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Ultra-high-speed X-ray imaging of laser-driven shock into solid materials using synchrotron light

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A high-power, pulsed laser impacting the surface of a material can generate surface ablation, shock waves and crack propagation; while X-ray imaging can provide a time-resolved probe. Hard X-rays are perfectly suitable for visualizations of transient processes in optically opaque materials even for objects of several mm in size. The MHz pulsed time structure, tunable energy bandwidth, high brilliance, and the high degree of spatial coherence of hard X-rays (E > 30keV) from third generation synchrotron sources allowing transient processes to be tracked directly using ultra-high-speed image acquisition systems.
We report on an in-situ real time investigation of ns single-pulsed laser-driven processes studied by combined diffraction-direct-space-imaging experiments exploiting the single bunch structure at the hard X-ray imaging beam line ID19 of the ESRF investigating the process of laser hole drilling into single crystalline silicium. Whereas macroscopic changes in bulk materials can be quite easily deduced from X-ray phase contrast imaging; information probing changes at the lattice level can be obtained using diffraction imaging. The whole process was followed for 120sec with a maximum frame rate of up to 100kHz.
We have developed an experimental methods that allow to synchronize on the ns level the single shot laser operation with the high speed camera system matching the 4- and 16-bunch structure of the ESRF.

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