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CC) Organic-Inorganic Hybrids and Polymer Nanocomposites for Homeland Security and Sustainability
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Anisotropic Thermal Diffusivity of Boron Nitride- and Zinc Oxide-Filled Polyimide Films: Effects of Filler Particle Size, Aggregation, Orientation, and Polymer Chain Rigidity

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Composite films were prepared from various grades of hexagonal boron nitride (*h*-BN) particles having platelet shapes, needle-shaped zinc oxide (*n*-ZnO) particles, and aromatic PIs having rigid or flexible main chains. Using thermal diffusivity (a) measurements along the out-of-plane (a^) and the in-plane (a//) directions combined with SEM and wide-angle X-ray diffraction measurements, this study clarified that the PI films filled with large *h*-BN flakes exhibited a large difference (anisotropy) between a^ and a// due to the strong in-plane orientation of heat-conducting *h*-BN plane, while smaller anisotropy was observed in composites with small flakes and aggregates, which orient more isotropically. In addition, the effects of polymer chain rigidity/flexibility on the anisotropy in *a* and the void fraction (*v)* of *h*-BN/PI composite films were examined. *h*-BN-filled composites of rigid-rod PI exhibited smaller *v* values than the flexible PI composites owing to the rigid chain with smaller free volume and dense packing between components. The composites of highly anisotropic rigid-PI matrix exhibited larger anisotropy in *a* than the flexible PI composites. Moreover, composite films were prepared by mixing two kinds of immiscible sulfur- and fluorine-containing PIs with n-ZnO particles. These blend composite films exhibited significantly higher a^ than blend films containing pyramidal shaped *p*-ZnO particles due to the formation of vertical double percolation (VDP) structures. The *n*-ZnO particles confined in the VDP structures and partially oriented along the out-of-plane direction contributed to the enhancement of a^.

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