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A Study on Air stability of Pentacene Based MOS Diode Structures

Md. Akhtaruzzaman, S. Ohmi, J. Nishida, Y. Yamashita, H. Ishiwara

Interdisciplinary Graduate School of Science and Engineering

Tokyo Institute of Technology

J2-72, 4259 Nagatsuta-cho, Midori-ku,Yokohama-city 226-8502, Japan

Tel: +81-45-924-5473, e-mail: uzzaman.m.aa@m.titech.ac.jp

1. Introduction

A large number of organic semiconductors (small molecules and /polymers) have been investigated as electroactive materials for microelectronic / nanoelectronic device applications such as active matrix display, integrated circuits, RFID tags, sensors, solar cells, flexible memory devices etc.[1] Despite considerable improvement in device fabrication techniques and characterization of organic devices, the exact mechanism of charge injection and transport in these devices is not well understood yet. Still they have been suffering from several disadvantages such as low mobility, air-stability, high operational voltages etc. To restrict the hysteresis behavior in these devices which claimed to degrade their electrical properties and reduced the operation voltages, we examined pentacene based MOS diode structure on thin gate dielectric layer. Very often HMDS / OTS treated substrate has been used to reduce the hysteresis loops in organic devices, but there is no satisfactory results published yet to control it due to the effects of oxygen or moistures or fabrication techniques of SiO_2-gate dielectric.[2]

In this study, we have successfully fabricated pentacene thin films on thin SiO_2 gate dielectric with excellent interface properties without surface treatment by HMDS or OTS. The stability of these diodes in air was also examined.

2. Experimental Procedure

The schematic diagram of pentacene based MOS diode structure is shown in Figure 1. The top-contact type capacitors were fabricated utilizing 12 nm-thick thermally grown SiO_2 gate dielectric on n^+-Si (100) substrates. Pentacene film (24nm~64 nm) was grown by the vacuum evaporation (pressure 6.0 x 10^{-6} Torr) with deposition rate of 0.3 nm/min at room temperature. Au (φ 300 μm) for pentacene and Al for n^+-Si as electrical contacts were ex-situ evaporated. The C-V and X-ray diffraction (XRD) were measured. Furthermore, the stability of the diode was evaluated up to 30-days in air.

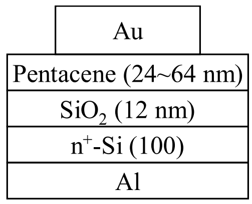

Fig. 1: Schematic diagram of pentacene MOS diode structure.

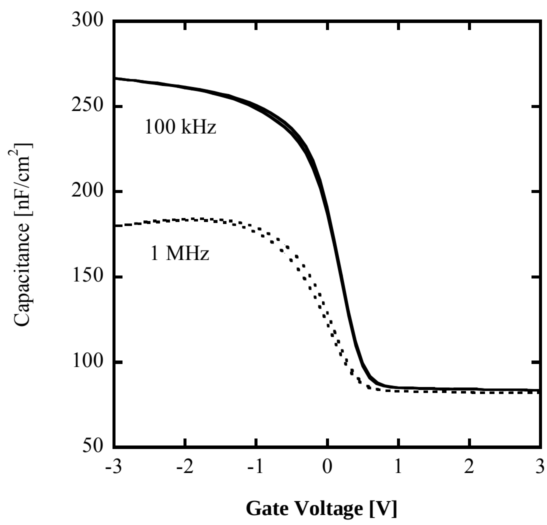

Fig. 2: C-V characteristics of pentacene (24 nm) based MOS diode.

3. Results and Discussions

Figure 2 shows the C-V characteristics of the diodes were measured as soon as finished the fabrication process. It shows excellent C-V characteristics without surface treatment by HMDS or OTS and observed very little hysteresis loops as well. Small frequency dispersion observed at accumulation region is probably due to the contract resistance between the Au electrode and pentacene film.[3] The XRD with Cu-Kα radiation shows that (001)-oriented pentacene thin film was formed on SiO_2 (Figure 3). To investigate the air-stability, the MOS diode was kept in air for 30 days. When the C-V measurement was performed after 7-days at 100 kHz, the flat-band voltages moves towards positive voltage and hystesis loop slightly increased as shown in Figure 4. After 30-days the hysteresis loop was further increased up to 100 mV and the maximum capacitance also decreased from 274 nF/cm^2 to 160 nF/cm^2 which indicates that the electron trapping effects become stronger either by moisture or oxygen and thus the stability degraded gradually.

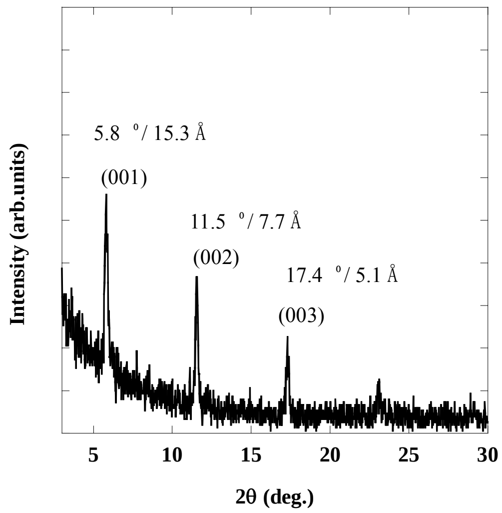

Fig. 3: XRD for 24 nm thick of pentacene thin film deposited on SiO_2

4. Conclusions

The interface properties and the air stability of pentacene MOS diodes were investigated. XRD measurement indicates that (001)-orientated pentacene film was formed. Very little hysteresis loops of pentacene MOS diodes was observed without any surface treatment. The electrical characteristics degraded gradually in presence of air or moisture.

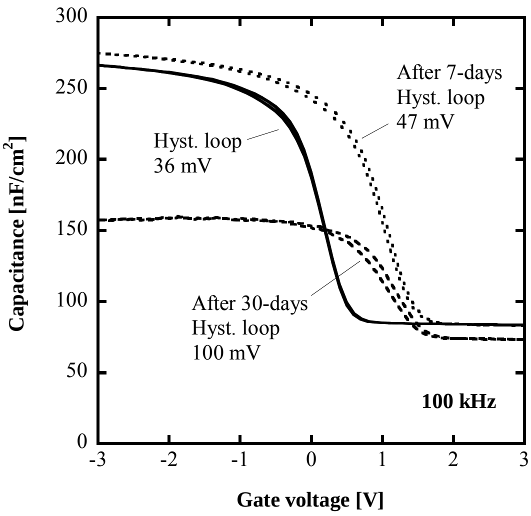

Fig. 4: Air stability of pentacene (24 nm) based MOS diode

5. Acknowledgements

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6. References

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