ESRF	**Experiment title:** **2D x-ray waveguides with pre-focussed beam**	**Experiment number**: MI 686
Beamline: ID22	**Date of experiment**: from: 28.01.2004 to: 02.02.2004	**Date of report**: 25.08.2004
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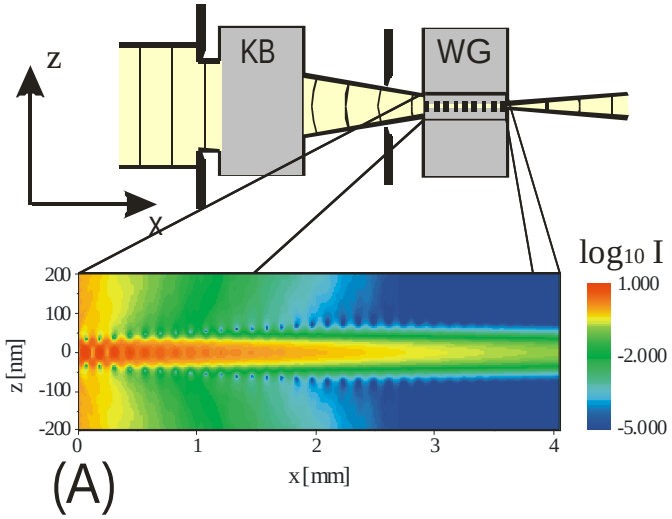
Report:

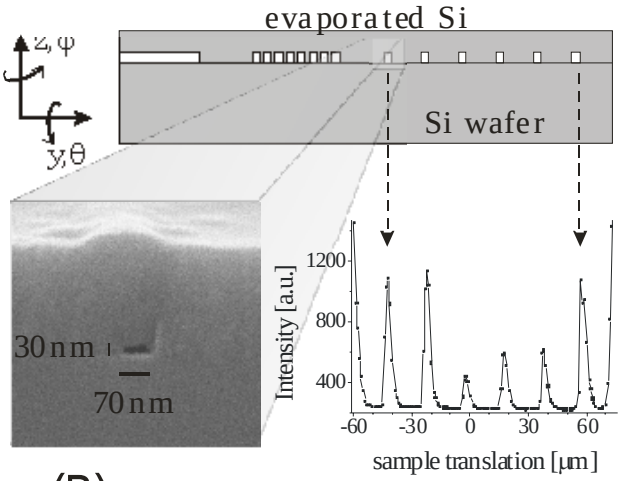
Two dimensonally confinig x-ray waveguides (2DXWGs) were up to recently suffering from low countrates and spurious reflected and transmitted beams [1]. We have overcome these limitations in the present experiment by combining the adaptive Kirkpatrick-Baez (KB) focussing optics, recently developed at the ESRF [2], with front coupling x-ray waveguides, fabricated by e-beam lithography. With this combination a small ($25*47nm^2$, Full Width at Half Maximum, FWHM) and intense ($3.5*10^6$ photons/second) hard x-ray (12.5 kev) beam has been produced [3].

The waveguides used in the present experiment consisted of a low density PMMA core, covered by a silicon cladding. The rectangular polymer cores were defineded by e-beam lithograpy in an originally 44nm thick PMMA layer, spincoated on a standard silicon wafer. After development of the ploymer film, stripes of height h=30 nm and width w ranging from w=60 nm to w=100 nm were left on the substrate. Evaporation of another 200 nm of Si completed the structures. An SEM micrograph of the front side of one of the guides is shown in Fig.1B. In order to facilitate the alignment of the 2DXWGs, an additional mono modal 1DXWG [4], and a 2DXWG-grating were prepared on the same wafer (Fig.1B).

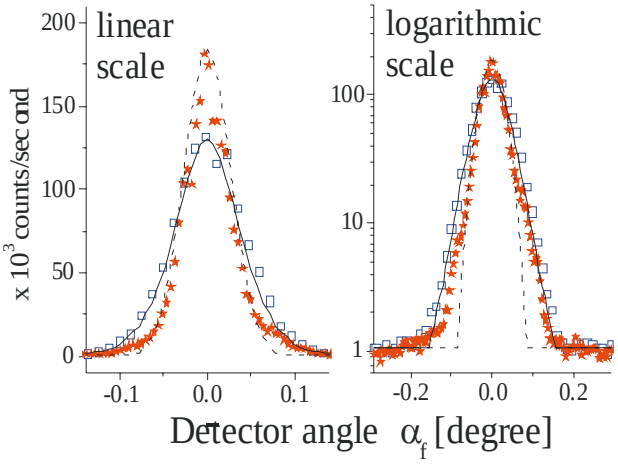
The KB optics at the ID22 undulator beamline provided an intensity of 3.3×10^{11} counts/second in a 2.5×3.8 μm^2 spot at an x-ray energy of 12.5 keV. At this beamsize, 0.02% of the primary beam (PB) were hitting the waveguide entrance. Those parts of the PB that did not hit the entrance of the guide were damped in the silicon cladding. The farfield scans of the exiting beam showed, that only the guided modes are harvested at the exit of the device (see Fig. 1A and C).



(A) side view



(B) front view



(C) farfield

The experiment was simulated solving the Helmholtz equation numerically in the approximation of the parabolic wave equation. From these simulations we find, that the beam dimensions (FWHM) at the exit of the device are smaller than the actual core dimensions, i.e. a 25×47 nm^2 beam (FWHM) exits a 30×70 nm^2 core.

The overall enhancement in flux-density of the combined KB-2DXWG system was measured to $g \approx 4000$. The WG-beam with a total intensity of $>10^6$ cps (current settings) will be used for in-line holography and scanning flourescence microscopy. (continuation of MI 686 / Proposal 9/04)

Fig 1A: Sketch of the experimental setup (top) and simulated field distribution inside the waveguide in logarithmic scales (bottom).

Fig 1B: Sketch of the device (top), SEM micrograph of a 2DXWG (left) and one scan showing the subsequent detection of several 2DXWGs (right).

Fig 1C: Measured (symbols) and simulated (lines) farfield of a 30×70 nm^2 2DXWG, both in linear (left) and logarithmic scales (right).

[1] F. Pfeiffer, C. David, M. Burghammer, and T. Salditt, Science **297** (230), 2002
[2] O. Hignette, P. Cloetens, W.-K. Lee, W. Ludwig, and G. Roasting., J. Phys. IV **104** (231), 2003
[3] A. Jarre, C. Fuhse, C. Ollinger, J. Seeger, R. Tucoulou and T. Salditt, in preparation
[4] C. Fuhse A. Jarre, C. Ollinger, J. Seeger, and T. Salditt, Appl. Phys. Lett., in press