Title:

Enhanced Thermal Conductivity over Percolation Threshold in Phase Separated Polyimide Blend Films Containing ZnO and MgO Nanoparticles

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Abstract: (Your abstract must use **Normal style** and must fit in this box. Your abstract should be no longer than 300 words. The box will 'expand' over 2 pages as you add text/diagrams into it.)

Introduction: Owing to the strong demands from micro- and power-electronic materials industry, polymer/inorganic composites containing micrometer-size ceramic particles, such as Al_2O_3, AlN, and BN, have been widely examined to enhance the thermal conductivity of polymer films. However, the improvement is still limited due to the interfacial contact resistance between particles and polymer matrix. In this study, we report effective increases in thermal conductivity even at low particles loading based on a selective localization technique of ZnO and MgO nanoparticles in phase-separated polyimide/polyimide (PI/PI) blend films.

Methods: Two types of PI, sulfur- and fluorine-containing PIs, were blended with pyramidal ZnO and cubic MgO particles. Under the optimized conditions of spin-coating and thermal curing, microphase separated structures with "vertical double percolation (VDP)" morphology were spontaneously formed in the blend films, in which two phases are separately aligned along the out-of-plane direction, and ZnO and MgO particles were selectively confined in the fluorine-containing PI phase.

Results & Discussion: PI blend films with VDP morphology exhibited more than 400 % enhancement of thermal conductivity in the out-of-plane direction at 24 vol% loading of ZnO and MgO particles, whereas monophase PI films with homogeneously dispersed particles exhibited only 90-150 % enhancement. These results indicate that the VDP structure with selectively localized particles functions as an effective thermal conductive pathway which goes over the percolation threshold. Moreover, PI blend films with larger-size MgO particles exhibited higher conductivity than those with ZnO particles between 0 and 24 vol %, whereas similar conductivities were observed over 24 vol %. This demonstrates that 'filler size effect' which effectively reduces interfacial contact resistance is significant at lower filler contents.