EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

# Experiment Report Form

**The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF**.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

*http://193.49.43.2:8080/smis/servlet/UserUtils?start*

***Reports supporting requests for additional beam time***

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

***Reports on experiments relating to long term projects***

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

***Published papers***

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

## Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

## 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 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.

| ESRF | **Experiment title: Effect of confinement on the dynamics of colloids** | **Experiment number**: SI-547 |
|---|---|---|
| **Beamline**: ID10A | **Date of experiment**: from: **14-06-2000** to: 20-06-2000 | **Date of report**: 21-08-2000 |
| **Shifts:** 18 | **Local contact(s)**: F. Zontone | *Received at ESRF:* |


**Names and affiliations of applicants** (* indicates experimentalists):

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## Report:

*The experiment on the dynamics of colloids was proposed for the ID10C beamline. This beamline is expected to generate coherent beams of much higher intensity than station ID10A. However, ID10C was not yet open to users at the time of the experiment. Instead we performed experiments at the ID10A station, which were aimed at enhancing the flux of the primary beam by pre-focusing the beam onto the entrance of the waveguide. This will greatly facilitate later XPCS experiments.*

We have performed x-ray waveguiding [1] experiments in conjunction with a transmission Fresnel Zone Plate (FZP), which focuses the beam in one dimension. The FZP was fabricated by Ch. David at the Laboratory for Macrostructures and Nanostructures (LMN) at the Paul Scherrer Institute. The FZP increases the coherent flux inside the waveguide by focusing the 150 micron wide coherent x-ray beam into a line focus at the entrance of the waveguide which has a width of a few hundred nanometers. This increase in flux is needed for X-ray photon correlation spectroscopy (XPCS) experiments on thin confined fluids.
The zone plate pattern was applied with electron beam lithography and subsequent wet-etching of a silicon wafer of 50 micron thickness. The transmission of 13.3 keV x rays through the 50 micron membrane is 85%. The zone plate consists of ribbons with a height of 10 microns, each resulting in a phase shift of $\pi$ of the incident beam. The width of the outermost Fresnel zone is 326 nm. This FZP has only two height levels and therefore has a limited focusing efficiency of ~ 25% compared to a 'perfect' FZP with curved Fresnel zones. The diffraction limited focus width is equal to the outermost zone width of 326 nm at full illumination. The theoretical gain in intensity in the focus is a factor ~37. The focal distance is 72 cm. The lens used in the experiments is shown in the electron microscopy picture in Fig. 1.
The waveguide set-up is schematically drawn in Fig. 2. In front of the waveguide a pre-reflection creates a sinusoidal standing wave pattern which can be matched to the TE modes of the waveguide by tuning the angle of incidence. In this experiment, the incident plane wave is focused onto the entrance of the waveguide.

The intensity of the far-field diffraction pattern of the electric field at the end of the waveguide is measured by a 2D detector at 129 cm from the exit. By changing the angle of incidence the intensity distribution is obtained as a function of incidence and exit angle.

When the mode spacing is smaller than the angular spread in the focus, multiple modes are excited coherently. This is visible in the countour plot in Fig. 3, which shows the measured intensity distribution $I(\theta_i,\theta_e)$ versus incidence and exit angle for a waveguide width of 1200 nm. The small horizontal lines on the diagonal indicate excitation of modes over a ~0.01 range of incidence angles. In fig. 4 the far field diffraction pattern is shown for a gap of only 150 nm. The incidence angle is 0.021°, in between two modes (mode $TE_0$ and $TE_1$ are both excited). The integrated intensity is about a factor 8 higher with lens than without lens. This gain is lower than the theoretical gain factor of 37, because of non-flatness of the wave front falling onto the lens, and non-uniform illumination of over the lens height. Small modifications to the beamline and the set-up should make an experimental gain factor of ~20 feasible. But ID10A provides insufficient mechanical stability for experiments with micron-sized beams on sub-micron sized samples.

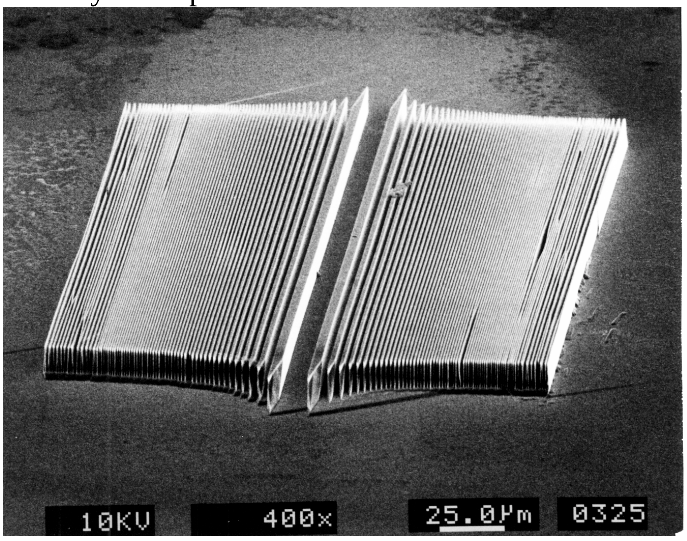


*Fig. 1 Scanning electron microscope image of the one dimensional Fresnel Zone Plate designed to work at 13.3 keV. The height of the lamellae is 10 microns, the width of the outermost Fresnel zone 326 nm. The FZP was fabricated at PSI by Ch. David.*

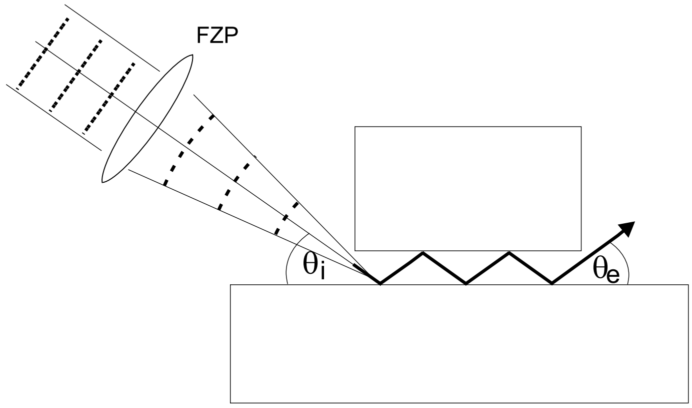


*Fig. 2 Schematic of the waveguiding set-up. The plane waves incident onto the Fresnel Zone Plate (FZP) are focused on the entrance of the waveguide.*

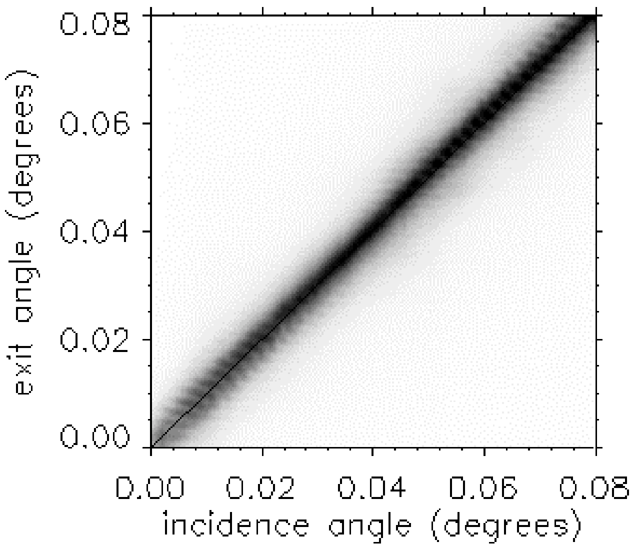


*Fig. 3 Intensity distribution vs incidence and exit angle for a waveguide of width 1200 nm.*

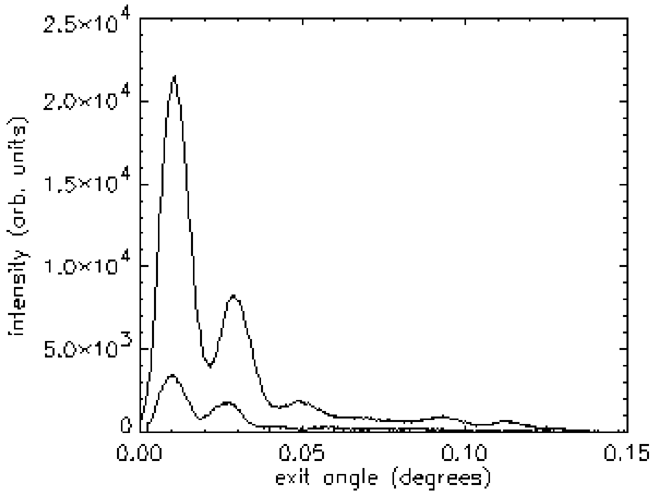


*Fig. 4 Far field diffraction pattern of a gap of 150 nm with incidence angle 0.021°. Top line is with lens, bottom line without a lens. The gain in integrated intensity is a factor 8.*

[1] M.J. Zwanenburg, J.F. Peters, J.H.H. Bongaerts, S.A. de Vries, D.L. Abernathy, and J.F. van der Veen, Phys. Rev. Lett. 82 (1999) 1696.