



Contribution ID: 175

Type: **Poster presentation**

Laboratory X-ray microscopy with a nano-focus X-ray source

Tuesday, 5 July 2011 15:15 (1 minute)

X-ray microscopy setups based on the principle of geometric magnification are attractive for laboratory setups because of the simplicity of the concept as well as the possibility to use a wide range of photon spectra. However, in such setups the focal spot size of the source limits the spatial resolution that is achievable. Therefore an X-ray source providing a nanometer sized focal spot is needed to achieve resolution in the nanometer range. Conventional state-of-the-art micro- and nanofocus X-ray tubes provide focal spot sizes in the range of 700 nm to 900 nm, some manufacturers claim sizes down to 250 nm in their product flyers.

We are using the electron gun and optics of an electron probe micro analyzer as the basis for our nanofocus X-ray source. To minimize the X-ray focal spot not only the focussing of the electron beam is important but also the interaction of the electron beam and the target material. Using the Monte-Carlo X-ray simulation ROSI [1] we calculated the optimal tungsten layer thickness for different types of targets, providing either high resolution or high X-ray flux. Compared to a standard target we could achieve a substantial reduction in focal spot size (up to 1/3) with the high resolution target or a significant gain in X-ray flux (more than a factor of 3) with the high flux target.

The photon flux, however optimized, is still low compared to conventional X-ray sources. Thus a photon counting detector is required to allow imaging free of electronic noise. We use the Quad version of the Medipix2 MXR detector [2]. It consists of 512 x 512 pixels with a pixel size of 55 μm x 55 μm and has a 300 μm silicon sensor layer.

In this paper we present the process of target optimization and will compare simulated results with measurements of focal spot size and X-ray flux. Also, resolution tests and imaging examples from applications will be shown.

References:

- [1] J. Giersch, A. Weidemann, G. Anton, Nuclear Inst. and Methods in Physics Research A, 509:151–156, 2003.
- [2] X. Llopert, M. Campbell, R. Dinapoli, D. San Segundo and E. Pernigotti; IEEE Trans. Nucl. Sci. NS49 (2001), p. 2279.

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Session Classification: Poster Mini Talks VI

Track Classification: Applications