The impact of grain size/interface at Boron Carbide/epoxy composites: dielectric properties and molecular dynamics.

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Recently composite systems consisting of epoxy resin and inorganic fillers have drawn the scientific interest because of their wide variety of applications and ease manufacturing. The incorporation of micro/nano-inclusions seems to have an impact at the properties of the composites, since the interactions between the matrix and the filler are changing with filler size [1,2]. Decreasing the particle's size the properties of surface/interfacial area dominate the properties of the overall material giving thus the opportunity to tailor its performance according to specific requirements [3].
The aim of this study was to investigate the influence of grain size on the properties of B_4C/epoxy composites. Two different filler types were used as inclusions and embedded in an epoxy resin. The first one has an average particle size of 30-60 nm, while the second one has mean particle diameter >10μm. Manufactured composites were characterized by means of BDS (Broadband Dielectric Spectroscopy), SEM (Scanning Electron Microscopy) and (Differential Scanning Calorimetry). BDS tests were conducted in a wide frequency (10^{-1}Hz – 10^{6}Hz) and temperature (30^{o}C - 160^{o}C) range.
Experimental data reveal the impact of filler's size decrease on the properties of the composite systems as well as the influence of the employed volume fraction (Table 1).

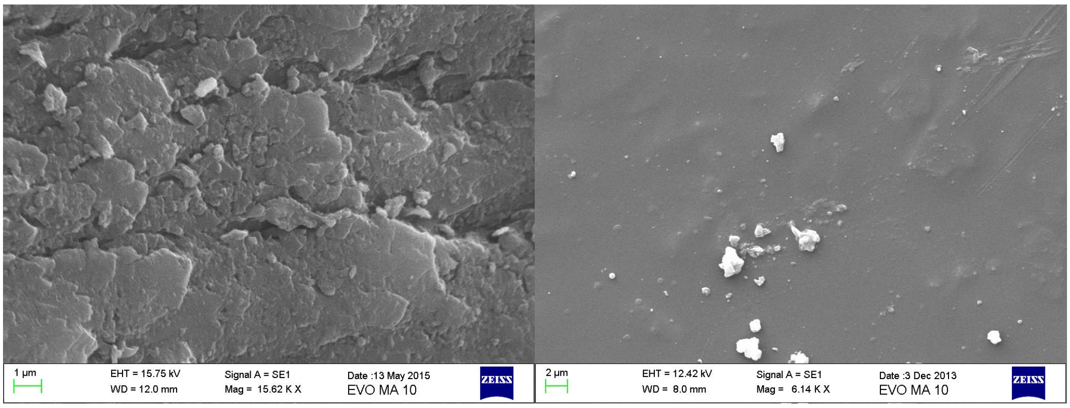

Figure 1: SEM images for the nanocomposite with 10 phr B_4C content (left) and for the microcomposite 10 phr B_4C content (right).

The type of interactions between the matrix and the filler exhibit size dependence and as a result the molecular dynamics and relaxation processes are affected. This is evident from the dielectric and thermal data.

Table 1: Volume fractions (%) and T_g temperatures for the manufactured composites with 5 and 10 phr nano- and micro-B_4C content.

Sample	Vol.% (nanocomp.)	Vol% (microcomp.)	T_g (ºC) (microcomp.)	T_g (ºC) (nanocomp)
5phr	3.39	1.45	56.8	57.3
10phr	6.94	3.94	55.7	57.6

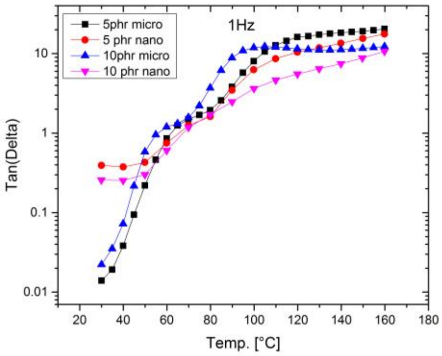

Figure 2: Loss tangent versus temperature for the specimens with 5 and 10 phr nano- and micro-B_4C content, at 1Hz.

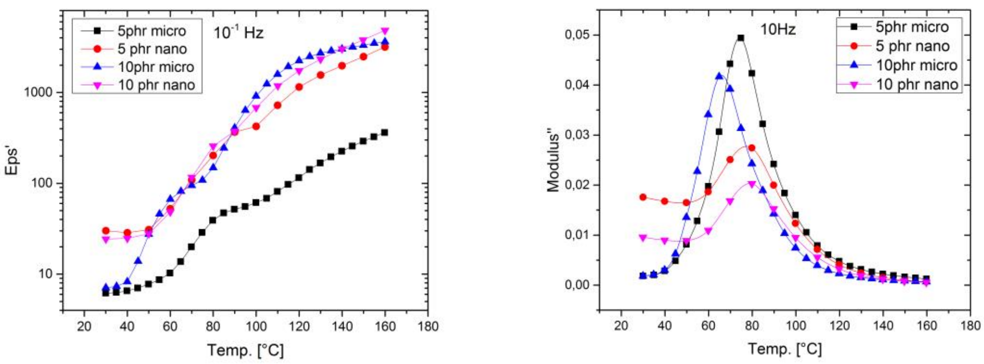

Figure 3: Real part of dielectric permittivity (ε΄) (left) and imaginary part of electric Modulus (right), versus temperature for the specimens with 5 and 10 phr nano- and micro-B_4C content at 0.1Hz and 10Hz.

Fittings according to the VFT (Vogel-Fulcher-Tammann) formalism were also conducted in order to investigate the dynamics of the α-relaxation mechanism and the influence of the filler's size on it.

References

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