Poster

RESISTIVE SWITCHING OF ROSE BENGAL DEVICES - AN INTERFACE EFFECT?

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As conventional semiconductor memory technology (both DRAM and FLASH) faces tough barriers for scaling below 50nm feature size resistive memories have recently attracted considerable interest. Organic systems are promising candidates for this regime offering the potential of scalability down to the molecular level. Switching mechanisms in organic semiconductors and conjugated polymers were first proposed more than 30 years ago and since then many investigations about this phenomena have been done. [1,2]

Here we report on resistive switching behavior in metal-insulator-metal (MIM) devices consisting of a layer of Rose Bengal (4,5,6,7-Tetrachloro-2',4',5',7'-tetraiodofluorescein disodium salt) (Figure 1A) sandwiched between a bottom electrode (Indium Tin Oxide (ITO) or Zinc Oxide(ZnO)) and a top electrode (Aluminum or Titanium). In such devices, two different conducting states are observed at the same applied voltage with a R_{OFF}/R_{ON} value of 50. (Figure 2A)

In ref. 3-5 this switching mechanism has been explained by molecule-specific behavior of the Bengal Rose material but the origin of this mechanism is still under discussion. In order to examine the switching behavior in more detail, the composition of our device was systematically varied and the I/V-characteristic measured. Furthermore, the temperature, frequency and pad-size dependences of the samples were studied. We observed that by replacing the Rose Bengal layer by a much simpler molecular layer, Xanthene (Figure 1B) and even by leaving out any molecular layer, the switching effect is also present in a very similar way (Figure 2B). However for the Xanthene device and for the device consisting of an Al or Ti top electrode deposited directly upon a ZnO or ITO bottom electrode, the R_{OFF}/R_{ON} ratio is much lower than for the devices including Rose Bengal as molecular layer.

Especially for the Al/ZnO and Al/ITO devices we propose that the resistive switching is due to a thin layer of aluminum oxide which will form between ZnO or ITO and aluminum. Such resistive switching of binary oxides is already known for several oxides (i.e. Al_2O_3 [7, 8, 11], NiO [9], TiO [10]). This interpretation is supported by two experiments: with gold top electrodes, an ohmic contact without any switching is observed. Furthermore, when intentionally including a 4nm thick aluminum oxide layer between aluminum and ZnO, resistive switching also occurs in a very similar fashion as for the molecular devices. Similar effects have been recently reported in MIM devices with three different LB molecular monolayers. [12]

Using MIM structures with Rose Bengal as organic layer the formation of an aluminum oxide layer at the interface to the top electrode is enhanced, due to the oxidizing effect of B.R. An increase in the R_{OFF}/R_{ON} value is seen, when the B.R. layer thickness is enlarged.

Measuring the I/V characteristic with different pad sizes we were able to show that the on resistance is not dependent on the pad size. This points towards a local mechanism, which is likely to be a dielectric breakdown in form of a conductive filament at the weakest point of the device.

In conclusion we have shown resistive switching in devices with several combinations of bottom electrode/organic layer/top electrode. Our findings indicate that the switching is an effect of the electrode /organic layer interface. The use of Bengal Rose can enhance this interface effect.

References:

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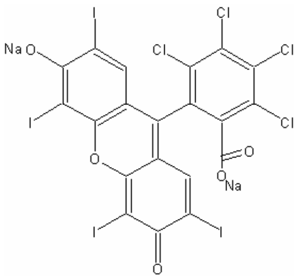
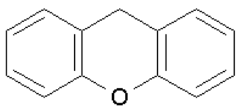
Figures:

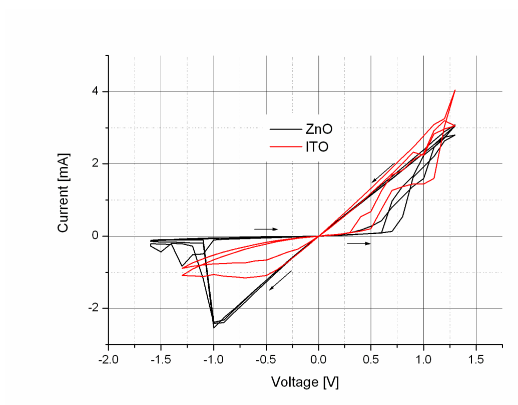
1A) Bengal Rose Molecule



1B) Xanthene Molecule



2A) I/V characteristic of a layer of Rose Bengal spun onto ZnO at 1000rpm and onto ITO at 2000rpm.



2B) I/V-characteristic of an ITO/Aluminum stack.