Abstract Submitted
for the SHOCK19 Meeting of
The American Physical Society

Heating of tantalum upon shock breakout from a free surface

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The standard picture of uniaxial release from the shock state treats it as close to isentropic. As such, a sample shock-compressed to of order 100GPa pressures is expected to cool on release by several hundred degrees due to the thermoelastic effect. However, this fails to account for the approximately GPa strength of the rapidly-releasing material close to the rear surface, which thus suffers substantial heating from plastic work. Considerable energy can also be recovered via defect annihilation. We present MD simulations of shock and release in tantalum that exhibit release temperatures far exceeding those expected under the assumption of isentropic release. An energy-budget analysis shows that this is due primarily to plastic-work from material strength that largely counters thermoelastic cooling. The simulations are corroborated by experiments where the release temperatures of laser-shocked tantalum foils are deduced from their thermal strains via in femtosecond situ x-ray diffraction.

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Date submitted: 21 Feb 2019 Electronic form version 1.4