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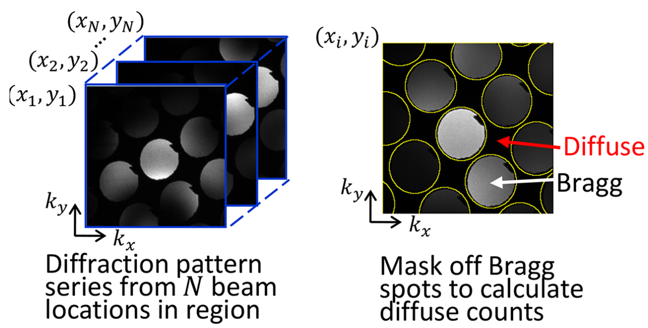
Measuring the diffuse scattering in energy-filtered scanning electron nanodiffraction patterns provides way forward for nanoscale temperature readings.



Improving the thermal design of microelectronics, optoelectronics or thermoelectric technologies requires a better understanding of how heat flows in nanostructures. Recently, researchers have developed new scanning transmission electron microscopy (STEM) thermometry techniques with the aim of probing temperature at less than 100 nanometers in length from the far-field. One approach drawing on temperature-dependent thermal diffuse scattering (TDS) looks to provide a path forward for making such measurements.

Wehmeyer et al. have demonstrated that TDS can be used to take nanoscale temperature readings using STEM. By measuring the diffuse scattering in energy filtered scanning electron nanodiffraction patterns of an isothermal single-crystal gold film, the authors showed that the diffuse counts can be calibrated to use as a small-scale thermometer, with a position-averaged temperature coefficient of 2,400 parts per million/kelvin between T = 100 and 300 K.

“This work helps researchers move closer to the dream of single digit nanometer spatial resolution temperature mapping,” said Geoff Wehmeyer, an author on the paper. “This capability would enable fundamental studies of the thermal boundary conductance at interfaces, heat transfer through multilayers, and heat dissipation in nanostructures.”

Existing STEM thermometry methods rely on measuring thermal strains due to thermal expansion; this is challenging because thermal expansion coefficients are relatively small (less than 30 ppm/K). Since TDS relies on a mechanism of temperature-dependent atomic vibrations rather than thermal expansion, it can provide local temperature measurements with larger temperature coefficients for a wide range of materials.

Wehmeyer said the group is next looking to demonstrate the technique’s use in mapping temperature gradients.

Source: “Measuring temperature-dependent thermal diffuse scattering using scanning transmission electron microscopy,” by Geoff Wehmeyer, Karen C. Bustillo, Andrew M. Minor, and Chris Dames, *Applied Physics Letters* (2018). The article can be accessed at https://doi.org/10.1063/1.5066111.