Broadband dielectric spectroscopy of composites with nanocarbon inclusions

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Electrically percolative polymer-based composites have been attracting much attention because of their potential applications such as electroactive materials, sensitive materials, and electromagnetic coatings. Owing to the advanced electrical, thermal, and mechanical properties, various carbon nanoparticles like carbon nanotubes or carbon black have been widely studied and often used as nanofillers in the past few years. In this work results of broadband dielectric (20 Hz – 3 THz) spectroscopy of composites filled with various nanocarbons inclusions (multiwall carbon nanotubes, onion-like carbon) are presented in wide temperature range (20 K - 500 K).

The onion-like carbons (OLCs), consisting of stable defected multishell fullerenes, exhibit the high conductivity similar to carbon nanotubes. The electrical percolation thresholds for OLC embedded in various polymers like Poly(methylmetacrylate) (PMMA), Polyurethane (PU), Polydimethylsiloxane (PDMS) and epoxy resin were estimated. It was demonstrated that after annealing of OLC/PMMA and PU composites above the glass transition temperature the percolation threshold decreases. It was find also that the percolation threshold is dependent from OLC aggregate size. Close to the percolation threshold the value of the complex dielectric permittivity is very high in all investigated frequency range from hertz to terahertz. Therefore, investigated OLC composites are promising candidates for various electronic applications. The dielectric properties of pure OLC powder were also investigated in a wide frequency range as well. In OLC/PDMS composites above the percolation threshold a metal-insulator transition was observed.

The dielectric studies were also performed in carbon nanotubes composites with fixed carbon nanotubes mean length and diameter. The impact of carbon nanotubes length and diameter on composite dielectric properties and the electrical percolation in wide frequency range will be discussed in the presentation. Also the dielectric properties of all these composites will be compared with carbon black composites properties. The main physical mechanism which is responsible for high dielectric permittivity of composites are the electron tunneling via the insulating matrix, the electron hopping inside nanocarbon clusters and the electron transport in conductive matrix. It will be demonstrated that the main factor, which affect dielectric properties of composites is the spatial distribution of nanoparticles inside composites [1].

References

[1] A. Plyushch, J. Macutkevic, et al, Composites Science and Technology **128**, 75 (2016).

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