Localized Detection of Phase Transformation in Tungsten Using Laser Ultrasonics

Zhandos Utegulov [C, S,1,2], Farhad Farzbod[2], Stephen Reese[2], Robert Schley[2] and David Hurley[2]

[1]Nazarbayev University, Department of Physics and Center for Energy Research, Astana, Kazakhstan
[2]Idaho National Laboratory, Department of Materials Science and Engineering, Idaho Falls, ID, U.S.A.
ZHUTEGULOV@NU.EDU.KZ

We demonstrate containerless, localized measurement of the melting point temperature of pure tungsten using laser ultrasonics. We use nanosecond laser pulses to generate bulk acoustic waves in a tungsten plate and photorefractive interferometry to track the time evolution of bulk waves propagating along the epicentral axis. By gradually increasing the pulse energy of the generation laser, the thermoelastic, melting and ablation regimes are investigated. The onset of laser-induced melting is characterized by a slight delay in the arrival of the shear wave which is attributed to the changing character of the ultrasonic source. In the thermoelastic regime shear waves are generated solely by mode conversion at the sample surface. In the melting regime shear wave generation is greatly limited because the melt pool can't sustain shear waves. Thus, above the melting threshold the source character changes with radial distance from the source center. In this regime shear waves are generated by an annular thermoelastic source surrounding the melt pool. This has the effect of weighting more heavily off-axis sources resulting in a slight delay of the shear arrival. By carefully measuring the laser spot size and energy we use a continuum based model of laser heating to relate the sudden delay in shear arrival to the melting point temperature. In addition the ablation threshold is identified by noting the point at which the height of the longitudinal precursor peak no longer increasing linearly with pulse energy.