| ESRF | **Experiment title**: **TWO REFRACTIVE LENS SYSTEM FOR FOCUSING HARD X-RAYS** | **Experiment number**: MI487 |
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## Report:

Local investigations of crystals structure and imperfections using refractive X-ray optics are extremely actual for to-days material science. Compound refractive lenses (CRL) with the cylindrical profile provide an efficient method of collimating synchrotron radiation. The divergence of outgoing beam in one dimension was shown to be reduced by a factor about 3. But extremely long focal distances (>40 meters) of used CRL make this approach questionable for many applications.

For this purposes the new beam formation systems must be created. First of all two-lens system may be mentioned which is quite analogous to lens condenser in the visual optics. In such system can be attained sufficiently small beam divergence in two dimensions alongside with beam crossover of a few microns. X-ray condenser has the first lens rather long focal one, and second lens is short-focus. Silicon parabolic lenses were proposed earlier [1] that can converge X-ray beam to the point focus. Such lenses each having 5 μm diameter are grouped into square matrix with period 8μm in both directions. In such matrix with dimensions 2mm in width and 3 mm height the number of working lenses is of about $10^4$. The short-focus parabolic lenses with extremely small curvature radius were realised by a method of deep photoanodic etching of silicon. The analysis of focusing properties of such lenses having the aperture A=5mm, has appeared practically possible to conduct only on a matrix combined from single lenses with the period d=8mm.

These lens matrices were investigated preliminary on synchrotron radiation during the beamline allocated within the proposals MI-371 in the energy range 12-30 kev using high-resolution CCD-camera ( pixel size 0.6 μm). The transmission of lenses is estimated on the basis of general considerations of properties of parabolic lenses to be over 98%. Experiments done with the ultra short-focus lenses were successful and obtained results may be considered as an initial step for creation of two-lens condenser.

The best choice as a first lens in condenser is parabolic lens with the focal distance of 1 meter [2-5]. By combination of the first lens and short-focus lens picked from the matrix outgoing beam can be formed with diameter less than 5 μm. Theoretical estimations carried out for beamline ID22 show that beam divergence angle in the vertical direction can be diminished up to 11 μrad ( ≈3 arc seconds ) downstream the X-ray condenser. In the horizontal direction beam divergence is 10 times greater.

These parameters may be considered as sufficient to use X-ray condenser for local diffraction measurements of interplanar spacing and broadening of rocking curve on crystals with defects, impurities or structured surface. Thus far local probing technique can be developed applicable to reconstruct deformation fields around defects or another peculiarities of monocrystalline objects.

The experimental technique, assumed for creation and optimisation two-lens system, was recessed to obtain planar refractive lens and lens matrix common characteristics, which can influence on outgoing beam intensity, its diameter and divergence. The task of tuning for mutual arrangement of the two focusing elements was essentially simplified because of long focal depth and large number of working lenses in the matrix. Data of outgoing beam divergence and intensity distribution across beam were obtained and analysed.

X-ray biprizm was proposed as a new tool for investigation of coherence properties of synchrotron beams. Two versions of biprizm were prepared. The first one was made as independent blocks from large-sized synthetic diamond crystals. These blocks were carefully stacked with each other to obtain X-ray biprizm. The second version was prepared on V-shaped grooves etched in silicon wafer. Computer simulation technique was developed to obtain interference patterns generated by biprizm with account of variety of experiment geometrical conditions, source size and absorption in biprizm material.

Experiment with diamond biprizm was fulfilled using high resolution CCD-camera. Interference patterns recorded were in good agreement with predicted ones for a given experimental conditions. Thus complete description of brightness distribution in source can be obtained by reconstruction of intensity distributions in interference fringes using the developed technique.

**References.**


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