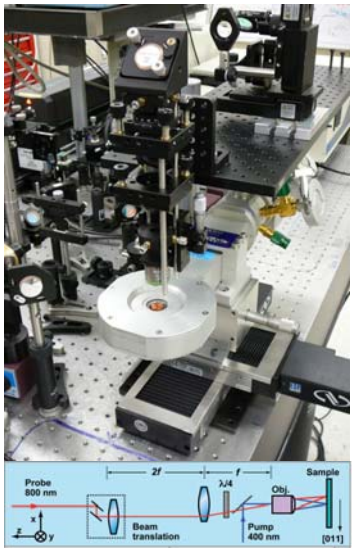
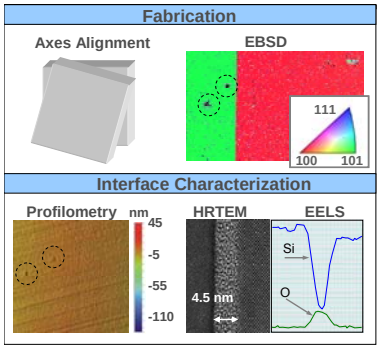
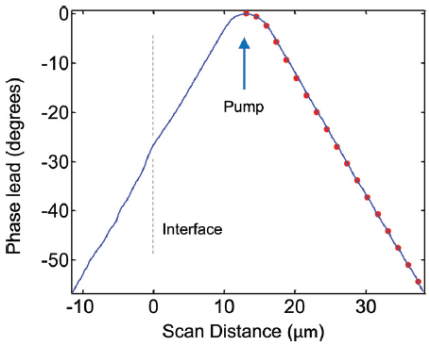
**EFRC Center for Materials Science of Nuclear Fuel**

**Idaho National Laboratory**

# Highlight: Thermal transport measurement across an interface by laser based thermal wave imaging techniques




EFRC researchers Drs. **Marat Khafizov** (senior researcher) and **David Hurley** (PI) at Idaho National Laboratory implement laser based thermal wave imaging techniques to study phonon scattering mechanisms limiting thermal transport in $UO_2$ and its surrogate materials [1,2].

**(Left)** Experimental technique is based on pump probe thermoreflectance approach, where an amplitude modulated pump beam acts as a local harmonically oscillating heat source. A probe beam is scanned across the surface and measures the temperature by recording small temperature induced changes in optical reflectivity. With tight focusing we can achieve submicron resolution of thermal wave in the lateral and depth directions. In a typical implementation a phase lag between temperature and heat source is measured and when plotted as a function of distance between pump and probe reveals a linear dependence. The slope of this profile is a measure of thermal diffusion length and is determined by thermal properties of the material and modulation frequency. By changing the modulation frequency we can control the penetration depth of the thermal wave. This technique is well suited for studies of thermal transport across individual microstructure features, thin film, and nonuniform damage profiles caused by ion irradiation.

Thermal transport across individual interface was studied in Si bicrystal interface as a model system. **(Middle)** High resolution microscopy characterization reveals an oxide layer, between two Si single crystals oriented to form Σ29 grain boundary. **(Right)** Our experimental analysis suggests that thermal conductance of this interface is 0.11 GW/m2K [3]. Researchers at University of Florida Bowen Deng (Ph.D student) , Dr. Alex Chernatynski ( postdoc) and Prof. Simon Phillpot (PI) performed molecular dynamics simulation of thermal transport across interface based on the atomic level structure revealed by microstructure characterization. Calculation based on Stillinger Weber potential suggest conductance of 0.13 GW/m2K. There is a close agreement with our experimental results. This study on Si bicrystal interface allowed us

to both test our experimental capability and establish a procedure for direct comparison with the model.

[1] “Measurement of thermal transport using time-resolved thermal wave microscopy”, M. Khafizov and D. H.Hurley, J. Appl. Physics 110,083525 (2011)

[2] “Spatially localized measurement of thermal conductivity using a hybrid photothermal technique”, Z. Hua , H. Ban , M. Khafizov , R. Schley , R. J. Kennedy, D. H. Hurley, J. Appl. Physics 111, 103505 (2012)

[3] “Measurement of the Kapitza resistance across a bicrystal interface”, D. H.Hurley, M. Khafizov, S. L. Shinde, J. Appl. Physics 109,083504 (2011)