Thermal Property Measurement of Micrometer-sized Samples

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A frequency-domain thermoreflectance technique has been developed in the past for measuring SiC thermal diffusivity of micrometer-sized slab that is attached to a TEM grid. For low conductivity materials such as ceramic fuels, however, the technique needs to be specially designed for the measurement to be successful. This paper introduces a new approach that, using an intensity modulated laser heating on the front surface, measures the thermoreflectance signal at the rear surface to simplify the bean size control and alignment. An analytic model was developed to include the thin film coating and heat transfer to the TEM grid. Because the laser heating can cause a large temperature rise in the sample, high thermal conductivity thin film coating is found to effectively reduce the DC temperature rise. Measurements of a fused silica sample of 2.16μm×11.2μm×18.3μm coated with a 95nm Ti film on the front surface and with a 120nm Au film on the rear surface are presented to demonstrate the design and optimization of the approach. The experimental result is in good agreement with the literature value. The uncertainty analysis showed that the measurement uncertainty is within 6%, and the uncertainties of the thickness of layers contribute the most to the final uncertainty. The experimental approach, characterized by the micrometer sized sample from Focused Ion Beam (FIB) lift off, enables thermal property determination at a high spatial resolution and offers a unique option to minimize radiation exposure for measurements of irradiated nuclear fuels.