Diffractive Optics and Shearing Interferometry

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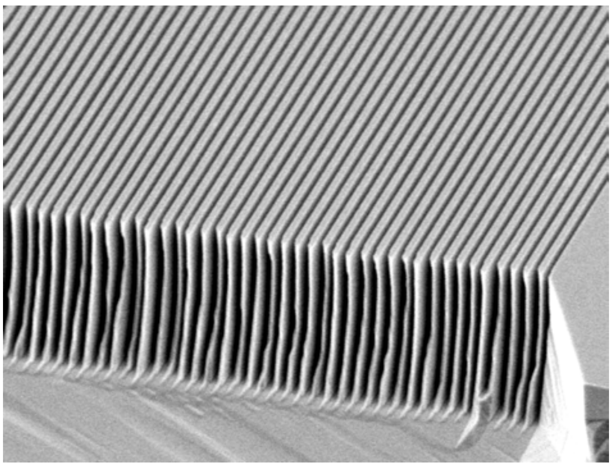
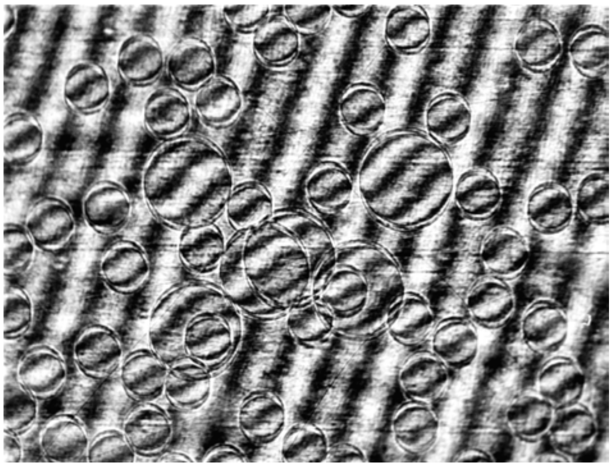
The dramatical increase of coherence that will be available from the planned fourth generation x-ray sources gives rise to the question as to what extend optical elements in the beam can preserve this high level of coherence. The deformations of the x-ray wave fronts should be much below one wavelength. In the case of diffractive x-ray optics operated in transmission, this directly translates into a placement accuracy of the diffractive structures of much better than one structure width. State-of-the-art lithography tools are capable of placement accuracies in the range of nanometers, meaning that the above condition can be met in most practical cases. In consequence, diffractive optics have a significant advantage over refractive or reflective x-ray optics in terms of aberrations that may deteriorate the degree of coherence of an x-ray beam. This is of special importance in context with future hard x-ray sources with transverse coherence lengths in the millimeter scale. To make effective use of such a beam, optical elements should be of similar size and simultaneously control the wave fronts with sufficient precision.

At the Laboratory for Micro and Nanotechnology we have been developing a large number of diffractive x-ray optics for a wide range of photon energies and applications. The areas of these elements cover, in some cases, many square millimeters. In addition to Fresnel lenses for micro-focusing applications, we have recently developed diffractive hard x-ray optical elements made by wet chemical etching of single crystal silicon. These elements serve as beam splitters and analysers in interferometer set-ups. The applications of such interferometers include phase contrast imaging, wave front sensing and metrology of x-ray mirrors. Although the above-mentioned devices are at the moment optimised for use with radiation from third generation sources, the majority of the developed technological processes could be applied to produce optical elements tailored to the requirements of fourth generation sources. Furthermore, the presented interferometry techniques could be used in interesting novel applications taking advantage of the dramatically increased coherence lengths and flux levels.





Left: Silicon diffraction grating for interferometry applications. Right: Hard x-ray interferogram of polymer spheres.