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 via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can 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:** Characterization of novel polymer X-ray nanolenses by ptychography and full-field imaging methods	**Experiment number**: MI-1331
Beamline: ID13B	**Date of experiment**: from: 27.03.2018 to: 01.04.2018	**Date of report**: 20.11.18 *Received at ESRF:*
Shifts: 9	**Local contact(s)**: Manfred BURGHAMMER	

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Report:

We have assembled the setup for high-resolution microscopy based on the polymer refractive microlenses [1] at the ID13 beamline (Fig.1).

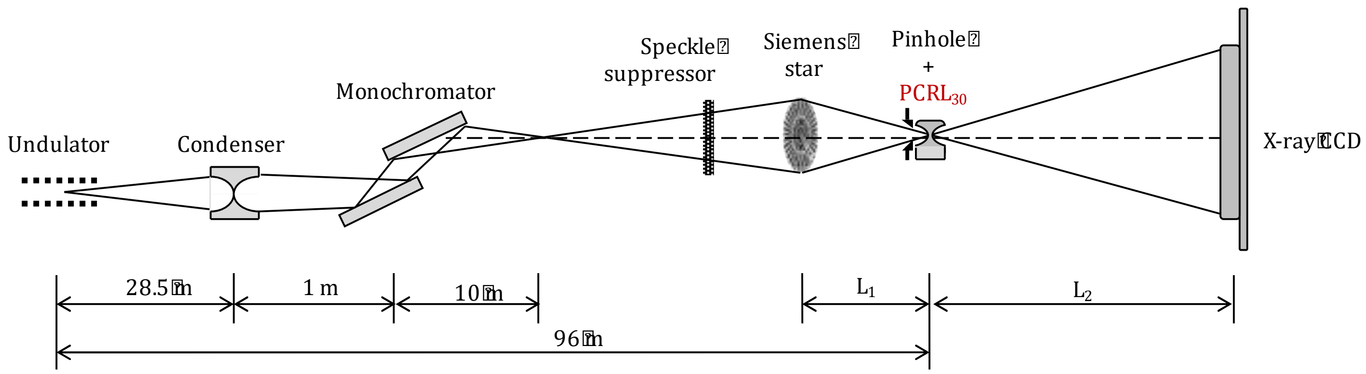

Fig. 1. Scheme of setup for high-resolution microscopy of the Siemens Star.

We used the 12.7 keV energy monocromatic and collimated X-ray beam. Moreover, we used the condenser located at the optics hutch. Siemens star and 25 μm-pinhole were also mounted upstream the $PCRL_{30}$ on the micro-manipulators. The Siemens star was located at the distance L_1 of 43 mm from the $PCRL_{30}$. According to the thin lens formula

$$\frac{1}{F} = \frac{1}{L_1} + \frac{1}{L_2} \quad (1)$$

and assuming that the focal distance F equals $F_1 = 41$ mm, we located the X-ray detector at the distance $L_2 = 885$ mm from the PCRL. Thus, we achieved the lens magnification of $\frac{L_2}{L_1} = 20.6$, giving an effective detector pixel size of 18 nm (Fig. 2).

However, different resolution in vertical and horizontal directions indicated an asymmetry in contrast transfer function due to presence of astigmatism in the optical system.

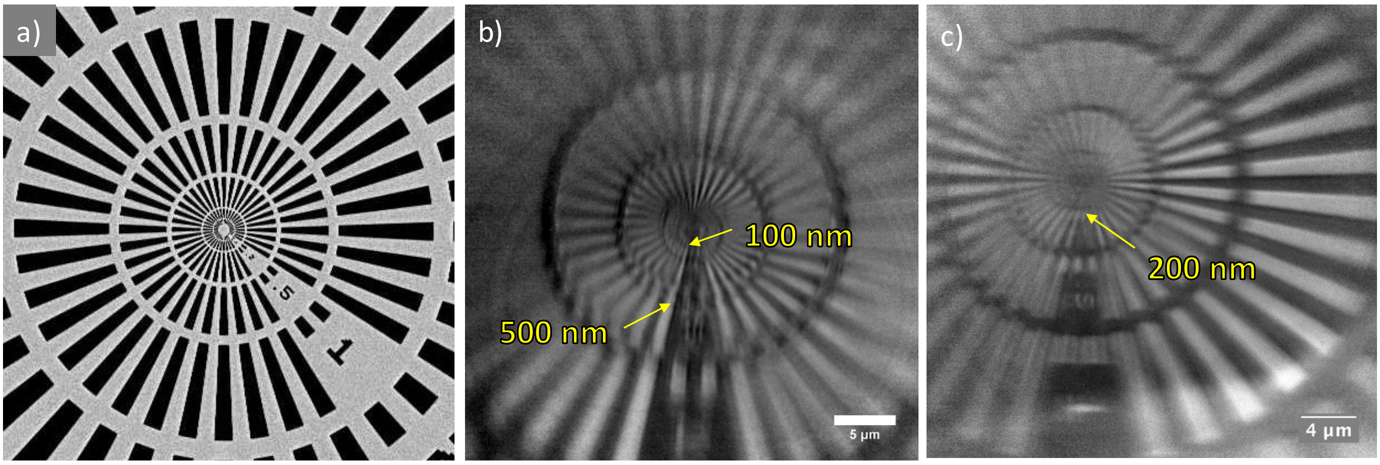

Fig. 2. Scanning electron (a) and flatfield-corrected X-ray images (b) of the Siemens star. The resolution remains the same after the 5.5-hour X-ray exposure (c).

To estimate the value of possible radiation damage to the lens, we simply exposed $PCRL_{30}$ for 5.5 hours to the X-ray beam with a flux density of $7{\times}10^{11}$ photons/sec×mm^2. During that time, individual lenses of the $PCRL_{30}$ absorbed the average dose of $\sim 15 \times 10^6$ Gy each. X-ray radiograms of $PCRL_{30}$ before and after exposure (Fig. 3) show the non-uniform polymer lens shrinkage - lenses almost did not change around the substrate-lens conjunction because of the mechanical stress and therefore higher stability. However, they shrunk significantly around the freestanding top. Despite the complexity of lens shape after the exposure, we roughly estimated the decrease of the size to be $17 \pm 2\%$ in average.

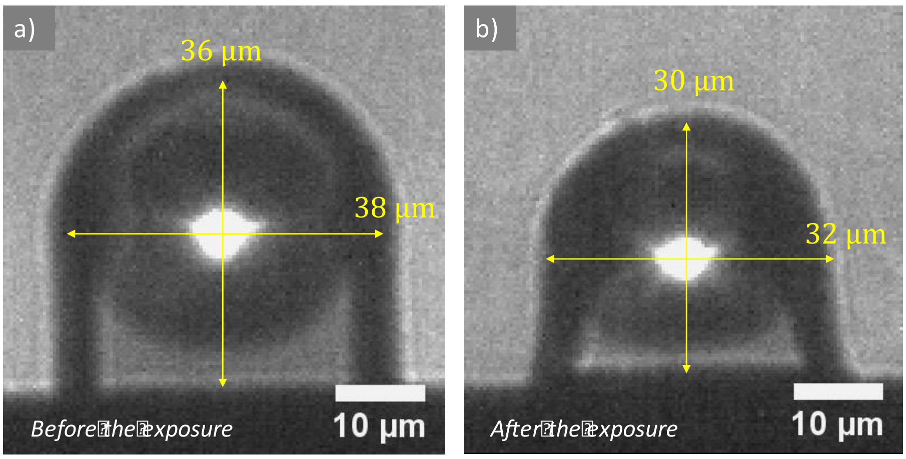

Fig. 3. X-ray radiograms of the $PCRL_{30}$ were taken with the same experimental conditions before and after the 5.5-hour X-ray exposure.

We also repeated the focusing experiment to see the change of the focal distance. $PCRL_{30}$ focused the radiation in the circle of the least confusion with $1.8 \times 1.8\ \mu m^2$ size and at the focal distance $F_2 = 35 \pm 2$ mm. The distance F_2 is 15% smaller than F_1, which corresponds to our observations of geometrical size reduction. $PCRL_{30}$ was still having the astigmatism with meridional and sagittal planes located at distances $F_{m2} = 32 \pm 2$ mm and $F_{s2} = 38 \pm 2$ mm, respectively.

[1] A.K. Petrov, V.O. Bessonov, K.A. Abrashitova, N.G. Kokareva, K.R. Safronov, A.A. Barannikov, P.A. Ershov, N.B. Klimova, I.I. Lyatun, V.A. Yunkin, M. Polikarpov, I. Snigireva, A.A. Fedyanin, and A. Snigirev, Opt. Express 25, 14173 (2017).