

Ultrafast Coherent Diffractive Imaging of Acoustic Waves in Nanostructures

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We present the first full field dynamic imaging using tabletop high harmonics, where we directly visualize nanoscale thermal and acoustic wave propagation in real time with $\approx 0.1\text{nm}$ axial resolution, 90nm lateral resolution, and 10fs time resolution. To achieve this, we combine ptychography coherent diffractive imaging (CDI) [1] with a tabletop high harmonic (HHG) source. After exciting the nanosystem with a 23fs laser pulse, we stroboscopically image the resulting thermal expansion and heat flow, as well as the impulsive longitudinal and transverse acoustic wave propagation of nickel nanostructures patterned on a silicon substrate. This work is a first step toward combining the ultra-high spatial resolution possible using EUV-CDI with the ultra-high femtosecond temporal resolution of HHG sources [2,3].

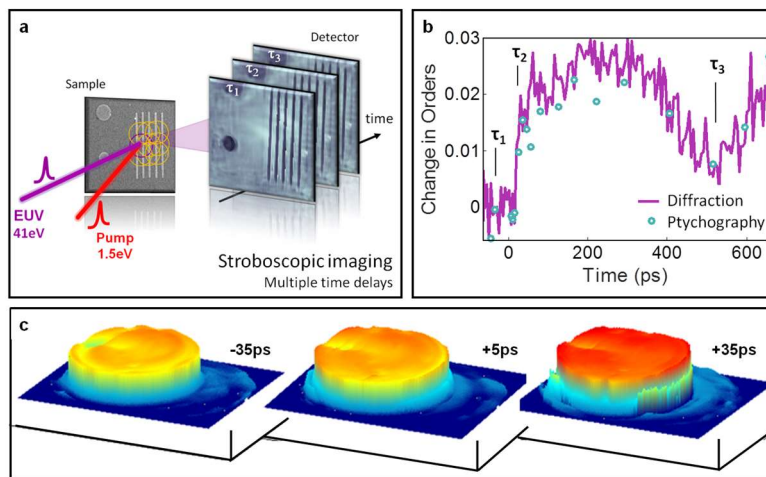


Fig. 1. (a) Schematic for full field EUV dynamic imaging on a tabletop. A series of stroboscopic images are reconstructed for every pump-probe delay with ptychographic scanning CDI. (b) Time trace displaying the change in the 1st diffraction order efficiency for a single diffraction pattern (purple line) and for the 81 diffraction patterns at each time delay from the ptychographic data set (blue circles). (c) Ni pillar, $16\mu\text{m}$ diameter and 20nm height: ptychographic phase images, with $\approx 0.1\text{nm}$ axial resolution and 90nm transverse resolution.

References:

- [1] A. Maiden et al., *Ultramicroscopy* 109, 1256–1262 (2009).
- [2] D. Gardner et al., *Nature Photonics* 11, 259 (2017).
- [3] Z. Tao et al., *Science* 353, 62 (2016).