Lensless Imaging Using Tabletop Extreme-Ultraviolet Sources

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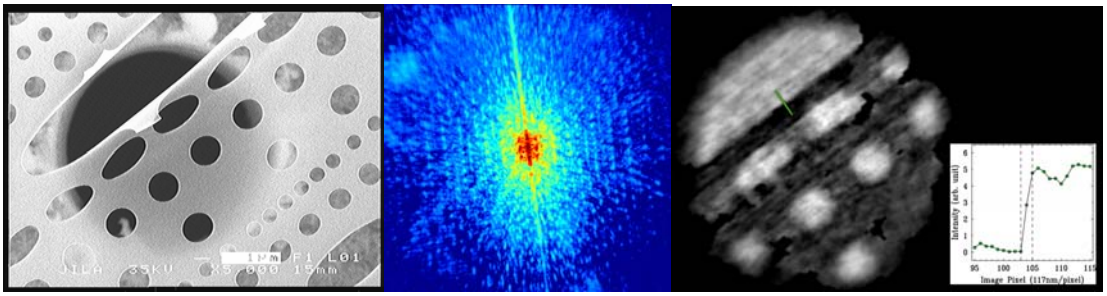
Abstract: We present the first work demonstrating lensless diffractive imaging in a tabletop setup, using two types of tabletop soft x-ray sources. Using 29 nm light obtained from high-order harmonic generation, we have obtained images with ~200 nm spatial resolution. We have also successfully used the same setup with light from a 46.9 nm laser pumped by a capillary discharge. These results demonstrate the relevance of lensless diffractive imaging techniques (which had previously only been demonstrated using synchrotron light sources) to future tabletop EUV and soft x-ray microscopes. This technique has a significant advantage over more-conventional soft x-ray microscopes in that the long depth-of-focus simplifies sample positioning; it also is easy to extend to shorter wavelengths as bright sources become available. Applications that would benefit from such a tabletop microscope include nanoimaging, bioimaging, and EUV lithography mask inspection.

Figure 1 shows lensless imaging data obtained using high harmonic light. In this imaging system, 25 fs, 800 nm pulses from a ti:sapphire laser-amplifier system are upconverted to high order harmonics in an Argon-filled capillary waveguide. Two multilayer mirrors select the 27th order at 29 nm, and focus this light onto the sample. Fig 1a shows an SEM image of the sample-- a TEM diagnostic grid made of a patterned 40 nm-thick carbon film over a 15 µm diameter laser ablated aperture. Figure 1b shows the high-dynamic-range diffraction pattern collected from the sample. This was obtained by stitching several images together that use zero-order blocks of varying size. Finally, Fig 1c shows a reconstructed image, which clearly reproduces the features of Fig 1a. The inset is a lineout (as highlighted in the image) showing ~200 nm resolution.



a b c

Figure 1: a) scanning electron microscope picture of carbon TEM grid on 15 µm aperture. The smallest feature sizes are ~1 micron; b) high dynamic range diffraction from coherent 29 nm light, pattern collected on a CCD c) reconstructed image with line out showing ~200 nm resolution.