SYNTHESIS, STRUCTURAL AND ELECTRICAL PROPERTIES OF SWCNT THIN FILM ELECTRODES- FIRST RESULTS

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ABSTRACT

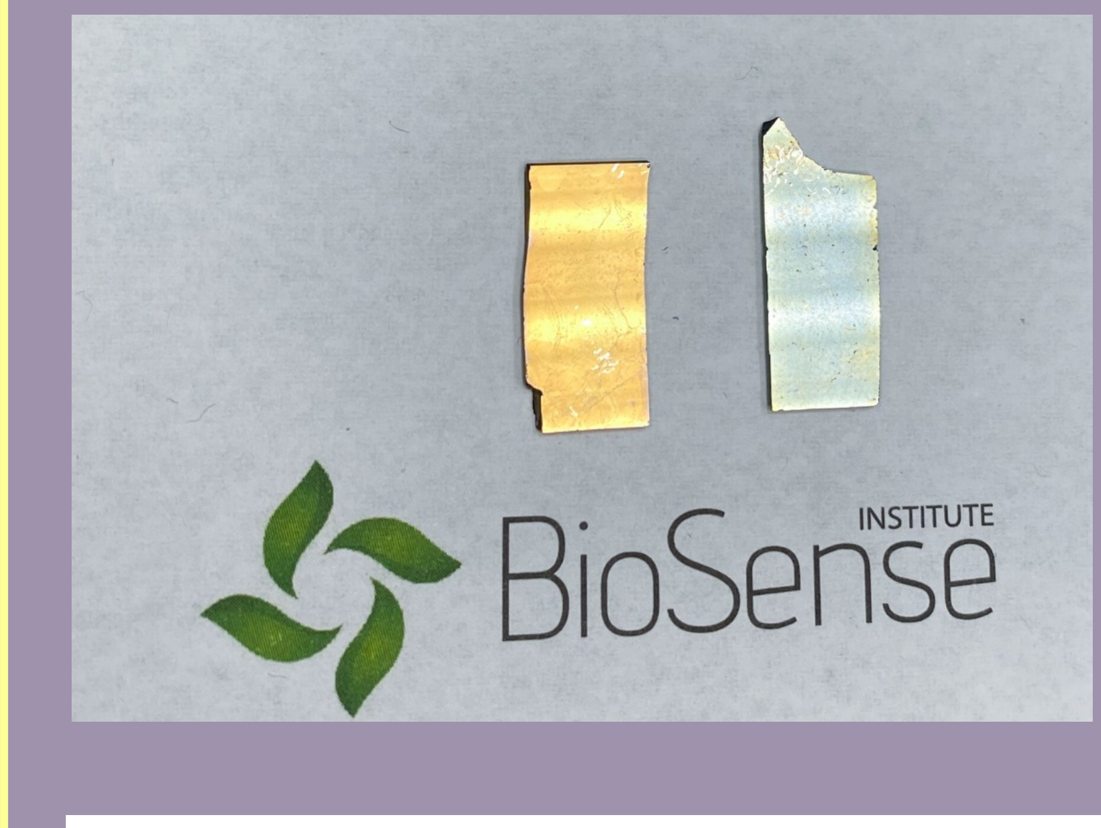
Due to growing demands for minituarization and small electronic devices, the production of novel composite material enhanced by the incorporation of nanomaterial fillers such as multiwall (MWCNT) and singlewall carbon nanotubes (SWCNT) is the subject of widespread research today. The investigations also shown that SWCNT explore better performance compared to MWCNT structures. One of the most promising aspects of SWCNTs applications, due their optical and electrical properties, are transparent conductive thin films or electrodes. The thin film electrodes were prepared on Pt substrates using very simple Layer-by-layer (LbL) technique, by alternate deposition of polyethileneimine (PEI) and carboxylic single walled nanotubes (SWCNT-COOH). This attractive technique allows deposition of polyelectrolytes with opposite charges using electrostatic interaction forming a multilayered films in nanometer range. In this work we present the results of preparation of the samples on Pt with 4 and 10 bilayers (PEI+SWCNT-COOH) using layer-by-layer technique.

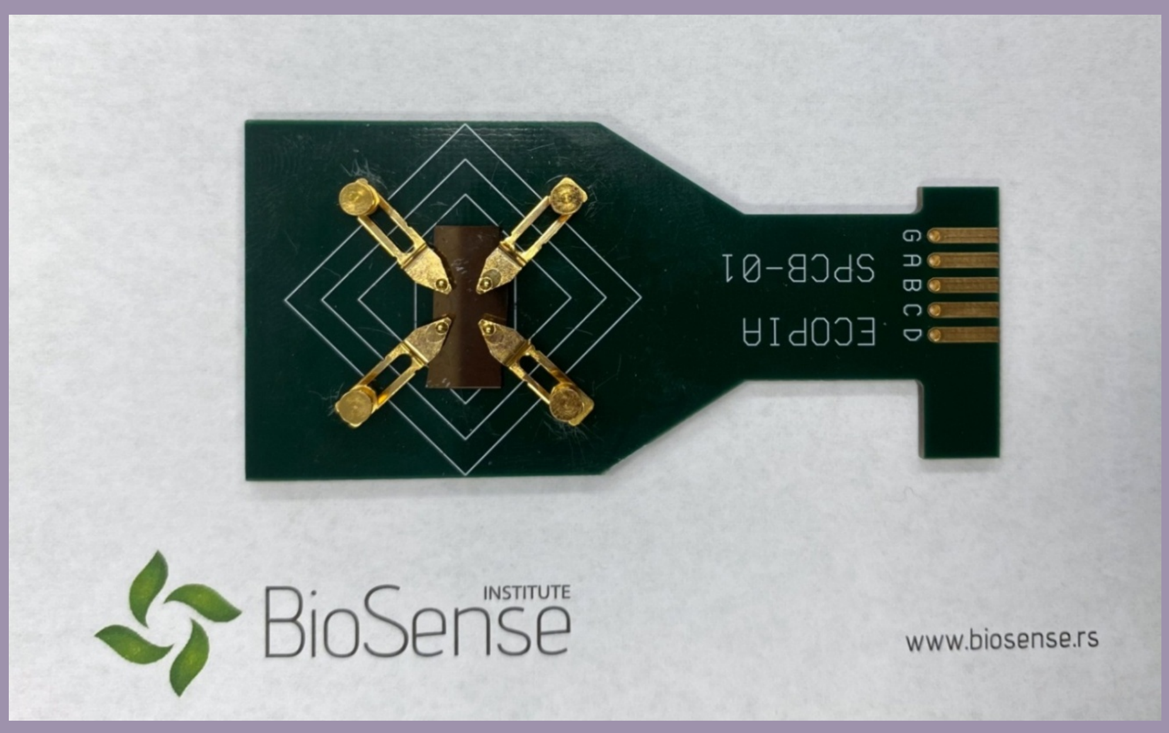
Raman measurements of synthetized samples were performed using confocal DXR Raman Microscope with CCD camera as a detector. Excitation is provided by diode pumped solid state (DPSS) laser λ= 532 nm. The obtained results enabled structural characterization and study of interface interactions. Due to the presence of sp^2 carbon in the nanotubes structure two G bands were noticed in Raman spectra of both samples. Their shape and ratio gives information about semiconductor type of SWCNTs.

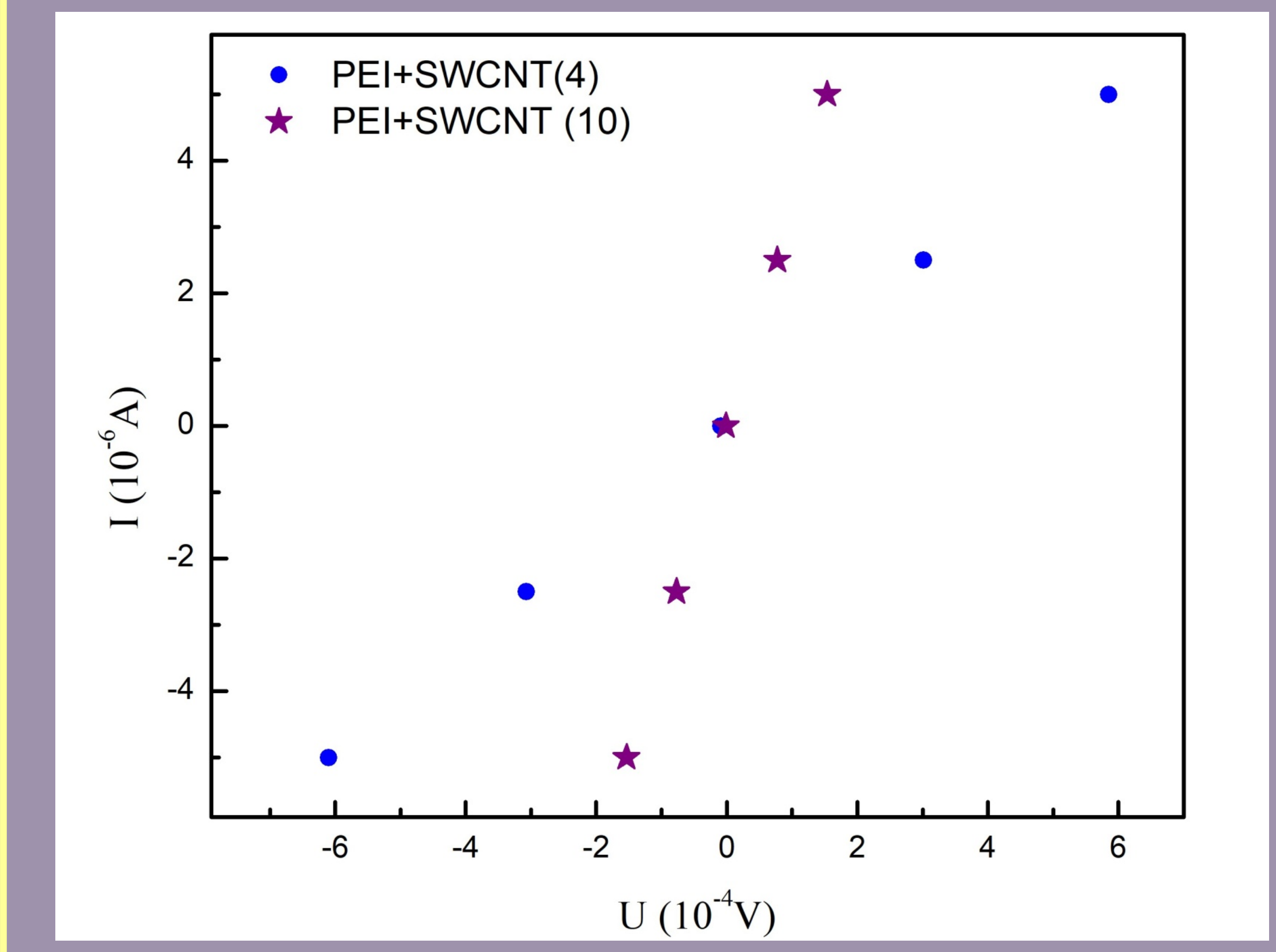
In order to get the insight into the fundamental charge transport through single nanostructures, the electrical properties of SWCNT were characterized using current-voltage and Hall effect measurements. The I-V characteristics of both samples are linear, thus exhibiting the ohmic behavior. The lower resistance of the sample with 10 layers is also noticed. The Hall effect measurements revealed the higher values of mobility, sheet resistance, sheet concentration and conductivity of the sample with higher number of layers.

FABRICATION PROCEDURE

A layer-by-layer (LbL) technique was used, by alternate deposition of polyethyleneimine (PEI) and carboxylic single-walled carbon nanotube (SWCNTs-COOH) layers. The average length of the tubes was 1 μm and with average diameter 10 nm. The platinum substrates were cleaned sequentially with acetone, ethanol and DI water. Afterwards, samples were treated with Piranha solution (1:3 mixture of H202 + H2SO4) for 10 min, followed by ultrasonication in 10 MΩ DI water for 15 min. The 1% solutions of PEI and polyacrylic acid were used for deposition of the first two adhesive layers. Subsequently, the substrates were soaked in PEI solution for 10 min, followed by soaking in the PAA solution for 15 min. The coated substrates were thoroughly washed with 10 MΩ deionized water after deposition of each layer to remove the excess material attached by weak van der Waals forces, thereby aiming to obtain monolayer film. Prior to each deposition of SWCNT-COOH layer, PEI layer was applied to ensure bonding of carbon nanotubes. The substrates were soaked in PEI solution for 10 min, and after that 60 min in SWCNT-COOH dispersion, with the washing step in between. Each SWCNT-COOH layer deposited was dried at 120 °C for 10 min.







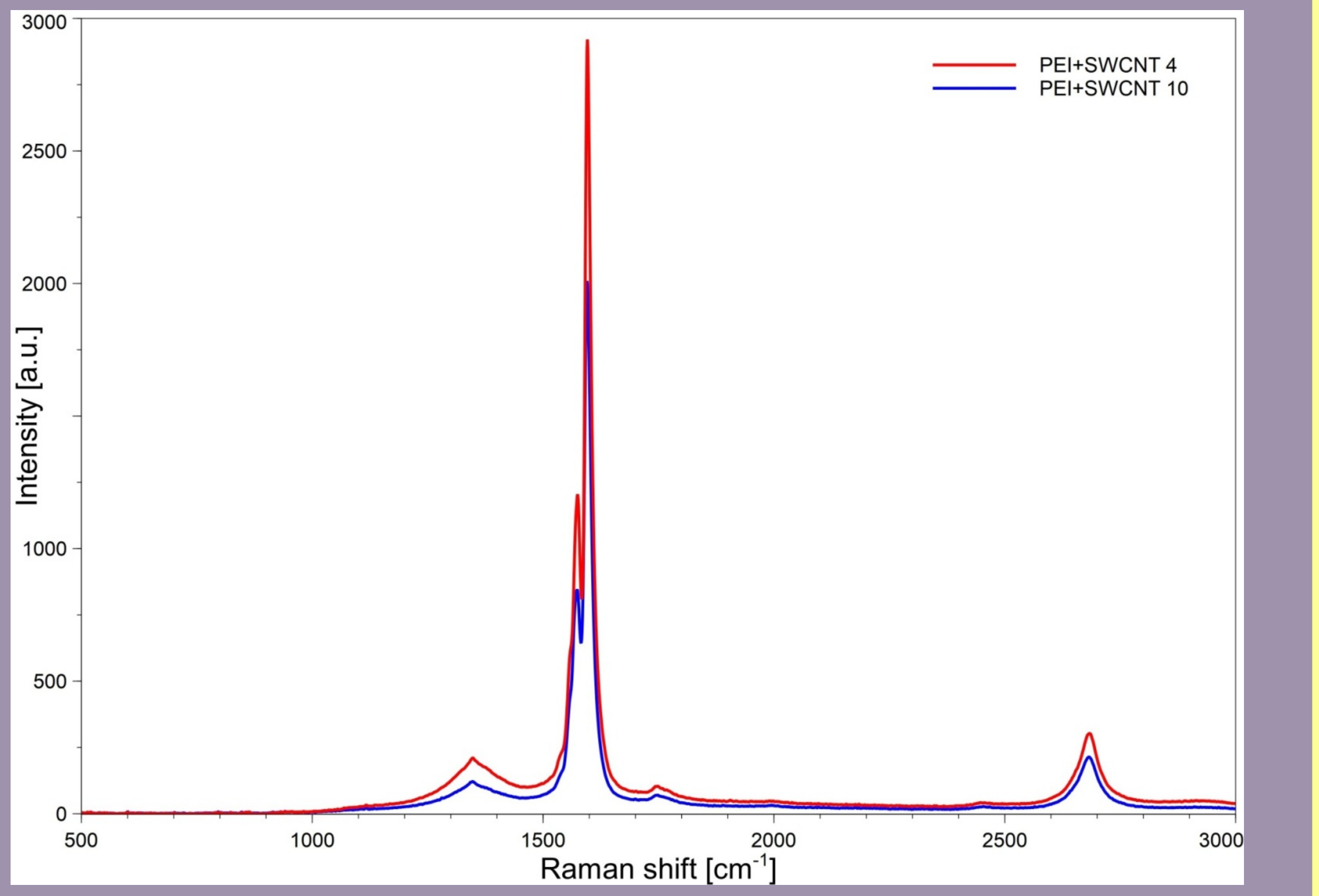
I-V measurements

The linear U/I characteristic of the film shows the absence of the potential barrier against metallic electrodes (such as Au and Pt), which is a necessary requirement in application in IR detectors!!

Hall effect measurements

sample	Bulk concentation (cm^{-3})	Conductivity (Ω^{-1} cm^{-1})	Hall coefficient (cm^3 /C)	Mobility (cm^2 /Vs)	Sheet resistance (cm^{-2})	Resistivity (Ω cm)
Pt+SWCNT (4)	-3.657E+20	7.961E+04	-1.707E-02	1.359E+03	-3.657E+15	1.256E-05
Pt+SWCNT (10)	-4.541E+20	1.011E+05	-1.375E-02	1.390E+03	-4.541E+15	9.891E-06

Raman measurements



In a SWCNT, the G band splits into G^+ and G^- peaks due to the strain effect, which is related to the curvature and/or due to electron–phonon coupling. Another peak present in the spectra of most sp^2 carbon materials is G′ band, appearing at ~2700 cm^{-1} for a 532 nm laser. It is related to the Raman scattering due to a vibrational mode characterized by the breathing of six carbons pertaining to a hexagon in the hexagonal lattice of graphene. The frequency for the breathing vibration is actually half of the observed value (~1350 cm^{-1}), but the hexagon-breathing mode is not Raman active in first-order Raman scattering, being observable only as an overtone, which is Raman allowed.