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Electrical Bistabilities of Organic Bistable Device utilzing Hyperbranched Polymer and Gold Nanoparticle composite

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1. Introduction

Organic devices including OLEDs and OTFTs are expected to develop new usages of electronic device for their flexibility and simple and low-cost process. The research of organic nonvolatile memory device is still relatively in an early stage, and various device structures have been proposed for application. The organic electric bistable devices (OBDs) using a metal nanoparticle is one of such organic nonvolatile memory device candidates, however its switching mechanism needs to be investigated. It is suggested that the bistable switching is affected by various factors, such as the formation of conduction filament, the oxide film on the electrode surface, or organic materials which functions as a donor or an acceptor.[1,2]

We have attempted to clarify the mechanism of bistable switching by using OBDs containing hyper-branched polymer and a nanoparticle. In this report, we investigated the influences of the electrode surface and the thickness on the device characteristics of the bistable switching.

2. Experimental

The device we have fabricated has single organic layer sandwiched by electrodes, and it is the same structure as was reported in the literature.[3] Hyper-branched polymer with dithiocarbamate endgroups (HPS), the gold nanoparticle which includes HPS as a dispersing agent (HPSAu), and 8-hydroxyquinoline (8HQ) are contained in the organic layer[4]. The electrodes were deposited in vacuum, and the organic layer was formed by spin-coating. The device on the glass substrate using aluminum electrodes is represented as Glass/Al/(HPS+HPSAu+8HQ)/Al.

First, we prepared the two devices, the electrodes of which were aluminum and gold, respectively, and compared those device characteristics, in order to evaluate the effect of natural oxidation layers at the electrodes to the switching of the OBDs. Next, the influence of the electric field to the switching was examined by the change of the threshold voltage accompanying the increase in the film thickness. Finally, the relation between bulk and interface was discussed from the impedance measurements of the ON state and the OFF state of Glass/Al/(HPS+HPSAu +8HQ)(90nm)/Al. All the measurement was performed in vacuum. The impedance was measured at a voltage of +1 V and at frequencies ranging from 10 Hz to 10000 Hz.

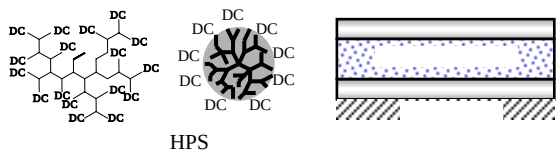

Fig. 1 Schematic structure of HPS and the OBD. DC indicate dithiocarbamate endgroup.

3. Results and discussions

Fig. 2 shows the current density-voltage (J-V) characteristics of the two devices, Glass/Al/(HPS +HPSAu+8HQ)/Al and Glass/Au/(HPS+HPSAu+8HQ)

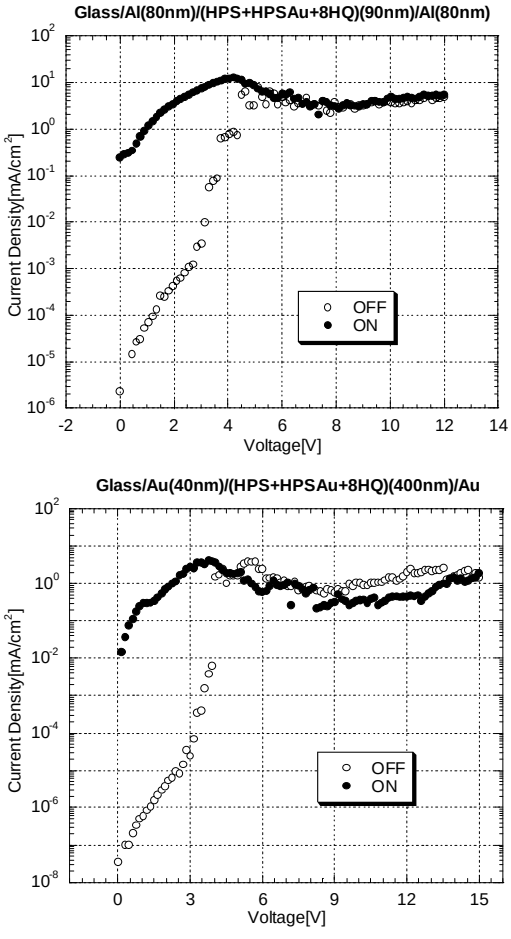

Fig. 2 J-V characteristics of the OBDs with two different electrodes.

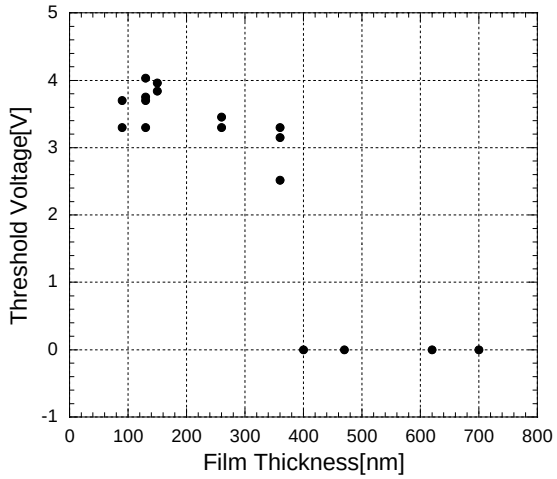

Fig. 3 Changes of the threshold voltage accompanying the increase in film thickness. The points of 0V represents that the device did not show bistabile switching.

/Au. Both of the devices showed unipolar switching characteristics. Since a thin organic film short-circuits when a top gold electrode was deposited on it, the film thickness of the two organic layers differs. The two devices show the almost same J-V characteristics, therefore it turns out that the oxide layers at an electrode surface has not affected bistable switching.

The relation of organic film thickness and threshold voltage to the device were illustrated in Fig. 3. In spite of the difference in the electric field induced in the organic layer, threshold voltage has not so much changed. It is also pointed out that the devices with organic film more than 400 nm thickness did not show the bistability. From these results, the bistability is not induced by specific intensity of the electric field that is entire organic film, however the start of bistability depends on film thickness.

A comparable suggestion is given also from the impedance measurements (Fig. 4). A bulk of organic layer and an interface are not distinguished in the results as two circuits. Although an interface does not function independently, threshold voltage is not influenced at field strength. Hence it is supposed that the electric field within an organic layer is not uniform.

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4. Conclusions

We fabricated OBDs using polymer and gold nanoparticle. From the characteristics of the device with Au electrodes, and the impedance measurements, it is probable that the interface has not influenced on bistable switching. The possibility that the ununiformity of electric field within the organic layer is taking part in switching is suggested from the relation between the film thickness and the bistability.

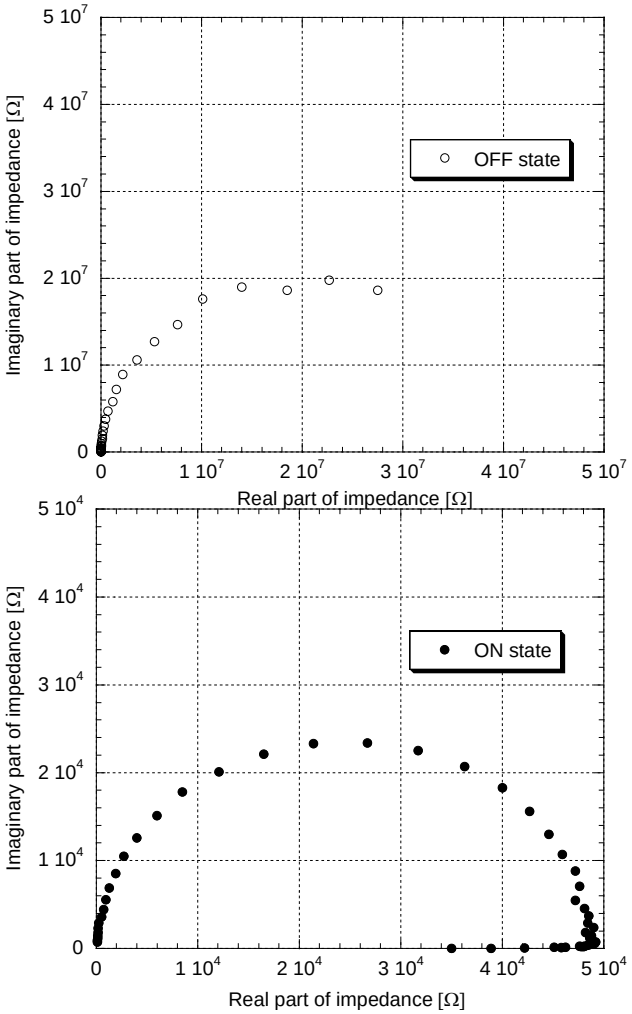

Fig. 4 Cole-Cole plot of Glass/Al/(HPS+HPSAu +8HQ)/Al. The scale of the OFF state is 1000times as large as that of the ON state.

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References

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