Anisotropic Thermal Property Measurement of a Polymer Composite by using the 3 Omega Method

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Polymer composites having thermal conductivity comparable to stainless steel (16 $Wm^{-1}K^{-1}$) are commercially available nowadays. Additives with superb thermal transport characteristics such as carbon nanotubes, graphene and etc. are added to base polymers to achieve up to 2 orders of magnitude increment in thermal conductivity. Thermally conductive polymers are expected to replace metallic frames of advanced heat exchanging systems that needs light weight and chemical inertness. However, in such polymer composites, the weight fraction of additive becomes comparable or even overwhelms the portion of base polymer. High loading of additives can cause problems such as inhomogeneous additive distribution leading to non-uniform and anisotropic thermal conductivity within the product. Often, thermal analysis techniques are used to analyze the effects of additive distribution but quantitative measurement is extremely difficult since the additive orientation inside a composite is a complicated function of measurement sample configuration, manufacturing method, thermal history and etc. In this paper, a modified 3-omega method is utilized to assess the additive orientation in a polymer composite sample. Thermal conductivity measurement by using microheater and temperature sensor arrays provide information of in- and through-plane thermal conductivity of a polymer composite with spatial resolution smaller than 1 mm. Localized thermal conductivity measurement results are used to analyze the additive concentration distribution within the sample and assess the additive mixing characteristics.