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## Investigation of the electrostatic phenomena at pentacene/metal interface; Electrical and optical approach for the study of FET operation

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### 1. INTRODUCTION

It is well known that, there has been an increase in interest in organic semiconductors along with the successful preparation of film with high mobility and high electrical conductivity. Since the injection behavior of charges at the metal/organic interface should be strongly influenced on the electrostatic phenomena at the interface, the study of electrostatic interfacial phenomena is of specially importance to the field of organic electronics. Nevertheless, for the actual device fabrication, as well as the investigating electronic structure of the interface, it is also essential to control the electronic structure of the interface for the practical application [1].

Such electrostatic interfacial phenomena have been revealed by not only the electrical method such as Kelvin probe method [2,3] but also the spectroscopic technique such as photoemission spectroscopy. Recently, we have made a proposal of a novel technique that enables us to detect the nano-interfacial polarization due to excess charge and dipoles by the optical second-harmonic generation (SHG) [4,5]. In this presentation, electrostatic phenomena occurring at pentacene/metal interface are investigated by using Kelvin probe and SHG technique. Oligoacene such as pentacene have a long time history as an organic semiconducting material. In particular, pentacene has recently attracted much attention because this molecule has a potential of high mobility which competitive with the standard amorphous Si. Within our knowledge, there is a small report related to the optical properties, especially nonlinear optical (NLO) properties, compared with the electrical properties. Accordingly, basic information related to the NLO properties is reported in the presentation in the framework of the improvement of

pentacene FET performance.

### 2. EXPERIMENT

In our experiment, pentacene was deposited on Al and Au covered glass substrate. Before the deposition of pentacene, some Au substrates was specially treated by UV/ozone for 30 min. Pentacene molecule was purchased from Sigma-Aldrich and used without further purification. During deposition, pressure and deposition rate were about  $10^{-6}$  torr. and  $0.5 \text{ \AA}/\text{sec.}$ , respectively, and the temperature of the substrate is about  $25^\circ\text{C}$ . An optical parametric oscillator (OPO) excited by the third-harmonics of YAG-laser was used as the fundamental light. To examine the surface potential by SHG, spectroscopic measurement (1000nm ~ 1400nm) was performed using OPO. Surface potential is also confirmed by Kelvin probe method in vacuum.

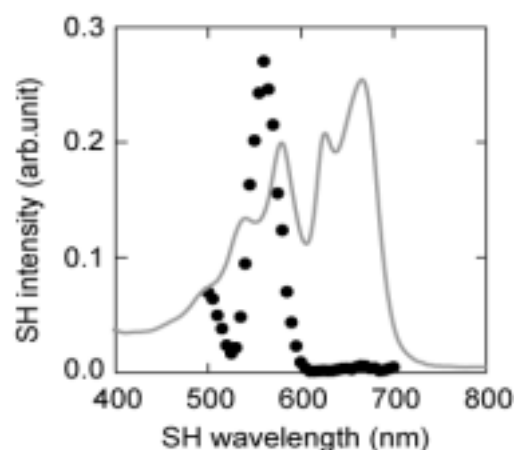


Fig. 1 : The SHG and absorption spectrum of pentacene(300nm)/glass sample.

### 3. RESULTS AND DISCUSSIONS

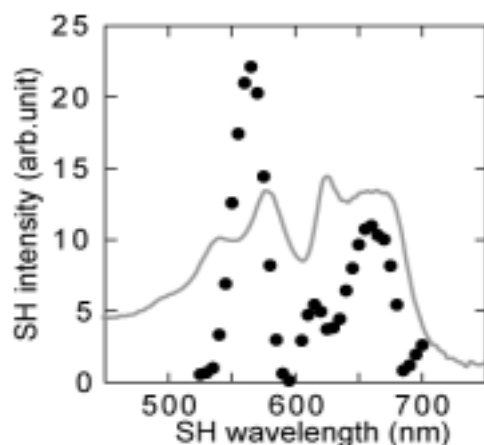


Fig. 2 : The SH spectrum of the pentacene (150nm) deposited on Al with the absorption spectrum.

Figure 1 shows the SHG spectrum of pentacene (300nm)/glass sample. Since the pentacene molecule itself and vacuum evaporated film possess the centrosymmetry, SH process should be forbidden under the electric dipole approximation. The SH peak observed at around 560nm can be assigned to the resonance to the forbidden excited state [6], probably due to the electric quadrupole transition as in the case of phthalocyanine [7]. Figure 2 shows the SH spectrum, indicating with the absorption spectrum, of the pentacene film (150nm) deposited on aluminum electrode. This spectrum was taken using reflected geometry. Absorption spectrum observed for pentacene/glass sample is almost coincident with that for pentacene/Al structure. On the other hand, SH spectrum for both sample are quite different. As shown in Fig.2, distinct peak was observed at 620nm in addition to the resonant peak to the forbidden state. Resonant condition for the SHG has been discussed in our previous paper. Position of the additional peak observed in pentacene/Al structure is almost coincident with the absorption peak. SH resonance to the allowed state in the centrosymmetric system is due to the lack of inversion symmetry. And surface potential breaks the symmetry in this case. Figure 3 shows the thickness dependence of the surface potential of pentacene deposited on Al and Au surface. Negative potential was formed across the pentacene film on Al surface, and this

potential activate the SH process in pentacene film with the inversion symmetry. Finally, as described in our previous paper [8], surface potential of pentacene on Au

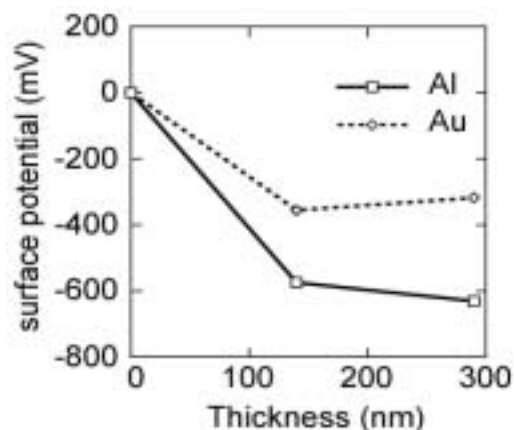


Fig.3 Thickness dependence of the surface potential of pentacene on Au surface.

surface changes drastically with the ozone treatment, and leads to the drastic change of the I-V characteristics of the pentacene films. The SHG properties and their dependency on the surface ozone treatment of pentacene/Au structure will be reported at the conference, and we then show that the present SHG study in association with the carrier injection properties of pentacene is useful for the improvement of FET performance.

### References

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