NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Optical Thermal Characterization Enables High-Performance Electronics Applications

Highlights in Research & Development

Critical experimental data for thermal performance of advanced materials help to develop next-generation electronic components.

With the rapid development of electronics systems, significant effort is being put into exploring effective thermal management strategies to remove excessive heat that can degrade or damage components and devices. The heat removal path in electronics packaging usually involves multiple layers. These layers and the associated contact resistances can present a significant bottleneck to heat flow.

A typical method for decreasing the contact thermal resistance and enhancing heat removal efficiency is the use of thermal interface materials (TIMs) to fill in gaps between mating surfaces. It is important to understand and quantify the thermal performance of TIMs to accurately determine the overall performance of electronic components. Therefore, a variety of methods have been developed to characterize TIMs.

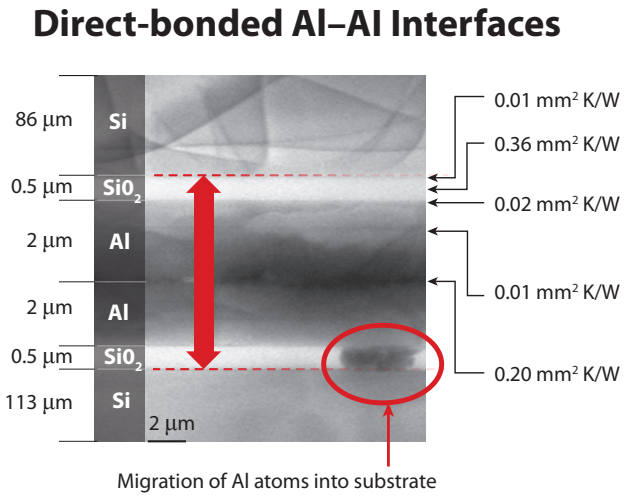

Figure 1. Thermal contact resistances at various interfaces measured by the laser-based optical technique developed through the research.
Photo by Andrew Norman, NREL

NREL scientists have developed a unique laser-based transient thermoreflectance technique that measures thermal performance of materials and the interfaces between material layers that cannot be resolved by conventional characterization methods. Laser-based transient thermal characterization techniques are non-contact and non-destructive, with high precision and accuracy.

Working in collaboration with industry partner Delphi, university partners Carnegie Mellon and Texas A&M, and the federal agencies U.S. Department of Energy and Defense Advanced Research Projects Agency, the technique was used to measure thermal performance of new and emerging TIMs for electronics packaging applications, such as thermoplastics, atomically bonded layers (Figure 1), boron-nitride nanosheets, and copper nanowires. The critical experimental thermal performance data obtained from this work will help in the development of electronics components that are more efficient, higher-performance, and inexpensive.

Technical Contact: Xuhui Feng, Xuhui.Feng@nrel.gov

Reference: Feng, X., King, C., and Narumanchi, S. (2016). "General multilayer heat transfer model for optical-based thermal characterization techniques," International Journal of Heat and Mass Transfer, Vol. 93, 695-706.

Key Research Results

Achievement

NREL developed a modeling and experimental strategy to characterize thermal performance of materials. The technique provides critical data on thermal properties with relevance for electronics packaging applications.

Key Result

Thermal contact resistance and bulk thermal conductivity were characterized for new high-performance materials such as thermoplastics, boron-nitride nanosheets, copper nanowires, and atomically bonded layers.

Potential Impact

The technique is an important tool for developing designs and materials that enable power electronics packaging with small footprint, high power density, and low cost for numerous applications.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 | www.nrel.gov

NREL/FS-5400-65848 | February 2016

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