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In-situ Monitoring of Residual Stress Behavior-Temperature Profiles in Transparent Polyimide/Tetrapod Zinc Oxide Whisker Composites

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Abstract : Tetrapod zinc oxide whiskers (TZnO-Ws) were successfully synthesized by a thermal oxidation method. A series of transparent polyimide (PI)/TZnO-W composites were successfully synthesized via a solution-blending method. The structural and morphological features of TZnO-Ws and PI/TZnO-W composites were characterized by Fourier transform infrared spectroscopy (FT-IR), wide-angle X-Ray diffraction (WAXD), and field emission scanning electron microscope (FE-SEM). Dynamic stress behaviors were investigated in-situ during thermal imidization of the soft-baked PI/TZnO-W composite precursor and thermally cured composite films using a thin film stress analyzer (TFSA) by wafer bending technique. The PI/TZnO-W composite films exhibited an optical transparency greater than 80% at 550 nm (≤ 0.5 wt% TZnO-W content), a low coefficient of thermal expansion (CTE), and enhanced glass transition temperature. However, the thermal decomposition temperature decreased as the TZnO-W content increased. The water diffusion coefficient and water uptake of the PI/TZNO-W composite films were obtained by best fits to a Fickian diffusion model. The water resistance capacity of PI was greatly enhanced and moisture diffusion in the pure PI was retarded by incorporating the TZnO-W. The PI composite films based on TZNO-W resultantly may have potential applications in optoelectronic manufacturing processes as a flexible transparent substrate.

Keywords : polyimide (PI), tetrapod ZnO whisker (TZnO-W), transparent, dynamic stress behavior, water resistance
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