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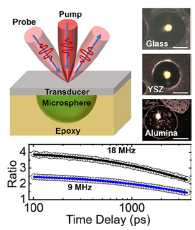
Method shows some deviations between bulk and microscale thermal conductivity for inorganic particles embedded in epoxy resin.



Microparticle-containing materials, called thermal composites, can potentially address heat dissipation issues in miniature electronics, so simulating the thermal properties of these materials can help engineers design more efficient devices. However, current models rely on thermal properties of bulk materials and may not accurately reflect material behavior. Thompson et al. reported a method to directly measure the thermal properties of microparticles as typical fillers for thermal composites.

The authors found the thermal conductivities of some microparticles differ from their bulk counterparts. The thermal conductivities of fully dense microspheres with either amorphous or homogeneous crystal structures approached those of their bulk counterparts. The thermal conductivity of a polycrystalline and morphologically complex material was much lower than its bulk, single-crystal form.

"This suggests that the thermal conductivity of fillers used in thermal interface materials may deviate significantly from expected values," co-author Matthew Thompson said.

To prepare samples for thermal studies, the team embedded the microparticles into epoxy and polished the composite to smoothen the surface for accurate thermal measurements. Finally, the team measured the thermal conductivity of the microparticles with time-domain thermoreflectance, an ultrafast laser-based technique.

The authors hope this work will serve as a basis for studying materials and properties beyond those in the study.

"The methods in this article could be straightforwardly applied to many other microscopic filler materials," co-author Xiaojia Wang said. "Further studies may include elucidating the role of microstructure and phase composition on the thermal conductivity of micron-scale fillers."

"Knowing the true value of the thermal conductivity of fillers produced industrially is critical to our thermal management technology platform," co-author Victor Ho said.

Source: "Direct measurements of thermal transport in glass and ceramic microspheres embedded in an epoxy matrix," by Matthew F. Thompson, Xuewang Wu, Dingbin Huang, Yingying Zhang, Nicholas C. A. Seaton, Chi Zhang, Matthew T. Johnson, Jacob P. Podkaminer, Victor Ho, and Xiaojia Wang, *Applied Physics Letters* (2021). The article can be accessed at https://doi.org/10.1063/5.0055038.