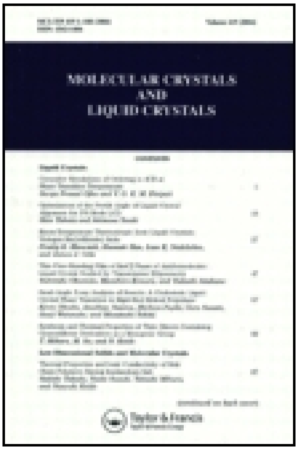

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Enhancement of Short-Circuit Photocurrent in Merocyanine LB Film Cell Utilizing Surface Plasmon Polariton Excitation

Kazunari Shinbo [a], Akira Baba [a], Hironori Tsuruta [a], Takaaki Ebe [a], Futao Kaneko [a], Keizo Kato [a] & Takashi Wakamatsu [b]

[a] Niigata Univ., Ikarashi 2-8050, Niigata, 950-2181, Japan

[b] Ibaraki Natl. Coll. of Tech., Nakane 866, Hitachinaka, Ibaraki, 312-0011, Japan

Version of record first published: 24 Sep 2006

To cite this article: Kazunari Shinbo, Akira Baba, Hironori Tsuruta, Takaaki Ebe, Futao Kaneko, Keizo Kato & Takashi Wakamatsu (2000): Enhancement of Short-Circuit Photocurrent in Merocyanine LB Film Cell Utilizing Surface Plasmon Polariton Excitation, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 349:1, 231-234

To link to this article: http://dx.doi.org/10.1080/10587250008024907

Mol. Cryst. Liq. Cryst., 2000, Vol. 349, pp. 231-234
Reprints available directly from the publisher
Photocopying permitted by license only

Enhancement of Short-Circuit Photocurrent in Merocyanine LB Film Cell Utilizing Surface Plasmon Polariton Excitation

KAZUNARI SHINBO[a], AKIRA BABA[a], HIRONORI TSURUTA[a], TAKAAKI EBE[a], FUTAO KANEKO[a], KEIZO KATO[a] and TAKASHI WAKAMATSU[b]

[a]*Niigata Univ., Ikarashi 2–8050, Niigata 950–2181, Japan and* [b]*Ibaraki Natl. Coll. of Tech., Nakane 866, Hitachinaka, Ibaraki 312–0011, Japan*

In this study, photocurrents enhanced by the surface plasmon polariton (SPP) excitation were observed in a merocyanine (MC) Langmuir-Blodgett (LB) film cell. The excitation of the SPP was carried out by the incidence of a laser beam in the attenuated total reflection (ATR) measurement system. The excitation of the SPP induces the strong absorption of the incident light and large photocurrents in the device.

Keywords: surface plasmon polariton; attenuated total reflection measurement; photoelectric effect; merocyanine; LB film

INTRODUCTION

Recently, several studies of organic photoelectric devices have been reported[1]. For development of photoelectric devices with high efficiency, it is quite important to evaluate optical and electrical properties and structure of the devices. The ATR method is one of useful measurements of evaluating optical constants and layer structure of ultrathin films using the SPP excitation[2]. In this method, the SPP due to incident light are resonantly excited on surface of metal electrodes and strong electromagnetic fields, that is, evanescent fields localized at the interfaces.

It is very difficult to obtain high efficiency in conventional organic photoelectric devices because of the light transparency of thin organic layer, the light reflection of electrode in the cell, and so on. In this study, enhancement of the light absorption and the short-circuit photocurrent (I_{SC}) utilizing the SPP excitation in the ATR system was investigated for an MC LB film photoelectric cell[3].

EXPERIMENTAL DETAILS

The MC dye indicates p-type conduction and was used for an organic layer in the device. The MC LB film photoelectric cell with MgF_2 layer was set on the prism as shown in Fig.1. The excitation of the SPP was carried out using the ATR method. The layer structure of the sample enables the SPP excitations at the interface between the MgF_2 and the Al thin film and at the interface between the Ag thin film and the air due to the Otto and the Kretschmann configurations, respectively[2]. The ATR property and the I_{SC} in the device were observed simultaneously.

RESULTS AND DISCUSSON

Figure 2 shows the ATR curve as a function of the incident angle of the laser beam at 594.1 nm. The large dip at around 74° and the small one at around 43° were caused by the SPP excitations at the MgF_2/Al and the Ag/air interfaces, respectively. The calculated curve fitted the experimental one. The strong excitation was obtained at the MgF_2/Al interface because of the strong evanescent fields from the prism. The same tendency was observed for the incidence of the laser beam at 632.8 nm. The dielectric constant and thickness of the each layer which were calculated from the ATR curves are shown in Table1 and Fig.1, respectively.

Figure 3 shows the I_{SC} curves as a function of the incident angle of two laser beams at 594.1 nm and at 632.8 nm. The peak angles of the curves almost corresponded to the dip angles of the ATR curves in Fig.2.

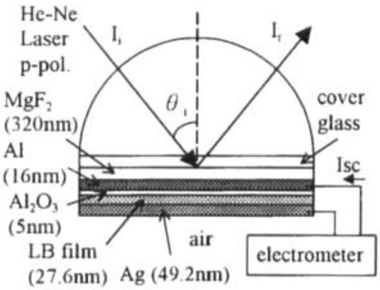

FIGURE 1 Structure of the photo-electric cell fabricated in this work.

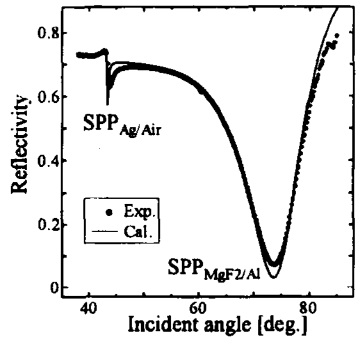

FIGURE 2 The ATR curves of the cell.

TABLE 1 Dielectric constants of the each layer in the device.

Film	ε * (594.1nm)	ε * (632.8nm)
Prism	2.300+i0.0	2.295+i0.0
MgF_2	2.0+i0.0	2.0+i0.0
Al	-36.0 +i13.57	-39.65 +i16.74
Al_2O_3	3.1+i0.0	3.1+i0.0
MC LB Film	1.992 +i0.861	2.531 +i0.137
Ag	-13.62 +i0.473	-15.92 +i0.544

This result indicates that the SPP excitation causes the large I_{SC} in the device. The large peak at around 74° and the small one at around 43° were also considered to be due to the strong SPP excitations and weak one at the each interface, respectively.

The light absorptions in the cell were calculated by the transfer matrix method[4] using the constants obtained from the ATR curves. The calculations were carried out for the absorptions at 38, 43.3 and 73.6° of the incident beam angles and exhibited no SPP excitation at 38° , the weak SPP excitation at the Ag/air interface at 43.3° and the strong SPP excitation at the MgF_2/Al interface at 73.6° . It was concluded that the enhancement of the absorption depended upon the SPP excitation. The light absorptions as a function of the incident angle were also calculated at 594.1 nm and at 632.8 nm. The calculated curves shown in Fig.4 almost correspond to the I_{SC} curves in Fig.3. It indicates that the increase of the incident light absorption dominates the enhancement of the I_{SC} in the device. The difference between the large I_{SC} at 594.1 nm and the

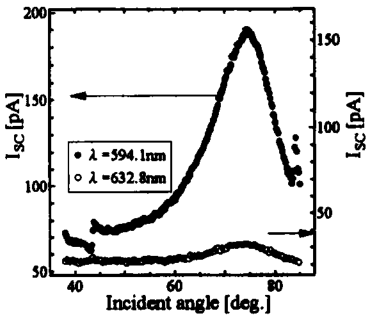

FIGURE 3 The incident angle dependence of the I_{SC}.

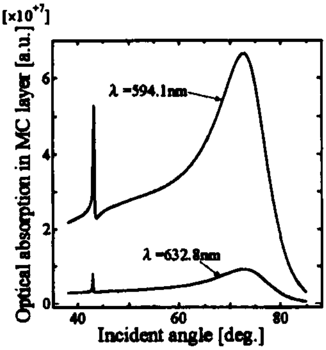

FIGURE 4 The calculated light absorptions in the MC layer.

small one at 632.8 nm in Fig.3 was caused by the strong absorption at about 600 nm due to the J-aggregation in the MC LB film.

CONCLUSION

The SPP excitations at the electrodes of the metal thin films enhanced the short - circuit photocurrent of the cell in the ATR configuration. The enhancement of the current was caused by the increase of the incident light absorption. This method is greatly useful for the development of new photoelectric devices with high efficiency.

Acknowledgement
This study is partly supported by Grant-in-Aid for Scientific Research from the Ministry of Education, Science, Sports and Culture of Japan.

References

[1] See for example, R.O. Loutfy and J.H. Sharp, J. Chem. Phys., **71**, 1211 (1979).
[2] See for example, *Surface polaritons*, eds., V.M. Agranovich and D.L. Mills (North Holland, Amsterdam, 1982).
[3] T. Wakamatsu , K. Saito, Y. Sakakibara and H. Yokoyama, Jpn. J. Appl. Phys., **36, 1A**, 155 (1997).
[4] G.J. Kovacs and G.D. Scott, Phys. Rev. B, **16**,1297(1977).