristics and potential for applications, such as light-emitting devices[1-3)], transistors[4)], photovoltaic cells[5,6)], and so on[7)]. These devices can be fabricated onto a wide variety of substrates, such as flexible conducting foils by the progress in the fabrication process of organic thin-film devices.

We have already reported the fabrication and the photo-response of organic photo detectors utilizing various kind of metal-phthalocyanine thin film[8)].

In this study, we report the fabrication and the characteristics of semi-transparent organic photo detectors with a sputter deposited indium thin oxide (ITO) top contact electrode.



(a) cupper phthalocyanine (CuPc)



(b) butylphenyl perylenedicarboximide (BPPC)

Fig. 1. Molecular structure of organic materials used for photo detectors.

2. Experimental

The photo detectors were fabricated by CuPc and BPPC on ITO – coated glass substrate using organic molecular beam deposition method. We used cupper phthalocyanine (CuPc) for n-type material which showing high mobility and photo activity and N,N'-bis(2,5-di-tert-butylphenyl) 3,4,9,10-perylenedicarboximide (BPPC) for p-type material as shown in Fig.1 (a) and (b), respectively. ITO cathode was deposited by using a mirrortron-type sputtering system (Thin-Film Process Soft Inc., Japan). Using the sputtering system, we can obtain high-quality ITO film without annealing process of the deposited film. The ITO film has a resistively in the order of the 4×10^{-4} Ωcm. In order to prevent ITO penetration into organic layer, a-C:N buffer layer was deposited using the sputtering system. The device structure is schematically shown in Fig.2. The active area of the device was about 0.1 mm^2.

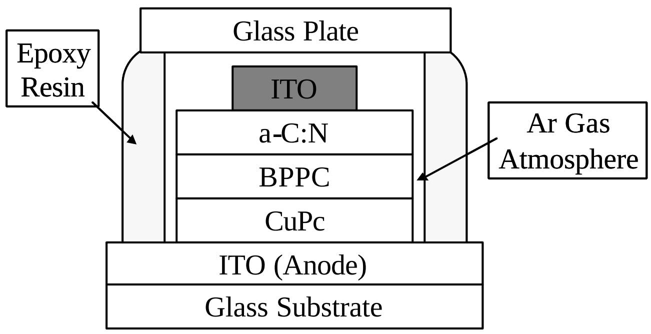


Fig. 2. A schematic of typical photo detector.

The voltage and photo current characteristics were measured Keithley 6517 system electrometer. The measurements of transient photo response were performed by using Agilent 8114A pulse generator and Tektronix TDS3054 digital oscilloscope. The both measurements were examined under illumination of DC and pulsed light of red LED with the peak emission wavelength at about 640nm.

For an application on the optical sensor such as pattern recognition, the photo responses with different reflection of papers in front of the glass plate were examined. As the object, black paper, white paper and aluminum sheet with reflection of 0.2%, 20%, 77.3% at 640nm, respectively. The reflectance of the papers was measured by Photo Spectrometer (Shimadzu UV-3100FS).

3. Results and Discussions

In Fig. 3, the voltage - current characteristics of ITO/ CuPc /BPPC /a-C:N /ITO organic photo detector is shown under illuminated and in dark. Shown in curve (a), the device shows the good rectifying characteristics under dark conditions. On the other hand, under red light illumination from the LED, the device shows good photo response in the reverse bias region, as is in curve (b). Even if compared with Ag /CuPc /BPPC /ITO organic photo detector, it observed the decrease in photo response of only about 30% at -1.0V bias regardless of the diffusion of ITO particles into the organic layer.

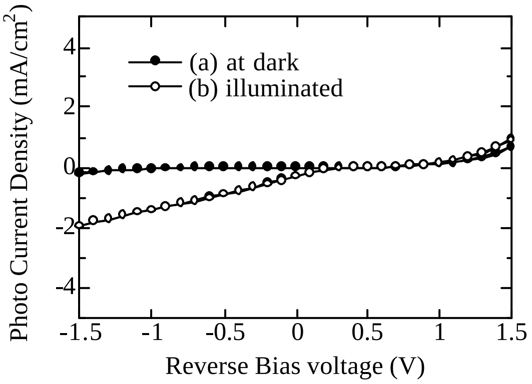


Fig. 3. Current-voltage characteristics of ITO / CuPc (20nm) / BPPC (20nm) / a-C:N /ITO with active area of $0.1mm^2$. The red LED for illumination has emission peak at about 640nm.

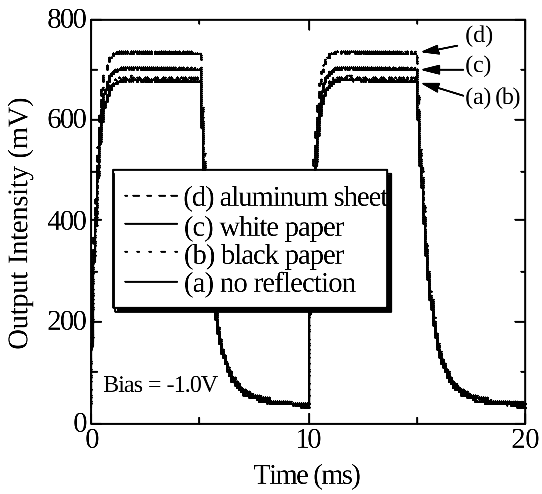


Fig. 4 Photo response dependence of the output current intensity with reflection of a black or white sheet and an aluminum sheet at -1.0V bias voltage at 100Hz modulation. 100kO terminal resistance was used for measuring the output current.

In Fig. 4, the photo responses with different reflection of papers in front of the glass plate were shown. The curve (a) shows at no object condition, (b) shows at black paper condition, (c) shows at white paper and (d) shows at aluminum sheet. The order of intensity of reflection used objects was black < white < aluminum. The curves in Fig. 4 show the intensity of photo response increases with the increasing the reflectance of objects.

On the other hand, the increase of photo response is not proportional to the reflectivity of object materials. The results will be due to the low absorbance and the insufficient thickness of used organic materials.

By optimizing thickness, absorbance and mobility of organic material and the device structure, the photo detection and the frequency response characteristics will be improved.

4. Conclusions

Fabrication and the photo response of semi-transparent organic photo detectors with a DC sputter deposited ITO top contact electrode have been discussed. We obtained the dependence of output current intensity on the reflectivity of the object in front of semi-transparent photo detector utilizing ITO top contact structure.

The technology of the semi-transparent photo detector will promise large possibility for the organic device process due to the lithography process on the organic material.

Acknowledgements

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