

Higher-order Structural Analysis of Transparent and Flexible High Thermal Conductive Liquid Crystalline Elastomer Sheet and its Composite

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Transparency, flexibility, and high thermal conductivity are trade-offs, and no resin that satisfies all has been developed yet. We have developed a new elastomer that combines transparency and flexibility with high thermal conductivity by monodomaining an acrylic monomer having a mesogen with polyether thiols and multifunctional thiols by Michael addition followed by stretch curing. While thermal conductivity generally increases in the stretch direction (x), this transparent LCE film exhibited high thermal conductivity in the perpendicular direction (y) to the stretching direction, with a maximum of over 3 W/(m · K) in the in-plane (y) direction. This value is about three times higher than that of inorganic glass. In this paper, this phenomenon was discussed by higher-order structural analysis using XRD analysis. The LCE molecules in the transparent sheet were aligned in the sheet in the stretching direction (x), but in the parallel (x)-direction inner layer, the molecular plane spacing was randomly oriented at the 0.45 nm level, and in the orthogonal (y)-direction inner layer, the molecular plane spacing was horizontally uniaxially oriented. In addition, in the (y)-direction inner layer, the large periodic structure on the order of a few molecular lengths was 6.22 nm, which was larger than that in the (x)-direction (5.89 nm). Thus, the aligned orientation of the molecular plane spacing and the large periodic structure on the order of a few molecular lengths are the reasons for the high thermal conductivity in the (y) inner layer direction.

Furthermore, a polydomain composite sheet filled with alumina filler has been fabricated, which then shows a thermal conductivity of 10.4 W/(m · K) in maximum while maintaining flexibility. We are convinced that this LCE material is a novel high heat-dissipating insulating material that can contribute to compactness, high performance, and energy saving for various equipment and devices.