Mesoscale Priority Research Direction

Thermal Conductivity of Thin Films at High Temperature (> 4000 K) and Pressure (> 100 GPa)

Opportunity

What is the nature of a solid-solid thermal boundary layer at high temperature (>4000 K) and pressure (>100 GPa)? Heat transfer within a thin film and across an interface under dynamic compression is not well understood.

Temperature (T) is a fundamental parameter in equation of state studies. Previous attempts to measure T at these conditions have failed due to improper target design or measurement techniques.[1,2] Those attempts utilized non-contact measurements to determine the surface T of the sample and lacked the ability to probe the bulk T, which is different. How do we relate surface T to bulk T? We must know the thermal transport properties.

Meso Challenge

For opaque materials, a sample's observed irradiance (i.e. temperature) originates from within 30 nm of the sample surface. How does energy transfer from the thin 30 nm layer to the bulk and vice versa? As the quantum interactions of the atoms are altered by dynamic compression, how do the energy transport mechanism and bulk temperature respond? What happens to this relationship as the material undergoes compression-induced structure changes?

References:
1.) K. G. Gallagher *et al.*, AIP Conference Proceedings **309** (1), (1994).
2.) G. Y. Hao *et al.*, Applied Physics Letters **90** (26), (2007).

Approach

Thermal transfer between thin film insulators and metals can be measured under dynamic compression through proper target design. We will use a new diffusion bonding technique to directly bond metal/insulator pairs, e.g., Al/glass, with varying thicknesses, enabling a direct measure of the thermal transport across the metal/insulator boundary. These targets will be dynamically compressed to high temperature (>4000 K) and pressure (>100 GPa). The thermal response across the boundary will be directly measured using optical pyrometry. The thermal conductivity of the metal and insulator will be determined by comparing the thermal decay rate of different thickness metal/insulator pairs.

Impact

- New ability: non-contact interior temperature measurement
- Better knowledge of thermal transport properties, improved understanding of thermal transport across and within thin boundary layers and at interfaces
- Applications to heat management in new materials/devices, e.g., batteries
- Improved equations of state

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