AUTOMATED NANOSECOND LASER PULSE-INDUCED HEATING, MELTING AND ACOUSTICS IN TUNGSTEN USING TWO-WAVE MIXING PHOTOREFRACTIVE INTERFEROMETRY

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Introduction. To ensure safety and high efficiency operation of nuclear power plants it is important to measure precisely and accurately solid-to-liquid phase transition and corresponding melting point temperature of nuclear fuels. Measurement of thermo-physical material properties of fresh and irradiated nuclear fuels is a key to understand, model and predict the performance of existing fuels and to develop new forms of fuels.

Experimental. We are developing novel automated "all-optical" technique for nanosecond laser pulse-induced heating, melting and vaporization in refractory solid-state materials via measured laser-generated ultrasonic waveforms using two-wave mixing photorefractive interferometry. Materials under study are refractory metals and ceramics which mimic nuclear fuels in their thermo-physical properties. The ultimate goal of the project is to develop fully automated technique based on combined laser ultrasonics and fast pyrometry for remote, spatially-resolved evaluation of thermo-physical properties of fresh and spent nuclear fuels in the melting and vaporization regimes to establish safe operating limits for the fuel in the operating nuclear reactor.

Results and Conclusion. Using motorized control of laser pulses incident energy, spatial and temporal profiles, the dynamics of an acoustic shear wave is carefully tracked upon the onset of laser-induced melting. We detected the delay in transient of this wave across metallic film, which is likely attributed to a change in character of the ultrasonic source [1]. In the thermoelastic regime, shear waves are generated from the entire laser irradiated area. Just above the melting threshold, a molten pool forms in the center of the generation volume where shear waves are not sustained. As a result, they are preferentially generated from off-axis thermoelastic source. This results in a delay of the shear wave arrival time [1, 2] and is used as a signature precursor for laser pulse-induced melting. Automation scheme and physics of laser pulse-matter interaction on nanosecond time scale for heat transfer and acoustics in tungsten plate will be discussed in the light of our recent experimental and modelling results [2].

Acknowledgments. Support is acknowledged from the 055 Program Grant of Kazakhstan Ministry of Education and Science and Seed Grant of Nazarbayev University Corporate Fund of Social Development.

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