

Enhancement of Thermal Conductivity in Composite Films of Polyimides with Needle-shaped ZnO particles

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Polyimide (PI) is one of the super engineering plastics, exhibiting high thermal and environmental stability with good mechanical and insulating properties. We have recently reported that the composite films based on blending of two immiscible PIs ((a) and (b) in **Fig. 1**) and pyramidal-shaped zinc oxide (p-ZnO) particles showed much higher thermal conductivity than that of the PI homopolymer containing p-ZnO due to selective dispersion of p-ZnO and formation of percolation paths [1].

In this study, novel polyimide composite films were prepared from the same PIs and needle-shaped ZnO (n-ZnO) particles, and the effects of anisotropy in shapes of fillers on the thermal conductivity were investigated.

The thermal conductivity of the composite films with n-ZnO is significantly higher than those of corresponding composite of PI homopolymer with p-ZnO and n-ZnO (**Fig. 2**). The vertical double percolation (VDP) morphology (inset in **Fig. 3**) in the composite film was observed by SEM, and the selective dispersion of n-ZnO into fluorine-PI phase was characterized by IR microscopy. Furthermore, WAXD analysis indicated that the orientation of n-ZnO particles in the composite film changed from planar orientation to isotropic orientation with increasing the n-ZnO content (**Fig. 3**). It can be concluded that the significant enhancement of thermal conductivity in the composite film is attributable to the increase in n-ZnO particles which orient in the out-of-plane direction originating from the confinement of needle-shaped particles by the formation of VDP structure.

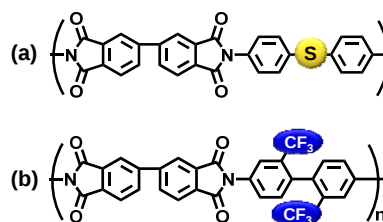


Fig. 1. Molecular structures of immiscible matrix polyimides (a) BPDA-SDA (SD) (b) BPDA-TFDB (TF).

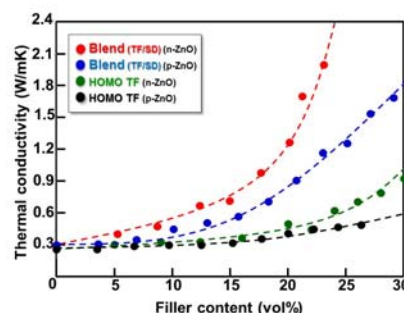


Fig. 2. (a) Enhancement in thermal conductivity of PI films and PI blend film with ZnO content.

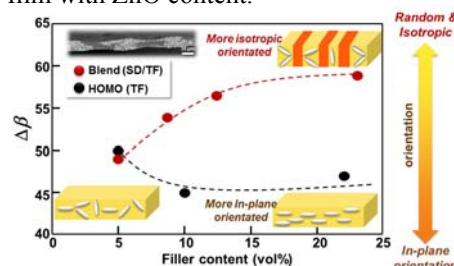


Fig. 3. The orientation analysis of n-ZnO in PI films by $\Delta\beta$. Inset: cross-sectional fracture surface of a SD/TF blend film.

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