Extended Abstracts of the 2012 International Conference on Solid State Devices and Materials, Kyoto, 2012, pp334-335

# Effects of the polymer molecular weight in organic resistive memory using Au nanoparticles / polystyrene composite film

Atsushi Fukushima[1] and Katsuhiko Fujita[1,2]

Interdisciplinary Graduate School of Engineering Science, Kyushu University[1]
IMCE, Kyushu University[2]
6-1 Kasuga Kouen, Kasuga, Fukuoka 816-8580, JAPAN
Phone:+81-092-583-7533 E-mail: hukusima1@asem.kyushu-u.ac.jp

## 1. Introduction

Recently, organic bistable memory devices (OBDs)[1] have been actively investigated due to their potential advantages of low-cost production, light-weight and flexible electronic applications. Especially, an OBD using a composite film of nanoparticles (NPs) and polymer has attracted considerable attention [2]-[4]. However, driving mechanism of OBDs hasn't been clearly revealed yet, and reproducibility and device yield are not so suficient for practical applications.

We have reported that OBDs using Au NPs/ hyperbranched polystyrene composite film show the low resistive state based on conductive path formation with series of NPs in polymer layer (filamentary conduction model)[5]. Illustration of filamentary conduction model is shown in Fig.1. The particle aggregate at the electrode interface during device fabrication, from which the filament would grow by applied voltage. Science the migration of the particles is the key step of the resistive switching, we study the relation between the molecular weight of the polymer and the low resistive state.

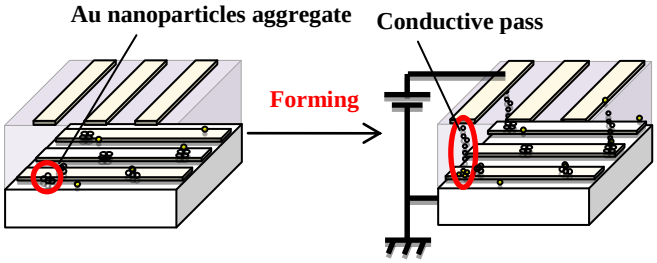


Figure1. Illustration of filamentary conduction model

## 2. Experimental

The device structure is shown in Figure2, Figure3. We applied polystyrene (PS) as matrix polymer and Au NPs which are covered by hyper-branched polystyrene (HPS-Au) [4], [6]. We used two PS with polymer molecular weight (Mw) of 66.0k and 320k.

OBDs were fabricated by the following process. First, a glass substrate was cleaned in boiling ethanol to remove residual contaminations; it was further cleaned by UV-$O_3$ treatment. The substrate was then introduced into a high vacuum chamber, and an Al bottom electrode was formed by evaporation. The substrate was spin-coated with the *o*-dichlorobenzene solution of polystyrene and HPS-Au, and then annealed at 150 $^{o}$C for 30 min in a nitrogen atmosphere. Finally, Al top electrode was formed by evaporation in a vacuum chamber. The device of cell area was 2×2 mm$^2$.

The electrical properties were measured in vacuum. We investigated the temperature dependence of device characteristics.

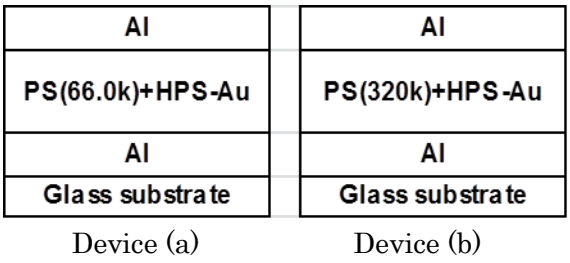


Figure2. Fabricated device structures

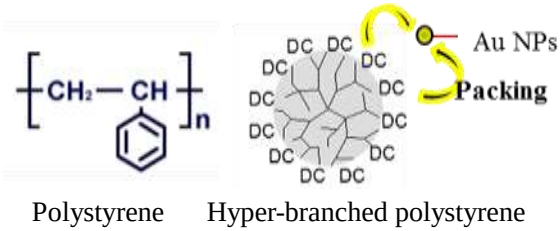


Figure3. Chemical structure of the materials used.

## 3. Results and Discussion

Current density-voltage (J-V) characteristics are show in Figure4. Initially the device showed the very high resistance below the high resistance state (OFF state) upon switching. Current density abruptly increased at around 2.8 V and switched to the low resistive state (ON state). Once the abrupt increase appeared, the resistive switching was observed (forming operation). The devices remained ON when applied voltage is instantly cut off at the negative differential resistance (NDR) region. Af-

ter applied voltage turned off at higher voltage region, the device remained OFF state. This feature exhibits that our device has non-volatility.

Next, when the first voltage applied to the pristine device at room temperature (RT), the abrupt current increase was observed in the device (a) using HPS-Au and PS (Mw: 66.0k) but was not observed in the device (b) using HPS-Au and PS (Mw: 320k) Moreover, when the forming operation was performed at 70 $^{o}$C, the abrupt increase was observed in device (b). After the forming, device (b) showed the switching at RT (Figure5).

The viscosity of the polymer depends on the molecular weight and temperature. It tends to be low as the molecular weight is lowered or the temperature rises. Therefore, the conductive path formation should strongly correspond to the mobility of the particles in the polymer matrix. It was demonstrated in this result that the mobility of Au NPs in an organic layer influenced device characteristics greatly.

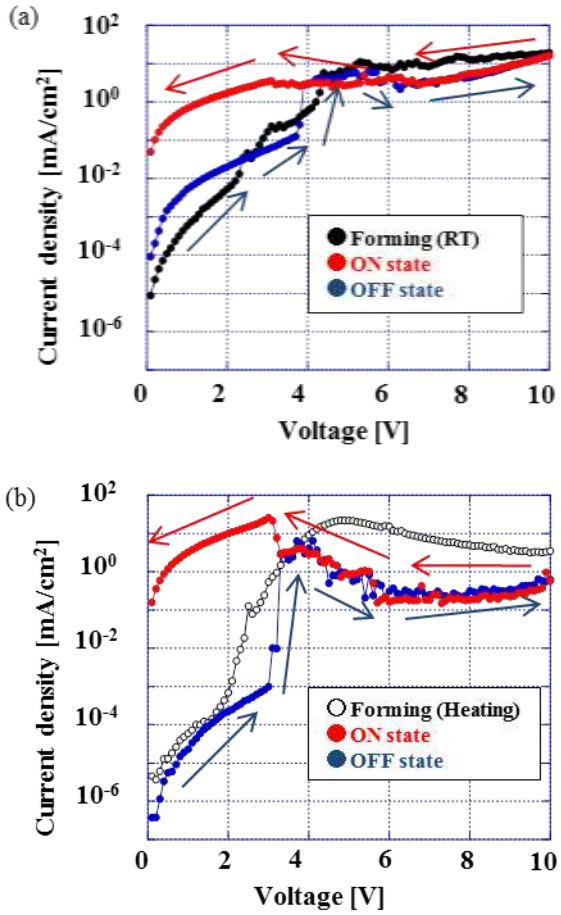


Figure4. Current density-voltage (J-V) characteristics of each device. (a) Al/ PS (66.0k)+HPS-Au / Al, (b) Al/ PS (320k)+HPS-Au /Al

## 4. Conclusion

We fabricated organic memory device of Au nanoparticles/ polystyrene composite film. Our devices exhibited a unipolar switching behavior with a NDR and good electrical bistability. From the device was shown the dependence of polymer molecular weight in the device characteristics (such as device yield and cycle endurance), it is suggested that the switching behavior of this OBDs may be attributed to the mobility of Au NPs in organic layer.

## Reference

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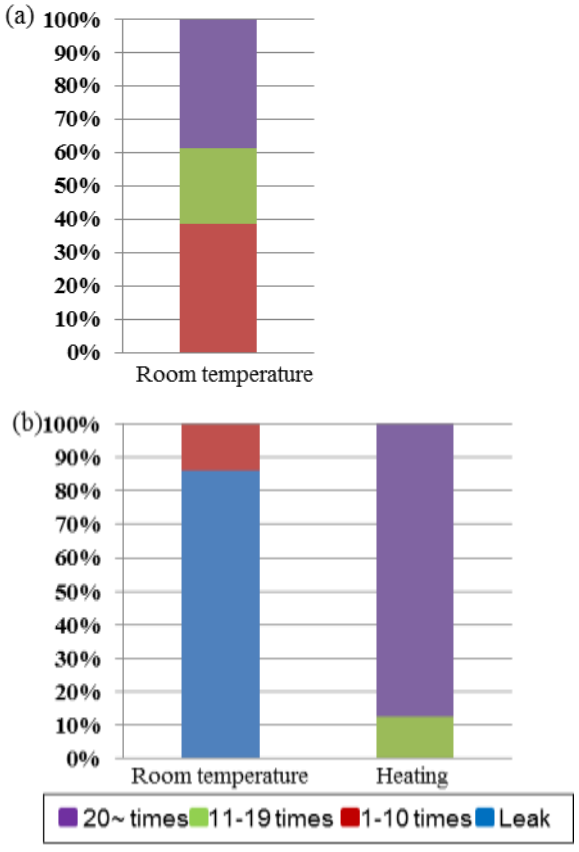


Figure5. Device yield and cycle endurance of (a) Al/PS (66.0k)+HPS-Au/Al, (b) Al/ PS (320k)+HPS-Au /Al