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Plastic Deformation, Amorphization, and Phase Changes in Extreme Laser Shock Compression of Ta and Si

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High-amplitude pulsed lasers probe the response of materials at pressures up to 100s of GPa and strain rates of 10^8 s^{-1}, revealing plastic deformation, phase transformations, and amorphization. Molecular dynamics simulations provide modeling at comparable strain rates and time durations. Shock compression of monocrystalline Ta reveals dislocations at low pressures and twinning at higher pressures (above 24 GPa). Results are compared with predictions from homogeneous dislocation generation and multiplication and the latter mechanism is dominant. The formation of an Omega phase was observed in monocrystalline tantalum at a shock amplitude of approximately 70 GPa. The shear stresses may play a role in the transformation. As shock energy increases, the following structural changes in monocrystalline Si are observed: dislocations and stacking faults; bands of amorphized Si forming on crystallographic orientations consistent with slip; broad regions of amorphized Si; nanocrystalline Si resulting from re-crystallization. MD simulations display similar amorphous regions.
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