Forschungszentrum Dresden Rossendorf

Experiment Report Form

The double page inside this form is to be filled in for each experiment at the Rossendorf Beamline (ROBL). This double-page report will be reduced to a one page, A4 format, to be published in the Bi-Annual Report of the beamline. The report may also be published on the Web-pages of the FZD. If necessary, you may ask for an appropriate delay between report submission and publication.

Should you wish to make more general comments on the experiment, enclose these on a separate sheet, and send both the Report and comments to the ROBL team.

Published papers

All users must give proper credit to ROBL staff members and the ESRF facilities used for achieving the results being published. Further, users are obliged to send to ROBL the complete reference and abstract of papers published in peer-reviewed media.

Deadlines for submission of Experimental Report

Reports shall be submitted not later than 6 month after the experiment.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the reference number of the proposal / experiment to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.
- bear in mind that the double-page report will be reduced to 71% of its original size, A4 format. A type-face such as ”Times” or ”Arial” , 14 points, with a 1.5 line spacing between lines for the text produces a report which can be read easily.

Note that requests for further beam time must always be accompanied by a report on previous measurements.

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ROBL-CRG	**Experiment title:** Optical properties of planar and lithographic x-ray waveguides	**Experiment number**: 2002670
Beamline: BM 20	**Date of experiment**: from: 01.09.2008 to: 25.02.2009	**Date of report**:
Shifts: 18	**Local contact(s)**: Carsten Bähtz	*Received at ROBL:*

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Report:

3rd generation synchrotron facilities offer high photon flux appropriate for x-ray based imaging such as holography and coherent diffraction imaging. Waveguide optics enable to control coherence properties and to focus the x-ray beam down to the nanometer scale in order to improve the resolution in imaging experiments.
We report on the properties of lithographic and two-component planar x-ray waveguides. The lithographic air/*Si* waveguides are fabricated using electron beam lithography, subsequent Reactive Ion Etching (RIE) and wafer bonding to obtain 10μm x 40nm channel cross-section dimensions minimal. Beam losses of the modes propagating through the waveguide are essentially due to absorption at the air/*Si*-cladding interfaces. Therefore the transmission of the waveguide is intrinsically high.
As already shown previously (*T.Salditt et al.*, PRL **100**, 184801 (2008)) the efficiency of a waveguide can be strongly optimized by placing an appropriate interlayer (*Mo*) between the guiding layer (*C*) and the cladding (*Ge*). The absorption of the evanescent tails of the modes propagating through the guiding layer is significantly reduced while the cladding dampes out the radiative modes. These two-component planar waveguides of 9/18/35nm guiding layer thicknesses are fabricated by Magnetron Sputtering.

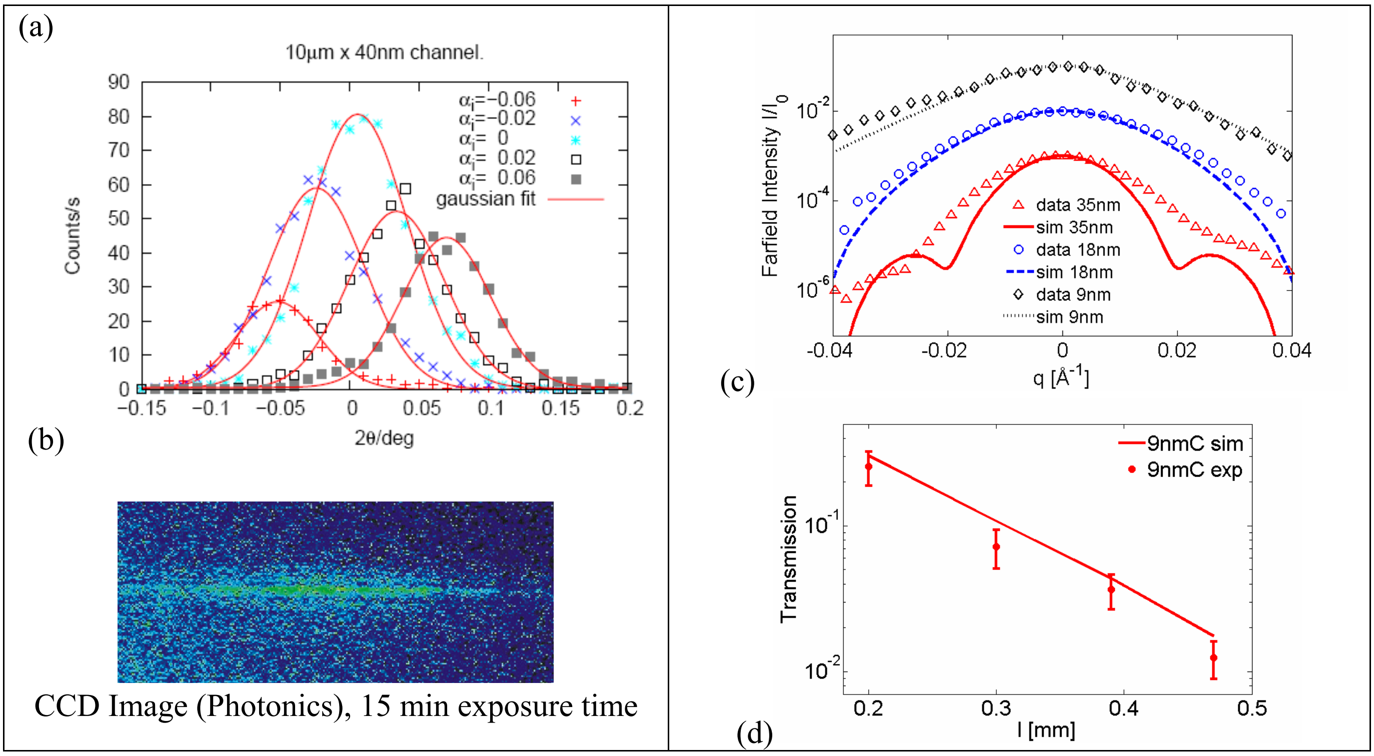

Fig 1: (a) Farfield Intensity of the lithographic waveguide for different angles of incidence α_i , along with Gaussian fits. The maximum positions are found to be at α_f = 0°. (b) CCD image of the farfield of the 10µm x *40nm channel. (c) Farfield intensity of the planar waveguides as a function of q along with simulations. (d): measured and calculated transmission T at E=13.5kev as a function of the waveguide length.*

The experiments were performed at the Rossendorf bending magnet beam on a wide range of energies defined by a double-crystal Si(111) monochromator. The beam shape and size was controlled by two collimating Pt-coated mirrors and motorized slits. A flux of 1-3 x 10^7 ph/s impinged on the waveguide entrance at 2 x 0.04mm^2 beam size depending on the energy and ring current. The farfield patterns of the waveguides were measured to obtain the divergence of the beam and therefore resolution properties of the optics in imaging experiments. The maximum of the farfield at different angles of incidence α_i is always found at $2\theta = \alpha_i$ as expected for waveguide properties. The farfield pattern of the planar waveguides are in good agrement with the simulations. The divergence Δq = 0.00255nm of the 9nm*C* mono-modal waveguide is significantly higher than for the 35nm*C* two-modal waveguide (Δq = 0.00147nm), i.e. the numerical aperture of the optics is enhanced. The transmission of the 9nm*C* two-component waveguide depends strongly on the energy *E* and the waveguide length *l*. The measured transmission at *E*=13.5keV reaches *T*=0.256 at *l*=200µm which is 84% of the calculated value (*T*=0.305). The experimental results show that high transmission is obtained for sub-10nm waveguides. A novel generation of lithographic waveguides with air-gap channels capped by wafer bonding was also tested. However, the flux density was seriously compromising these efforts.