Nickel zone plates for compact x-ray microscopy

A. Holmberg, M. Lindblom, S. Rehbein, and H. M. Hertz

Biomedical and X-Ray Physics, Royal Inst. of Technol., S-10691 Stockholm, Sweden; Phone: +46 8 5537 8213, E-mail: anders.holmberg@biox.kth.se

We have demonstrated the first compact x-ray microscope with sub-visible resolution.[1] It operates with a methanol-liquid-jet laser-plasma source providing λ=3.37 nm radiation. Our next microscope is designed for λ=2.48 nm operation with a liquid-nitrogen-jet source.[2] In order to optimise microscope system performance for, e.g., different sources and applications, a high degree of flexibility in the choice of design parameters of the optics is necessary. We have therefore started an in-house fabrication effort of high-resolution diffractive optics for compact x-ray microscopy. The optics are fabricated on 50 nm thin Si_3N_4-foils using a three-layer resist scheme and 30 keV e-beam lithography (Raith 150 system) in combination with reactive ion etching and nickel electroplating methods.[3] The emphasis of this program is on process control for fabrication of high-aspect-ratio electro-plated nickel structures with high uniformity and narrow line-widths.

In the present paper we report results based on recent improvements in the fabrication process. Figure 1 shows a micro zone plate with 25 nm outermost zones and a nickel height of 120 nm. The full zone plate has the quality shown in the figure. In order to further improve the process stability for high-aspect-ratio structures we are introducing an in-situ determination of the electroplating rate based on visual-light transmission measurements. By proper fitting of data this improves the accuracy of predicting the final nickel height in the plating mold and, therefore, avoids over or under plating. In addition to micro zone plates we have fabricated a 4.5 mm diameter condenser zone plate based on 656 100×100 μm stitched field with 50-60 nm zone widths.[4] The CZP is intended for the λ=2.48 nm microscope and has an groove efficiency of 11%±2% at that wavelength.

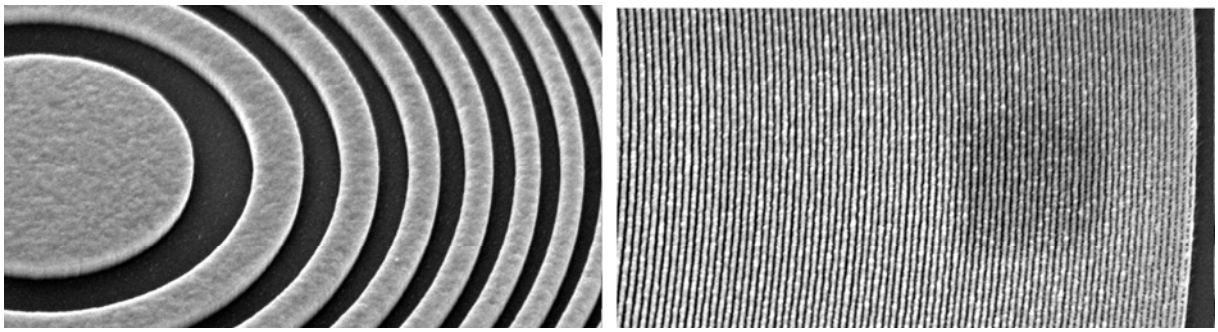

Figure 1. The centre and outermost part a nickel zone plate with 25 nm outermost zone. The innermost part has a nickel height of ~150 nm and the outermost part ~120 nm. (The shaded square in right image is due to SEM viewing contamination)

References

[1] M. Berglund, L. Rymell, M. Peuker, T. Wilhein, and H. M. Hertz, J. Microscopy **197**, 268 (2000)
[2] P.A.C Jansson et. al. Rev. Sci. Instrum., **76** (2005), in press.
[3] A. Holmberg, S. Rehbein, and H.M Hertz, Microel. Engin. **73-74**, 639 (2004).
[4] S. Rehbein, A. Holmberg, G. Johansson, P.A.C Jansson, and H.M Hertz, JVST B **22**, 1118 (2004)