Study of poly(amide-imide) thin films through impedance spectroscopy using MIS configuration

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Finding suitable organic dielectric materials is a key point to develop the organic thin film transistors (OTFTs) technology. Large capacitance per unit area, low leakage current, low surface roughness and low interfacial trap density are the most important properties required. A potentially useful insulating material for organic electronics is the co-polymer poly(amide-imide) (PAI): an amorphous polymer with exceptional mechanical, thermal and chemical properties.

To investigate the applicability of PAI films as dielectric gate in OTFTs impedance spectroscopy measurements were undertaken using metal-insulator-semiconductor (MIS) capacitors based on the organic semiconductor poly(3-hexylthiophene) (P3HT) deposited on ITO glass and having a gold top-electrode.

Capacitance- and loss-frequency curves, measured at different bias voltages and room temperature, provided unequivocal evidence that depletion is related to the formation of a space-charge layer[1]. Considering this effect and C-V results the semiconductor thickness was calculated to be 215 nm and the insulator thickness 740 nm. The doping density $N_a = 1.8\text{x}10^{16}$ cm^{-3} was obtained from the C-V curves using the Mott-Schottky expression. The conductivity, σ, of the semiconductor was determined from the Maxwell-Wagner relaxation time constant[1] and using the relation $\sigma = N_a q \mu$ the mobility, μ, in the bulk semiconductor was estimated to be $1.7\text{x}10^{-4}$ $cm^2\ V^{-1}\ s^{-1}$. The loss-voltage curves display a maximum when the device is depleted, which is characteristic of interface states[1,2,3]. From the voltage and frequency dependence of this maximum, the interface trap density was estimated[4] to be $7\text{x}10^{10}$ $eV^{-1}cm^{-2}$. Such values are in good agreement with results found in the literature for P3HT devices made from poly(silsesquioxane) insulator[1,2,3].

Our first results show that PAI has competitive properties as an organic insulator and so we believe that reliable OTFTs of P3HT/PAI with a very good performance could be prepared.

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References

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