Time-Resolved Micro-Spectral Radiometry During Nanosecond Laser Pulse Heating of Tungsten Thin Films

Yermek Yermekbay [S], Azat Abdullaev, A. Dawood, Tanat Kissikov and Zhanatay Nurekeyev
Department of Physics, Nazarbayev University, Nur-Sultan, Nur-Sultan, Kazakhstan

C. Spitas and K.V. Kostas
Mechanical and Aerospace Engineering, School of Engineering and Digital Sciences, Nazarbayev University, Nur-Sultan, Nur-Sultan, Kazakhstan

Zhandos Utegulov [C]
Department of Physics, Nazarbayev University, Nur-Sultan, Nur-Sultan, Kazakhstan
zhutegulov@nu.edu.kz

Melting is known to be a major property of solids closely associated with their structural and thermodynamic stability, and has consequently been studied for many years. However, the accuracy of high temperature measurements of thermophysical properties have always been hindered by the chemical reactivity of materials, especially in the molten state. In this regard pulse laser-based rapid, non-contact heating provides a feasible solution for suppressing the materials volatility at high temperatures via minimizing chemical interactions inside heated medium and with ambient environment. Fast laser heating can also induce very high temperatures while requiring low average powers and small sample areas. At the same time nanosecond laser pulse heating enables molten material to attain thermal equilibrium since thermalization times of laser-heated electrons to the lattice of a sample are typically in picoseconds.

Although melting plateau was clearly observed in long nanosecond pulse laser melting, the corresponding melting point temperature was measured by detecting time-averaged irradiance using ungated CCD detector [1, 2], implying that better temporal resolution can be achieved if time-gated CCDs are used.

In this work we have constructed micro-spectral transient radiometry apparatus engaging nanosecond pulse laser, confocal microscope, grating spectrometer and intensified CCD and demonstrate a method to accurately measure heated tungsten thin film temperatures. Time-resolved spectral irradiance during incoming trail of nanosecond pulses was fitted by Plankian black-body irradiance. Transient temperatures of heated metal were extracted from the fit and compared with time-resolved thermal diffusion model. Proposed method can provide time-resolved temperature excursion measurements down to 2 ns.

References

[1] S. Deemyad, E. Stere, C. Barthel, S. Rekhi "Pulsed laser heating and temperature determination in diamond anvil cell", Rev. Sci. Instrum., 76, 125104, (2005)

[2] S. Rekhi, J. Tempere, I. F. Silvera "Temperature determination for nanosecond pulsed laser heating", Rev. Sci. Instrum., 74 (8), 2003