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Shack-Hartmann sensors for X-ray multicontrast imaging

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Beam-modulation techniques in X-ray imaging can serve for disentangling different contrast modalities, such as absorption, phase, and dark-field contrast. These encompass Talbot-grating interferometry of shadow mask (Hartmann) techniques. We have devised micro-lens arrays to be used as Shack Hartmann masks for dose-efficient, single-exposure imaging of dynamic processes.

The Shack-Hartmann mask consists of a 2D array of microlenses that partition a wide X-ray beam into individual beamlets, whose attenuation, deviation and broadening will reflect sample properties like absorption, phase shift and scattering power, respectively. Thus, an efficient use of the incoming X-ray flux is made, which allows reducing exposure times down to few micro-seconds. This approach was used to image the structure formation process during pulsed laser ablation in liquids (PLAL). PLAL is a procedure to produce nanoparticles suspended in liquids by ablating a target with an intense pulsed laser beam. The product relies on an intricate interplay between different length and time scales.

We will show that different lens arrays as a 3D-printed crossed cylinder lens array (SHARX [1]) or a compound lens array (CARL [2]) of structured polyimide foils are capable of delivering in-formation on macroscopic dynamics as well as the occurrence of nanoparticulate mass during the process.

1. T. dos Santos Rolo, S. Reich, D. Karpov, S. Gasilov, D. Kunka, T. Baumbach, A. Plech: A Shack-Hartmann sensor for single-shot multi-contrast imaging with hard X-rays, arXiv: 1802.10045 (2018).
2. S. Reich, T. dos Santos Rolo, A. Letzel, T. Baumbach, A. Plech: Scalable, large area compound array refractive lens for hard X-rays, Appl. Phys. Lett. 112, 151903 (2018)

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