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Applications of thermo-optic phase spectroscopy (TOPS) to design of materials for thermal conductivity, dynamics of phase transformations, and thermal management of microelectronics

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Venue: Faculty of Engineering Bldg. 2, Room 31A

Abstract:

We recently developed a suite of quantitative optical beam-deflection methods to accelerate understanding of the thermophysical properties of materials. Thermo-optic phase spectroscopy (TOPS) offers exceptional signal-to-noise at micron-scale spatial resolution. The optical instrument uses superluminescent diodes as the light sources and is simple and low-cost. We have extensively applied a photothermal displacement variant (D-TOPS) in our studies of the molecular design of polymers with an expanded range of low and high thermal conductivities. D-TOPS also enables dynamic probing of phase transformations by capturing the frequency-dependence of the thermal expansion coefficient. Immersion-TOPS uses thermo-optic (mirage effect) detection of temperature fields to achieve a large enhancement in sensitivity compared to thermoreflectance when working on the 30-100 μm length-scales needed to probe 3D integrated circuits. These capabilities position TOPS as a powerful platform for materials discovery and thermal property metrology.

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Bio: David Cahill is the Grainger Distinguished Chair in Engineering, and Professor of Materials Science and Engineering at the University of Illinois Urbana-Champaign. He joined the faculty of the U. Illinois after earning his Ph.D. in condensed matter physics from Cornell University and working as a postdoctoral research associate at the IBM Watson Research Center. He served as department head from 2010 to 2018. His research program advances physical insights on thermal transport at the nanoscale; extremes of low and high thermal conductivity in polymers; thermal metrology for microelectronics; and the thermal science of electrochemical cells and battery materials. Cahill received the 2018 Innovation in Materials Characterization Award of the Materials Research Society, the 2015 Touloukian Award of the American Society of Mechanical Engineers, and the Klemens Award from the International Conference on Phonon Scattering in Condensed Matter. He is a fellow of the MRS, the American Physical Society, the AAAS, and is an elected member of the American Academy of Arts and Sciences.

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