ELEKTRICKÁ VODIVOST POLOVODIČOVÝCH POLYMER/KOVOVÝCH NANOČÁSTICOVÝCH KOMPOZIT
ELECTRICAL CONDUCTIVITY OF SEMICONDUCTING POLYMER/METAL NANOPARTICLES COMPOSITES

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Abstract

Composites of non-conductive polymers with metal particle fillers are the object of study for decades because of their useful applications in electronic industry, e.g. as resistors or recoverable fuses based on positive temperature coefficient. The introduction of semiconductive polymers bearing a delocalized pi-electron system, and decreasing the size of metal nanoparticles to nanometer scale brings together a new class of optoelectronic phenomena originating in an interaction of plasmons with electronic states of a polymer. However, level of understanding of the mechanism of electrical conductivity in such systems is still low. In this contribution we describe two polymer composites consisting of semiconductive polymers poly(3- hexylthiophene) (P3HT) or poly(3-octylthiophene) (P3OT), and gold nanoparticles (NPs) with size ranging 5 – 10 nm. In such systems the electrical conductivity is influenced not only by the concentration of the nanoparticles, their shape and bulk distribution, but in a large extent by the polymer regioregularity, length of the polymer backbone and side chains, and thin film preparation techniques that influence the morphology of the composite and polymer-metal nanoparticle interaction. The temperature dependence of electrical conductivity was measured for various NPs concentration below the percolation threshold and data related to the morphology determined from TEM imaging and optical spectra of the polymer. The electrical conductivity of the composite depends exponentially on the interparticle distance. In neat polymers, the electrical conductivity increases with temperature until 80 °C for P3HT and 70 °C for P3OT, respectively, and then the conductivity decreases upon the temperature increase. In composite systems, the transition temperature is shifted towards higher values. At low temperature region we found that the conductivity obeys the thermally assisted tunneling model including electron tunneling between nanoparticles through the polymer matrix and activation energy for charge carrier transport. The activation energy, \( E_a \), in pure polymers P3HT and P3OT was 0.16 and 0.28 eV, respectively, and about 0.3 eV in both composites, independently on the concentration of Au nanoparticles.

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