Coherent ultrafast diffraction imaging at the Abbe limit using a compact high average power high harmonic source

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Recent progress in the development of high-average power high harmonic sources (HHG) [1] opens possibilities for novel applications in the soft X-ray and extreme ultraviolet spectral range. Especially applications such as imaging benefit from the high photon flux that is available from these sources. At the same time the relatively long driving pulses guarantee narrow harmonic lines, which are essential for high resolution coherent diffraction imaging [2].

Using such a high power HHG source, which is driven by a ytterbium-doped fiber CPA system operating at 1030 nm central wavelength, we recently demonstrated coherent diffraction imaging (Fig. 1a & c) down to 26 nm spatial resolution at a numerical aperture of 0.8 [3]. As sample (Fig. 1b) we used a thin silicon nitride substrate coated with a 200 nm thick gold layer and the institute's logo written as aperture using a focused ion beam. The coherent diffraction imaging setup consists of two multilayer coated focusing mirrors that refocus the XUV light onto the sample and spectrally select the 31st harmonic at 33.2 nm wavelength. The achieved resolution thus compares to less than one wavelength, which is in good agreement with the Abbe limit for the NA used as well as the achievable resolution induced by the relative bandwidth of the harmonic line ($\Delta\lambda/\lambda$=1/220). Further we could demonstrate real-time imaging using one second integration time at a resolution of 65 nm.

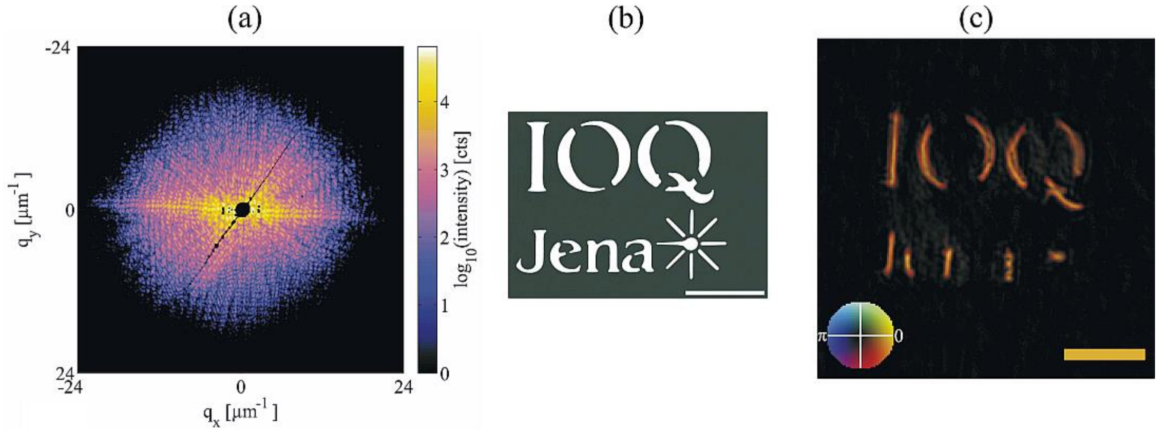

Fig. 1 (a) Measured diffraction pattern at 33.2 nm wavelength and a numerical aperture of 0.8. (b) STEM image of the sample used. (c) Reconstruction of the sample with 26 nm spatial resolution. The scale bars in (b) and (c) are 1µm.

Our experiment demonstrates the capabilities novel high-average power HHG sources have and that their excellent radiation properties allow for imaging close to highest possible resolution in a reasonable time. The achieved relative resolution marks a new record for any coherent diffraction imaging experiment reported in literature. More details and newer results of this ongoing experiment will be reported at the conference.

References

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978-1-4673-7475-0/15/$31.00 ©2015 IEEE