INTERNATIONAL FRONTIER SEMINAR №088

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Science Research Bldg. 1, 4th floor.
Ehime Univ.

Keywords:

1. Laser-shock
2. Dislocation dynamics
3. Diamond

Shock-induced ultrafast dislocation propagation in single-crystalline diamond

Dislocation motion is a key aspect of plasticity in crystals. Under deformations at extremely high strain rates (≥108 s-1), dislocation speeds are thought to be as fast as, if not faster than, the sound speeds of the crystal. Dislocation theory predicts the existence of limiting velocities in a given crystal near the sound velocities, indicating that stable dislocation motions are forbidden at those velocities. However, theories also suggest that stable propagation of dislocations at velocities faster than the sound wave velocities (and thus the forbidden velocities) is possible when they are created at such high velocities.
In this seminar, I will present our recent experimental results showing dislocations propagating faster than the transverse sound velocity in single crystal diamond. Though the ductility common to metals is usually absent in brittle materials like diamond, even brittle materials can exhibit ductility under pressure and temperature. Employing femtosecond X-ray pulses of X-ray Free Electron Laser (XFEL) at SACLA, we performed phase contrast enhanced X-ray radiography to time-resolve stacking fault extension in shocked diamond. Our observation gives indirect evidence of partial dislocations in diamond traveling faster than the transverse sound velocity [1]. The result provides crucial insights into accurate modeling of material deformation dynamics at extremes.

[1] K. Katagiri, et al., Science 382, 69–72 (2023).

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