Ultra high-speed X-ray phase-contrast imaging using single-pulse synchrotron radiation

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Third generation synchrotron light sources offer high photon flux, partial spatial coherence, and < 100 ps pulse widths with megahertz repetition rates. These properties present enormous potential for studies of processes, which evolve on timescales governed by material sound speeds in the order of km/s (µm/ns) [1-3]. We will report on hard X-ray phase-contrast imaging (XPCI) with single-pulse temporal resolution and multiple-frame recording with million frames per second rates that is being developed at the European Synchrotron Radiation Facility (ESRF) [3-5]. We will present visualizations of various transient processes such as crack propagation in glass, explosion during electric arc ignition, laser-induced micro-cavitations and jetting in water, laser-shock-induced compression in polymeric foam, and hypervelocity-impact-induced shock, cavity collapse and spallation. We will highlight the importance of multiple-frame recording to observations of stochastic transient processes which are impossible to realize using single-shot or stroboscopic XPCI. We will demonstrate XPCI as a powerful diagnostic to observe instantaneous velocities and internal structures, which cannot be obtained from X-ray attenuation-contrast imaging and cannot be probed, or only partially probed, using conventional ultra-high-speed optical shadowgraph techniques or laser-backlighters.

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