ESRF	**Experiment title:** The high-resolution reciprocal-space mapping by refractive X-ray optics	**Experiment number**: MI-1214
Beamline: ID13	**Date of experiment**: from: 06.03.16 to: 09.03.16	**Date of report**: 12.10.17
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Report:

We have assembled the setup for high-resolution reciprocal space mapping based on refractive X-ray optics at the ID13 beamline(*Fig.1*).

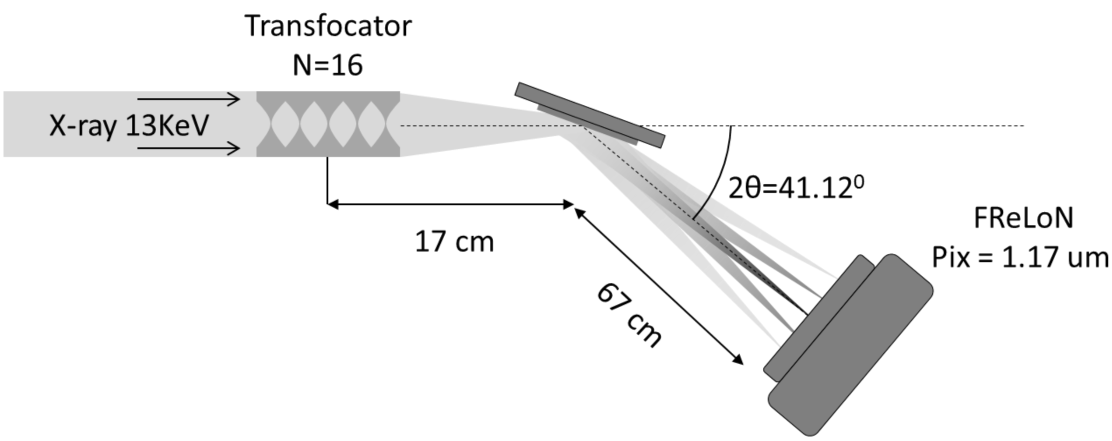

Fig. 1. Scheme of setup for high-resolution reciprocal-space mapping of a region near Si(004) reciprocal lattice point(RLP).

We used the 13KeV energy monochromatic and collimated X-ray beam. The Bragg-geometry for that energy has been satisfied by placing of a high resolution CCD FReLoN camera at the required 2theta angle 41.12^0 and by rotation of samples to the theta angle 20.06^0. It was performed for observation a region near Si(004) RLP. As refracive X-ray optics we used 16 Beryllium lenses with 50 µm radius of curvature installed in the transfocator.

For an initial alighnment of the experimental scheme we used Si-Ge nano-heterostructure(*fig. 2. A*), reciprocal space of which already accurately studied by conventional triple crystal diffractometery[1] and by Fourier transform method based on CRL[2].

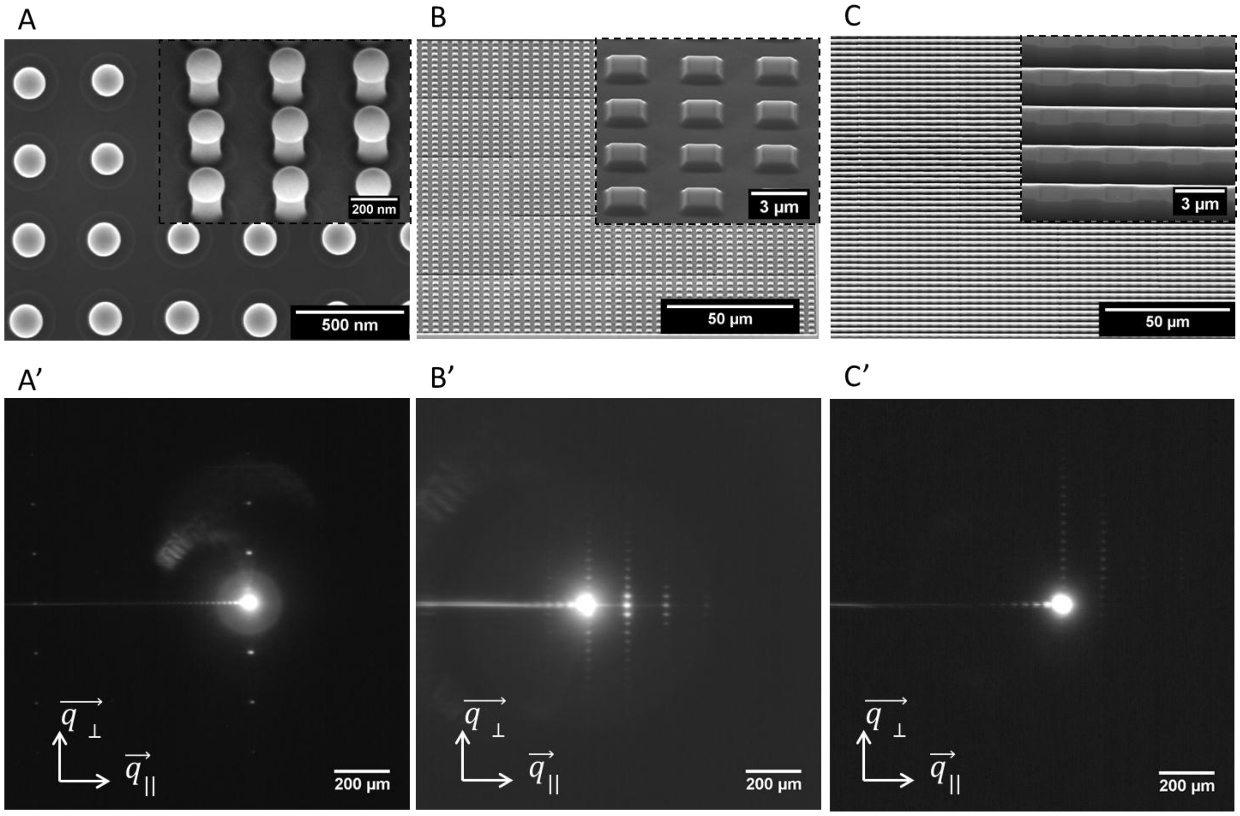

Fig. 2. SEM images of studied Si structures: A. Si-Ge nanoheterostructure, B., C. Si grids, manufactured by Focused Ion Beam(FIB). A’,B’,C’ - recorded CRL Fourier Transform(FT) patterns at bragg-geometry corresponding to the studying Si structures .The grayscale at images is logarithmic.

After the alighnment procedure we obtained several FT patterns for different Si microstructures manufactured by FIB (*Fig.2 B’,C’*). The feature of C structure is that the space between Si pillars in a rows consist of amorphous Si.

As one can see from the setup we assembled allows to resolve the mictroradian diffraction of 50 µrad angles that corresponds to the structures with 2µm periodicity at the Bragg geometry. In single shot we obtained detailed information about the reciprocal volume Δq_z=61µm^{-1}, $\Delta q_{\perp}$ =209 µm^{-1}, $\Delta q_{||}$=52 µm^{-1} near the Si(004) RLP.

FT patterns show a complex picture of X-ray diffraction by a periodical micro-structures manufactured by FIB with presence of defects. By means of numerical calculations a good correspondence between the FT patterns in the reciprocal space and structures periodicity in the real space was found. The influence of the 3D form of Si pillars on FT patterns was studied. We expect that further analysis of obtained FT patterns give better understanding of proposed method for single-shot high resolution mapping of a crystal reciprocal space.

[1] P. Zaumseil, Y. Yamamoto, A. Bauer, M.A. Schubert, T. Schroeder, X-ray characterization of Ge epitaxially grown on nanostructured Si(001) wafers, Journal of Applied Physics, 109 (2011) 023511.

[2] P.A. Ershov, S.M. Kuznetsov, I.I. Snigireva, V.A. Yunkin, A.Y. Goikhman, A.A. Snigirev, High-resolution X-ray diffraction based on 1D and 2D refractive lenses, J. Surf. Invest., 9 (2015) 576-580.