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Coulomb oscillations observed in organic junctions

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Abstract- We are interested in developing an organic single electron transistor capable of working at room temperatures. The devices were deposited on polyester substrate and basically consist of the interconnection of three metal-insulating-metal planar junctions composed by a poly(3,4- ethylene dioxythiophene): polystyrene sulfonate (PEDOT/PSS) and Poly(methyl methacrylate) (PMMA). The current oscillations with the gate tension variations observed in our devices were also present in the tunnel junction which is the basis for the SET. We observed on these devices the Coulomb blockade on the form of a Coulomb staircase.

Many papers present studies about inorganic single electron transistor (SET) made by silicon (Si). We are interested in developing an organic single electron transistor (OSET) capable of working at room temperatures. We reported here the fabrication of an all-organic transistor using tunnel junctions and its preliminary results.

The planar samples consist basically of three interconnected tunnel junctions each one formed by insulating film of Poly(methyl methacrylate) (PMMA) with 70 nm of thickness – measure taken by Dektak 150 – sandwiched between two electrodes of poly(3,4-ethylene dioxythiophene): polystyrene sulfonate (PEDOT/PSS) assembled on polyester flexible substrate. The inferior electrode and the insulating layer were deposited by Spin Coater and the top electrode was painted.

The junctions presented individual capacitances of ~1,403 pF measured with an Agilent 4284A precision LCR meter. The electrical measurements were taken at room temperature with a Keithley 2400 programmable semiconductor measuring system and the software LabView. For the measures, we randomly chose which junction should be the gate, the drain and the source, supposing the three junctions to be equal. The I-V curve presented in figure 1 was obtained with a 50 Hz ramp input signal with V_{DS} = 50 mV, the gate bias (V_g) swept from -3 to 0 V. The current oscillations were visible for the applied source-drain voltage; the drain current, which is in the nanoampere range, oscillates periodically with the increase in the gate bias. The same results were also presented in the tunnel junction which is the basis for the SET [1]. To make sure there was no noise in the curve shown in figure 1, our results were analyzed applying a Fast Fourier Transform (FFT) so we obtained the curve shown in figure 2. It can be observed that the signal presents a direct current component and two alternating current components with periods of ~429 mV e ~333 mV. The Coulomb blockade can be observed in the form of Coulomb staircase, as shown on figure 3.

In conclusion, we have succeeded in the fabrication of an all organic transistor using tunnel junctions and its operation at room temperature. The results obtained can be related to the SET behavior.

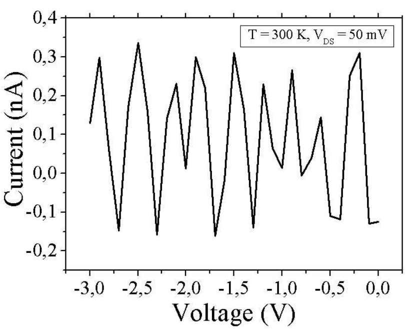

Figure 1: IV curve of the transistor taken at room temperature.

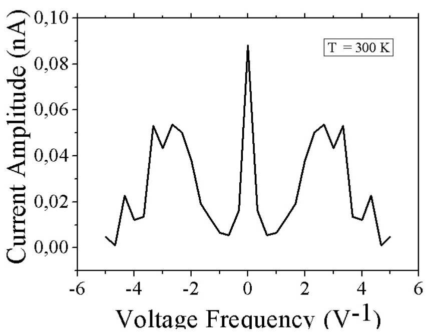

Figure 2: FFT Curve of the signal shown in figure 1.

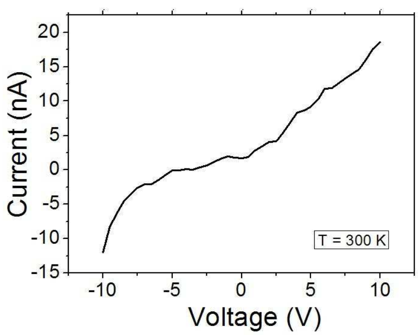

Figure 3: IV Curve of the metal-insulating-metal junction taken at room temperature.

References

[1] P.S. K. Karre, P. L. Bergstrom, G. Mallick and S. P. Karna *Journal of Appl. Phys.*, **102**, (2007) 24316.