Nanocomposite structures for radiation sensing and shielding

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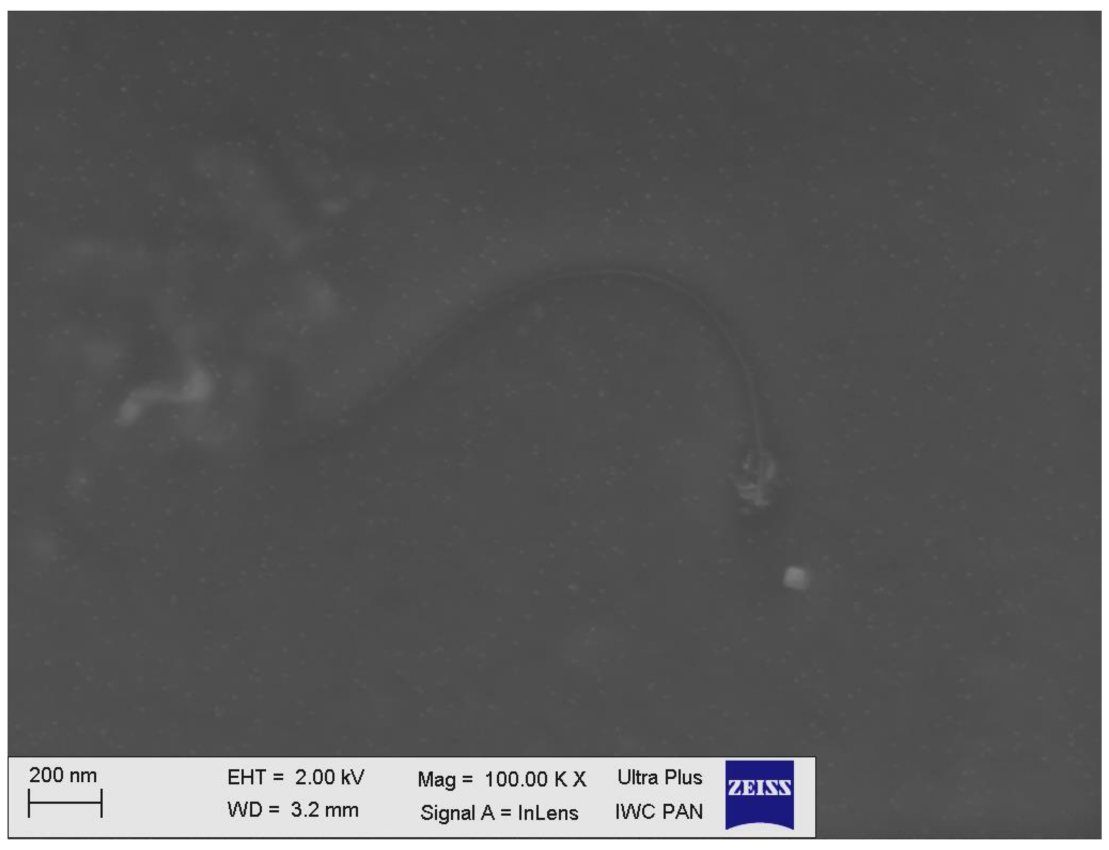
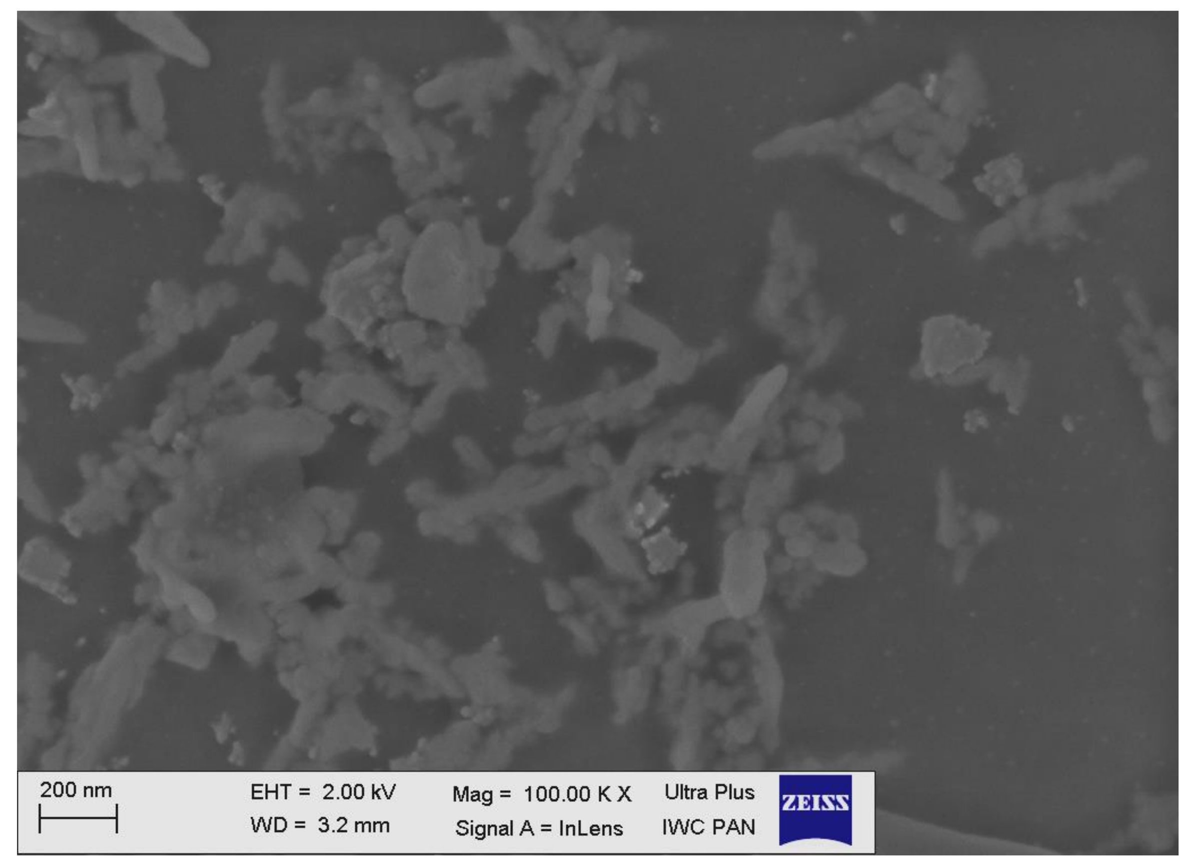
It has been demonstrated that composites reinforced with Boron, Nitrogen or Carbon elements in the form nanostructures dispersed in a matrix can provide radiation shielding for different range of energies and without the generation of harmful secondary particles. On the other hand, polymers reinforced with carbon nanotubes exhibit electrical response, strongly dependent on the absorbed dosage of radiation

SEM image



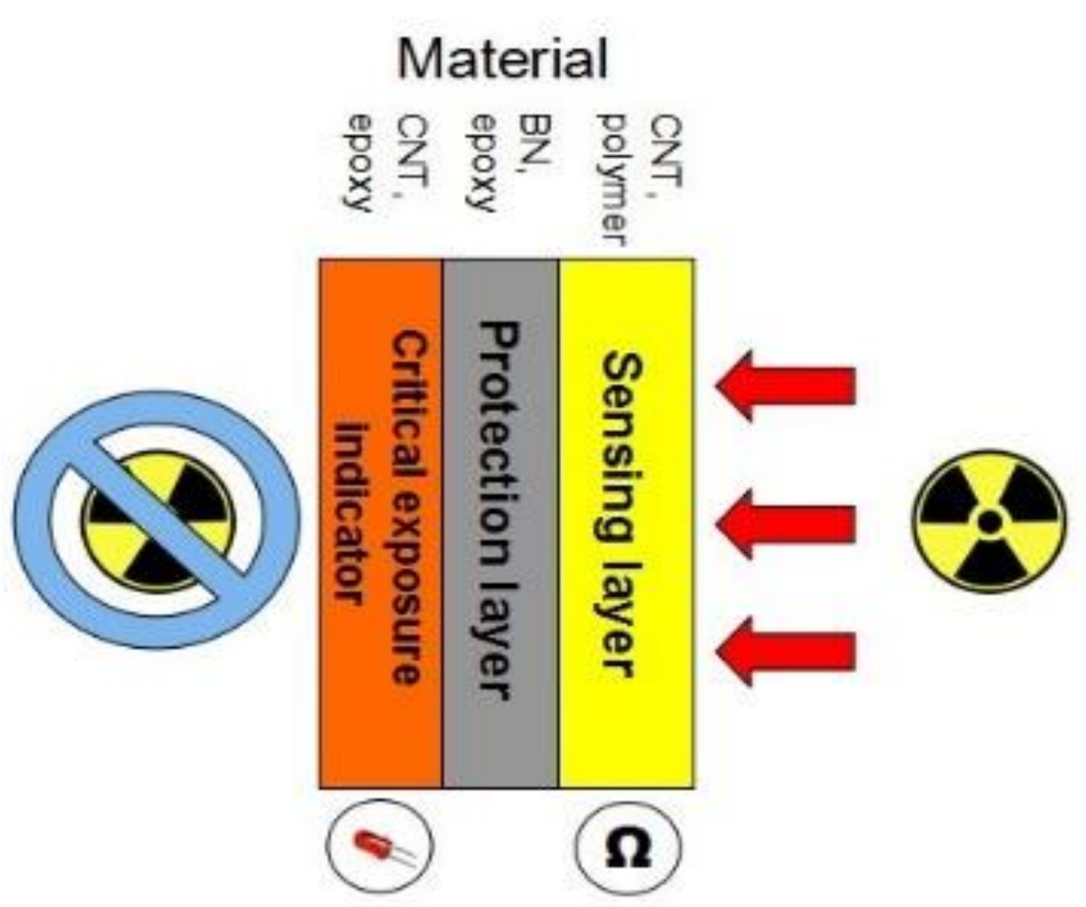
SEM image of an individual single-walled nanotube inside PEDOT:PSS / 12 wt. % SWCNTs composite

SEM image of a conductive path formed by several individual single-walled nanotubes inside PEDOT:PSS / 12 wt. % SWCNTs composite



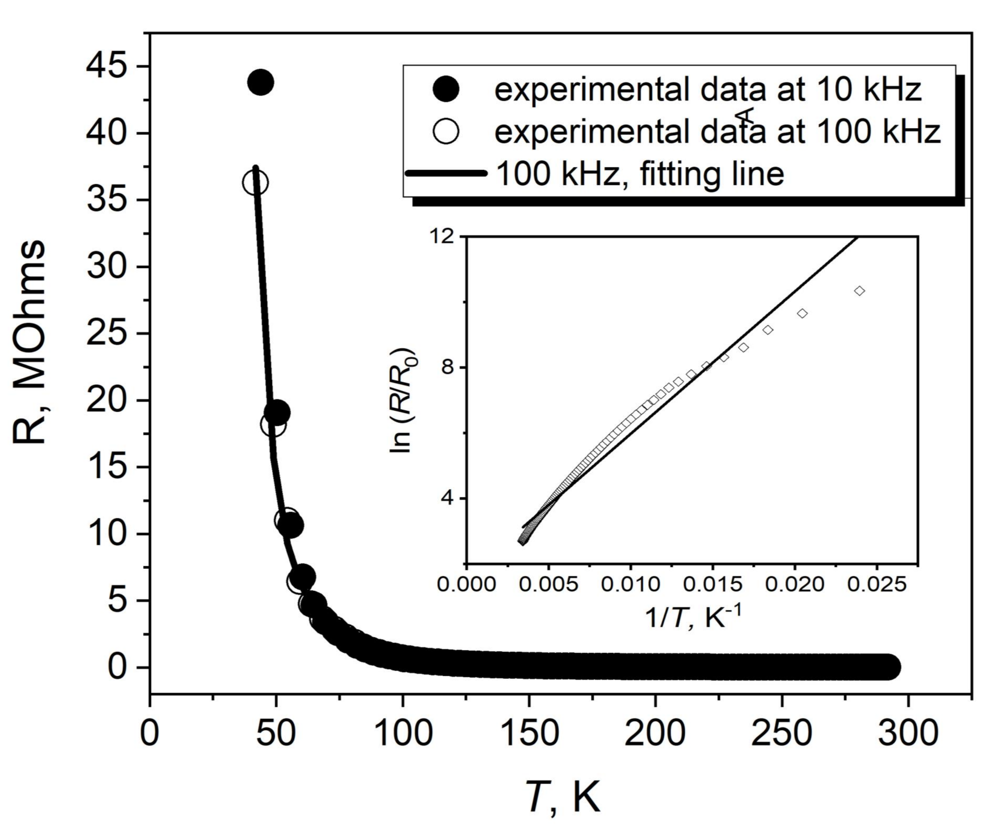
SEM image of bundles of MWCNTs inside (PEDOT:PSS / 12 wt. % MWCNTs composite)

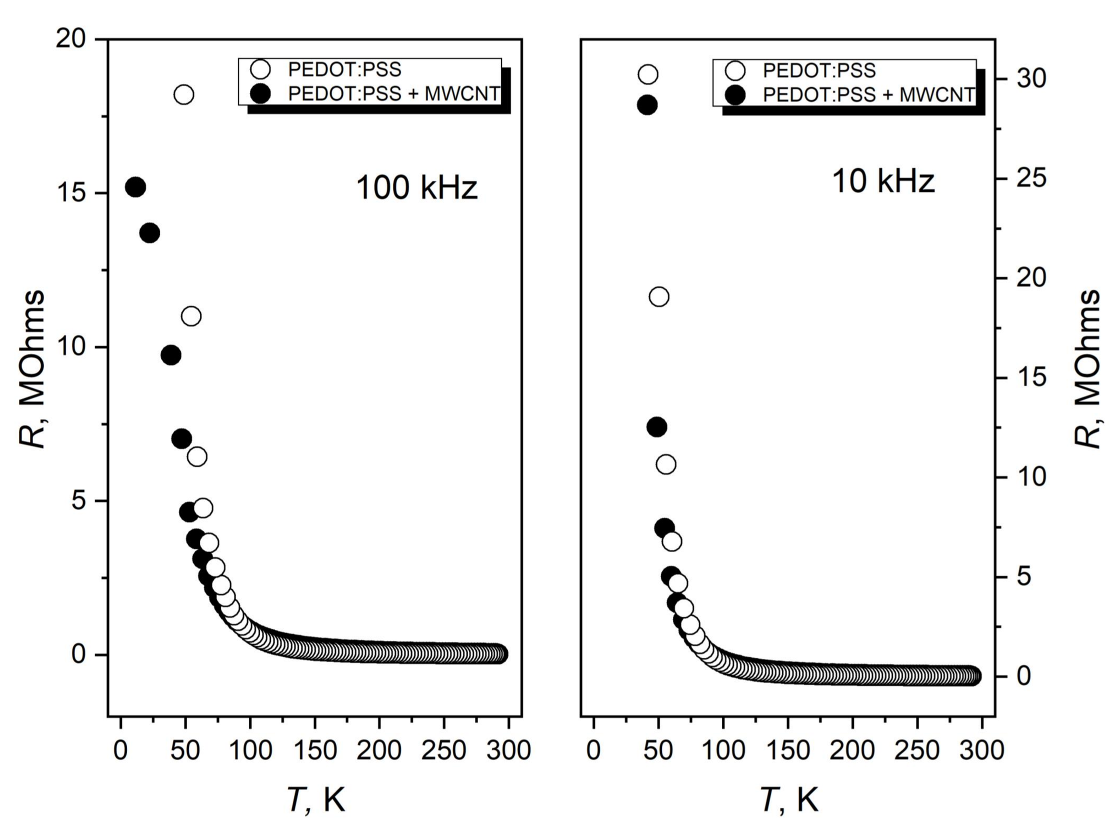
High-resolution imaging of the prepared samples was done using ZEISS Ultra Plus scanning electron microscope equipped with two secondary electrons detecting systems. SEM studies also indicated that aggregation of nanotubes is more likely to occur in MWCNTs composites.

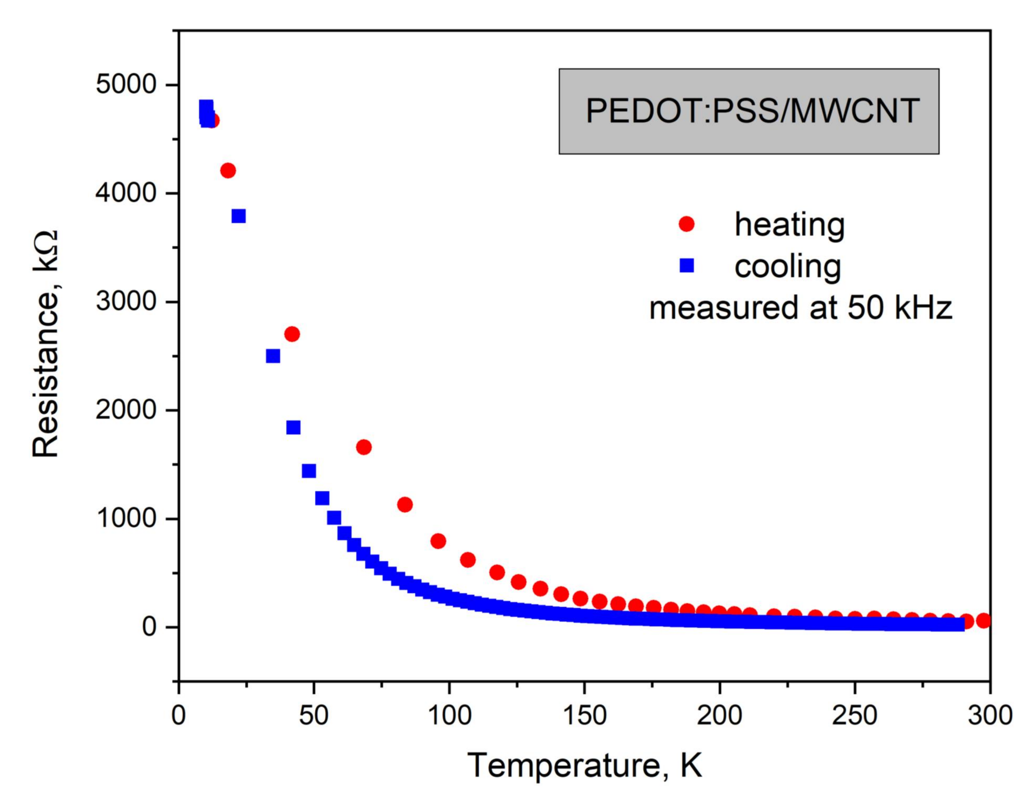


We are proposing to study radiation-shielding nanocomposites that will not have a stand-out performance as barrier materials but will incorporate an inbuilt sensor that can be used for protecting the inside from gamma harsh radiation.
The structure in Figure comprises electrical sensing layer, shielding layer made of epoxy/boron nanoparticles composite and, ultimately, a critical irradiation level indicator. This indicator is essentially CNT-doped epoxy resin plate that exhibits a percolation effect. The un-irradiated plate can be conductive or not, depending on the CNT doping level. If the level is above the threshold, the current is flowing across the plate, but that the conductive path can be destroyed by high enough dosage of radiation. Thus, one has a simple circuit breaker that will immediately signal about critical exposure, in case the protection layer can no longer stop the incoming rays.

Temperature effects in polymer-based nanocomposites







Two types of layers of conductive polymer PEDOT: PSS and polymer PEDOT:PSS with the addition of multilayer carbon nanotubes were prepared, with a thickness in the range of 30-50 micrometers. The electrical resistance of such layers was investigated depending on the temperature in the range of 10-300 K.
The observed temperature behavior of PEDOT:PSS resistance is consistent line with one-dimensional variable hopping model, which speaks speaking in favor of possible partial contribution of tunneling conduction, as well as thermal activation mechanism and, possibly, Coulomb electron-electron interaction.
The effect of adding nanotubes to the polymer matrix results also leads to the hysteresis of resistance measured in heating–cooling cycles, which is probably likely to be stimulated by the difference in thermal expansion coefficients of the matrix and the filler and by slow processes determined by these coefficients.