FP7-bion

Organic Memristor Based on the Composite Materials: Conducting and Ionic Polymers, Gold Nanoparticles and Graphenes

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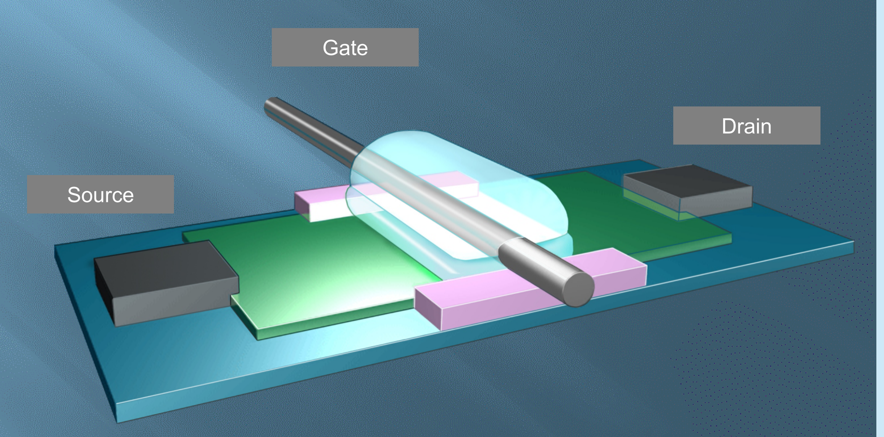
Organic memristor [1] is a solid state device whose electronic conductivity depends on the ionic current that has passed through it. This property is rather similar to the feature of biological synapses and allows to consider the device as a key element for the circuits capable of Hebbian type of learning [2]. The working principle is based on the reversible transfer of the conductivity of the active layer (channel) from good conductor to practically insulator by electrochemical modification of its redox state. This is achieved by depositing a solid electrolyte over the channel, using it as the medium for the electrochemical conductivity variations. Application of the positive voltage higher than the oxidation potential results in the increase of the memristor conductivity, while the application of any negative potential (reduction potential of PANI is about +0.1 V) results in the increase of its resistance.

Step by step manufacturing scheme of polymeric electrochemical element

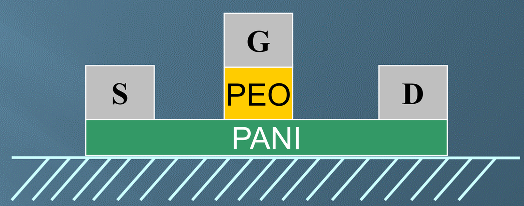
- Glass substrate with Cr electrodes
- Film PANI LS (48-72 monolayers) total thickness about 50-70 nm
- Doping of PANI in 1N HCl solution
- Fabrication of the active polyelectrolyte channel PEO
- First PEO stripe and drying
- Spacers +Ag wire
- Second PEO layer, drying
- Doping of the entire structure in HCl vapour



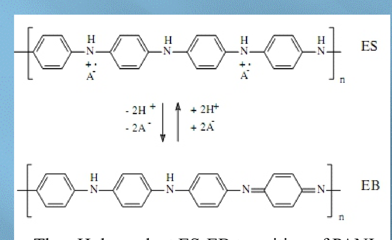
Installation of contacts and Measurement of electrophysical characteristics

ELECTROCHEMICAL NONLINEAR ELEMENT

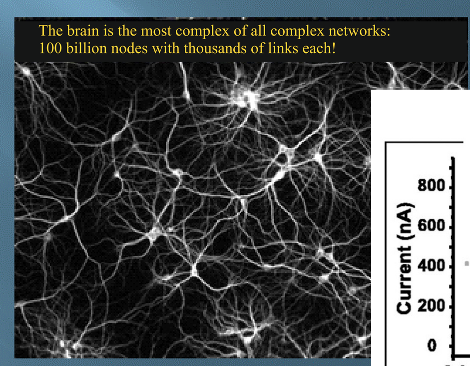
Materials:

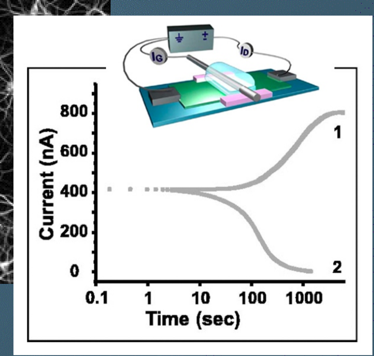


Doped Polyaniline (PANI) as the electronic conductive polymer



The pH dependent ES-EB transition of PANI



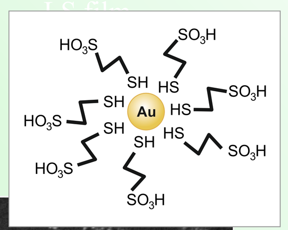


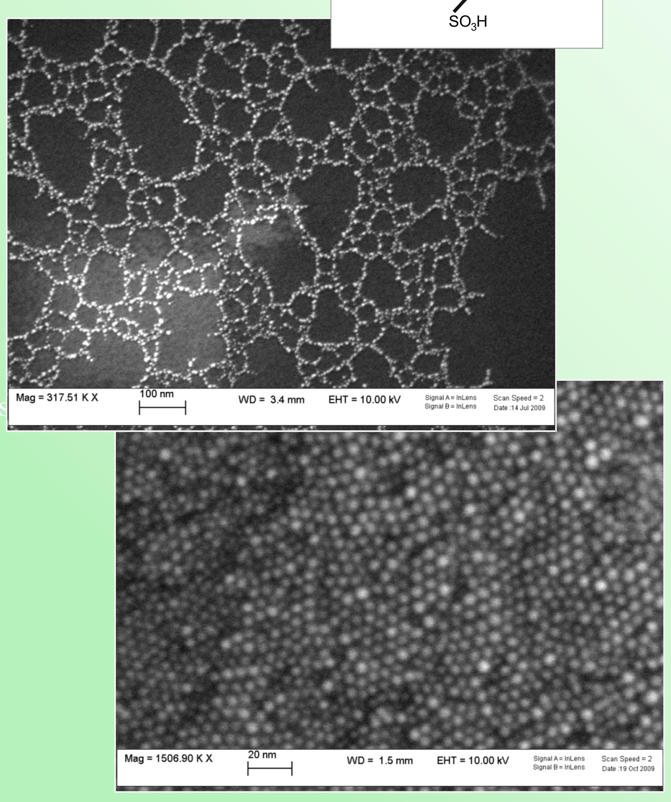
LiClO4 –doped Polyethyleneoxyde (PEO) as the ionic conducting polymer- solid electrolite.

$\left(CH_2\, CH_2\, O \right)_n$

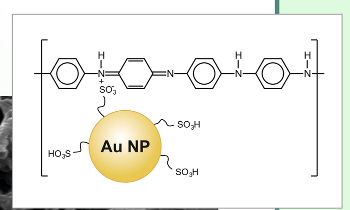
We need another nonlinear element, acting similarly to the body of the neuron, namely, providing a threshold for further signal propagation ("firing"). Such an element can be based on the AuNPs, directly connected to the PANI chain: the difference of the work functions of gold and PANI will provide a Schottky barrier, which while allowing the incoming currents, will block output until the signal overcomes the barrier, in analogy with real neurons.

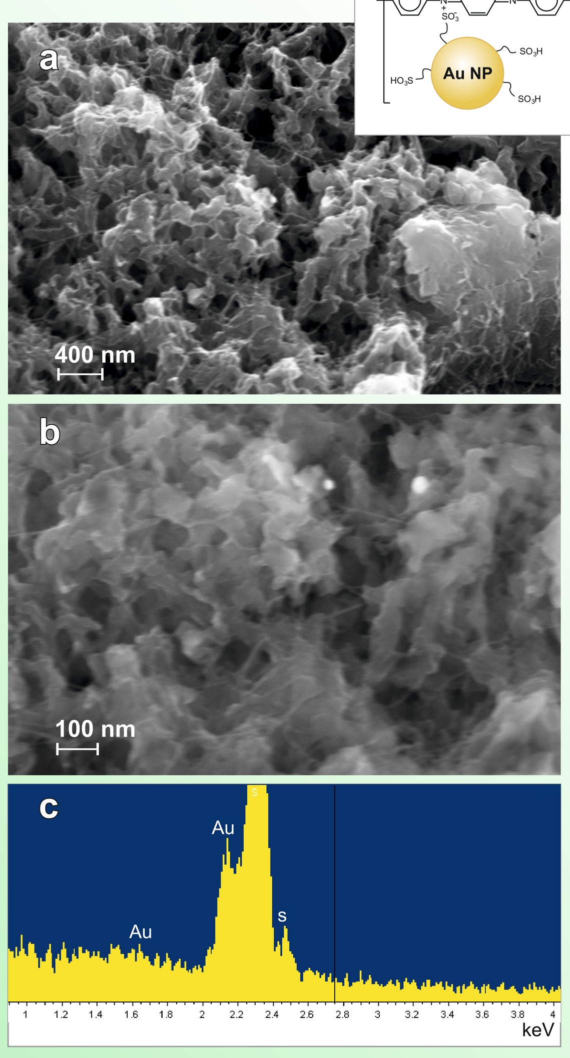
AuNPs(MESH)





PANI@AuNPs(MESH)

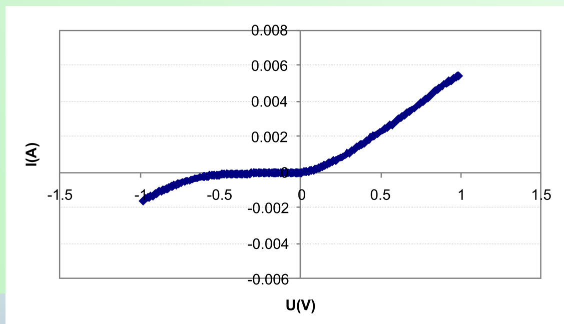


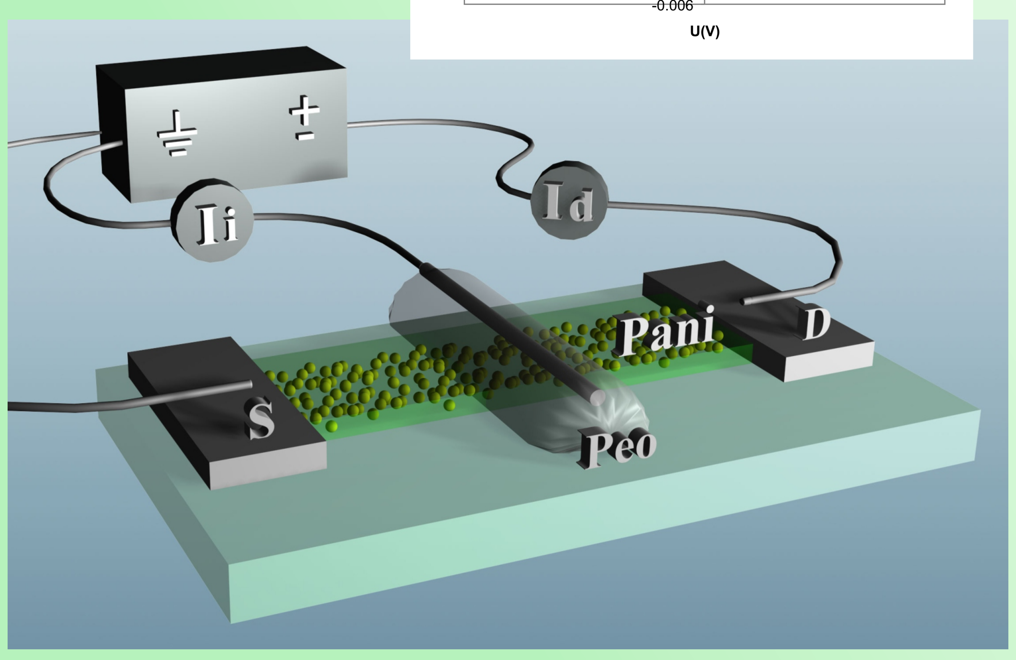


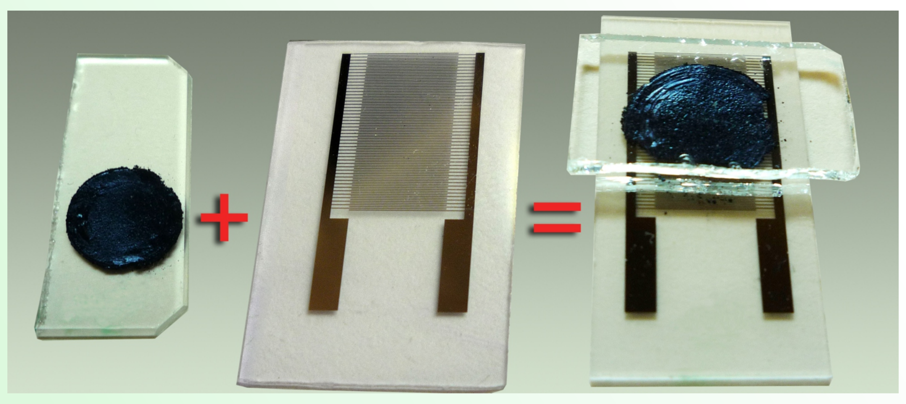
Morphology of the PANI@Au-MESH composite material was investigated with SEM.

Difference in the work functions of Au and PANI results in the rectifying characteristics

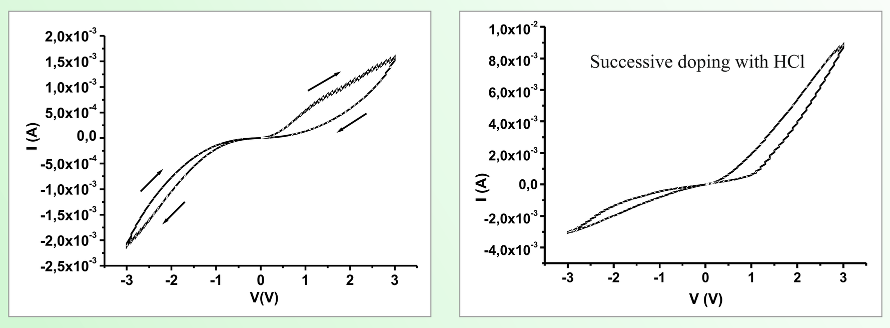
Schottky barrier
In PANI-Au structure





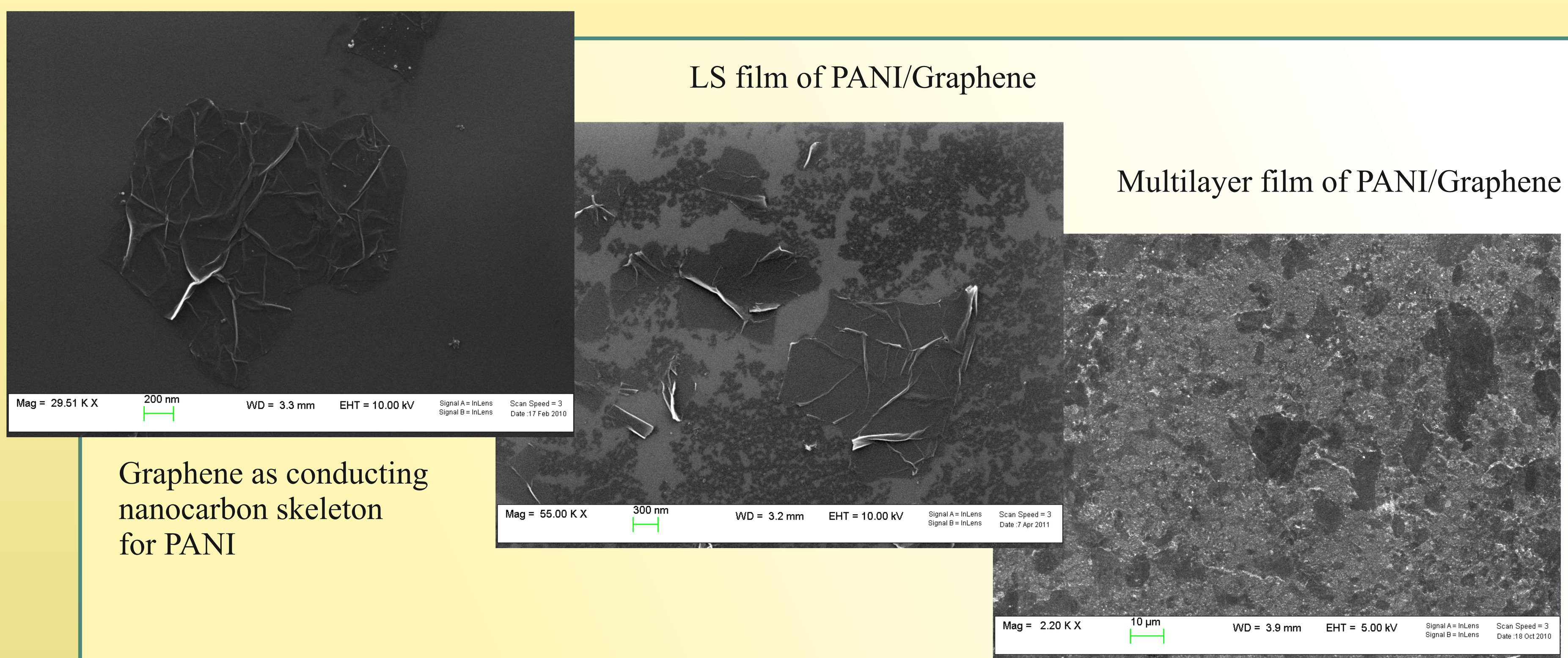


Cyclic voltage-current characteristic of the sample



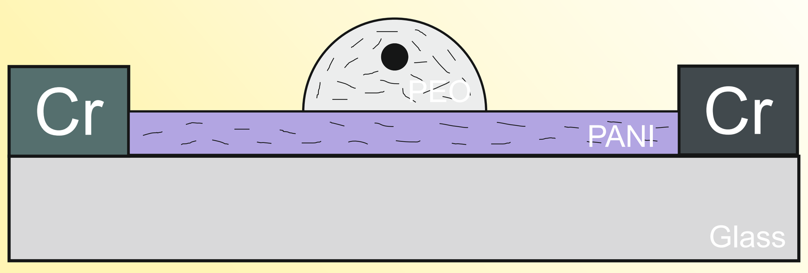
Arrows indicate the direction of the voltage variation. The characteristic clearly shows a nonlinear electrical behavior of the formed composite. The suppression of the conductivity in the low voltage range is connected to the presence of gold nanoparticles in the sample.

Graphene sheets integrated into PANI LS layer as well as into PEO stripe

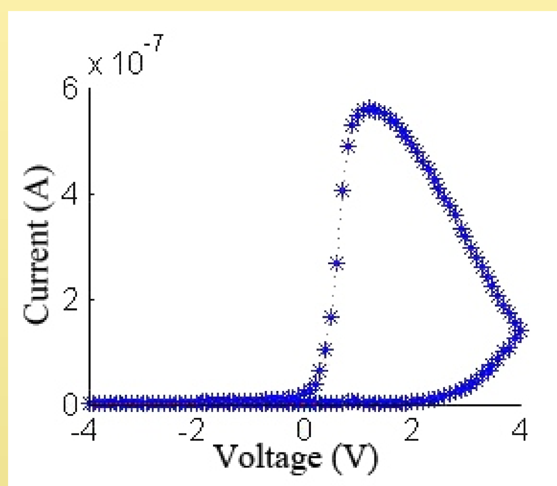


Graphene as conducting nanocarbon skeleton for PANI

Complex: PEO mixed GS PANI-GS-PANI



A pronounced hysteresis in the positive voltage range can be associated with charge trapping by graphene sheets similarly to the case of gold nanoparticles.



- **Smaller resulting current**
- **Bigger voltage of work of the element (±4 V)**

[1]Erokhin, V., Berzina, T., and Fontana, M.P. 2005. Hybrid electronic device based on polyaniline-polyethylene oxide junction. J. Appl. Phys. 97, 064501.

[2] Hebb, D.O. 1949. The organization of Behavior: a neuropsychological theory. Wiley and Sons, New York.

Acknowledgements

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