Kompozitų su trgilicinsulfato ir grafeno nanodalelėmis dielektrinės savybės

Dielectric properties of composites with triglicinsulphate and graphene

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Triglycine sulfate (TGS) is one of the most well-studied ferroelectric crystal with a second-order ferroelectric phase transition close to 322 K [1]. The ferroelectric phase transition is of order-disorder type with strong dielectric dispersion in the microwave frequency range and a typical critical slowing-down effect [2]. On the other hand, composites with nanocarbon inclusions is one of the most intensively studied field of material science. It was therefore assumed to be interesting to investigate the possibility of designing composite materials based on epoxy resin filled with both TGS particles and conductive inclusions. The main idea of the study is to find possible synergy effect in three-phase composite materials.

Monocrystals of triglycine sulfate (TGS) were first dissolved in distilled water and, after evaporation, TGS powder was obtained which was further ground in an agate mortar. Graphite nanoplatelets (GNP) were obtained by a succession of grinding and sonication steps applied to a suspension of exfoliated graphite in cyclohexane. Isopropyl alcohol was used as dispersion medium for sonication of TGS and GNP suspensions. During the sonication process, the alcohol was exchanged by epoxy resin (Buehler EpoThin Resin) and, after complete evaporation of alcohol, a curing agent was added. Dielectric properties were investigated in wide frequency (20 Hz - 30 GHz) and temperature (300 - 400 K) ranges, piezoelectric properties were studied by an automatic computer-controlled pulse-echo method [3].

Epoxy resin filled with TGS particles (30 wt.%) and with different addition of GNP present a second-order ferroelectric phase transition close to 322 K. The addition of GNP particles to TGS composites was found to substantially improve dielectric and piezoelectric properties of composites due to a strong synergy effect.

In particular, composites with only TGS particles does not show piezoelectric response without the external polarization field (see Fig. 1). Addition 0.5 wt. % of GNP significantly changes the situation: the weak piezoelectric response appears even without the external electric field. And finally, adding 1 wt. % of GNP provides the strong piezoelectric response without the external polarization. Even more, the difference between responses with and without the polarisation decreases with increasing GNP amount.

Dielectric permittivity demonstrates a maximum close to T=322 K for all studied composites is typical for ferroelectric phase in pure TGS crystals, except the substantially lower dielectric permittivity peak value due to the random orientation of TGS crystalites. Addition of GNP also does not affect the temperature of the phase transition. However, it increases the absolute value of the complex permittivity in wide temperature range, especially the real part, while the shape of curves does not changes strongly. This should be also considered as the strong synergy effect between TGS particles and grafene.

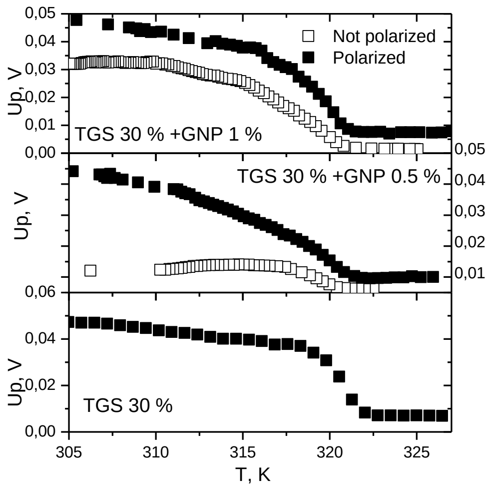

Figure 1. Piezoelectric response of composites with TGS and different amount of GNP inclusions. Solid symbols stays for sample polarized with external electric field, open - for virgin.

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References

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