High-resolution Zone Plates Made with Wideband Extreme-Ultraviolet Holography

H. H. Solak, C. David, J. Gobrecht

Paul Scherrer Institut, CH-5232 Villigen-PSI, Switzerland

Fresnel zone plates (FZP) made with electron-beam lithography (EBL) are used in x-ray microscopy applications providing resolution down to about 20 nm. The fabrication of high-resolution FZP with EBL poses certain challenges including zone placement errors due to thermal drift, resolution limitations due to the proximity effect and low-throughput due to the serial writing scheme. We have developed a new holographic fabrication technique using extreme ultraviolet radiation in order to address these challenges. In the scheme shown in Figure 1, a mask bearing two concentric FZP is illuminated by a spatially coherent EUV beam. The two FZP on the mask are written with EBL and they have the same outermost zone width. At a certain distance from the mask the diverging and converging spherical beams created by the mask overlap and form an interference pattern, which is suitable for recording a "daughter" FZP with half the zone-width of the "parent" FZP on the mask. This technique is achromatic since the two interfering beams travel equal optical path lengths before arriving at the image plane. Analytical and simulation results showing the formation of the FZP pattern was confirmed experimentally with the production and testing of a lens with 60 nm outermost zone width. Holography with extreme ultraviolet light has the potential to produce lenses with sub-10 nm resolution.

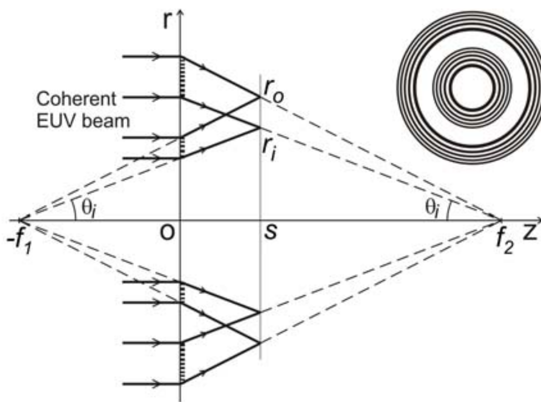

Fig. 1. Achromatic holography scheme for recording a FZP. A schematic frontal view of the mask is shown in the upper right.

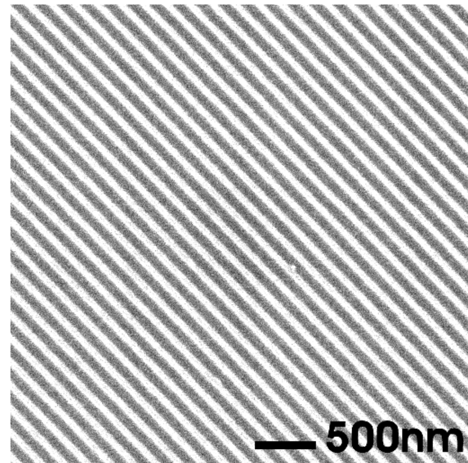

Fig 2. SEM image of 66 nm wide zones printed with EUV holography and etched into a Cr film.