X-Ray Microscopy with Laboratory Sources

H. M. Hertz, P.A.C. Takman, M. Bertilsson, A. Holmberg, M. Lindblom, H. Stollberg , and U. Vogt

Biomedical and X-Ray Physics, Dept. of Applied Physics,
Royal Inst. of Technol./Albanova, SE-106 91 Stockholm, Sweden,
E-mail: Hertz@biox.kth.se

X-ray microscopy in the water-window region (λ = 2.3-4.4 nm) is an attractive technique for high-resolution imaging. In this wavelength region state-of-the-art optics has demonstrated sub-20 nm resolution and the sample preparation techniques are maturing. Unfortunately present operational x-ray microscopes are based on synchrotron radiation sources, which limit their accessibility. Many biological investigators would benefit from having the x-ray microscope as a tool among other tools in their own laboratory. For this purpose we recently demonstrated the first compact x-ray microscope with sub-visible resolution.[1]

We have recently developed a flexible, compact x-ray microscope operating at λ = 2.48 nm. This wavelength should provide improved imaging of thicker structures compared to the λ = 3.37 nm microscope in Ref. 1. The microscope is based on a 100 Hz liquid-nitrogen-jet-target laser-plasma x-ray source [2], in-house fabricated diffractive condenser optics[3], in-house fabricated 25 nm Ni zone plates[4], and CCD detection. The sample holder is positioned in a helium atmosphere with silicon nitride membranes separating it from the vacuum in the condenser and imaging module. Initial images of test objects show structures down to 30 nm lines and spaces.

This presentation will discuss the source, the diffractive optics, the imaging properties and systems' issues. Some emphasis will be placed on the fabrication and testing of our uniform high-aspect-ratio diffractive optics with small other zone widths due to their importance for microscope performance. Furthermore, we will discuss the possibilities of DIC microscopy with compact sources by tailored diffractive optical elements (DOEs) [5]. If time allows we will touch upon operation of the microscope at λ = 3.37 nm with a methanol-liquid-jet laser plasma[6] and novel normal-incidence Cr/Sc multilayer condenser optics showing 2.5-3% average reflectivity.

References

1. M. Berglund et. al., J. Microsc. **197**, 268 (2000).
2. P. A. C. Jansson et. al., Rev. Sci. Instrum. **76**, 043503 (2005).
3. S. Rehbein et. al., J. Vac. Sci. Technol. B **22**, 1118 (2004).
4. A. Holmberg et. al., XRM 2005, Himeji (2005).
5. U. Vogt et. al., Opt. Lett. **30**, 2167 (2005)
6. J. de Groot et. al., J. Appl. Phys. **94**, 3717 (2003).