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ANOMALOUS HARD X-RAY FOCUSING BY NICKEL REFRACTIVE LENS AS A PROMISING DIRECTION IN THE DEVELOPMENT OF NEW ANALYTICAL METHODS OF X-RAY SPECTROSCOPY

Despite the successful use of X-ray refractive optics at synchrotron X-ray sources [1], questions related to the spectral features of beam focusing as a promising direction in the development of analytical methods of research have not yet been considered. In particular, this applies to issues related to anomalous dispersion absorption discontinuities in materials. Usually the dependence of the refractive index on the wavelength is monotonous (a monotonous function, which, if it changes with increasing value of the argument, then only in one direction). However, discontinuous change is observed in anomalous refraction because of the resonance nature of the interaction of X-rays with specific (defined) chemical elements.

The lack of interest in such type of research is due to the extremely limited set of instrumentation for studying the effects associated with refraction. In order to fill this gap, we investigated the focusing properties of a nickel refractive lens with a 50-μm radius of curvature and a thickness of 1 mm at the Micro Optics Test bench at the ESRF ID06 beamline (Grenoble, France). The high-resolution CCD camera with a spatial resolution of ~ 1.3 μm was used for determining position of the X-ray source image, demagni-

fied by lenses, depending on the energy in the region of K-edge absorption of nickel, which is 8.3328 keV [2]. The purpose of the experiment was to determine the position of the focal length as a function of the X-ray energy. The desired energy was selected by cryogenically cooled Si (111) double crystal monochromator, which provides the energy resolution 0.5 eV.

Experimentally was observed that the distance between the refractive nickel lens with a 50-μm radius of curvature and a thickness of 1 mm and the image of the source formed was determined as a function of the energy of the focused beam. Two pronounced maxima are clearly visible on the obtained experimental dependency (Fig. 1).

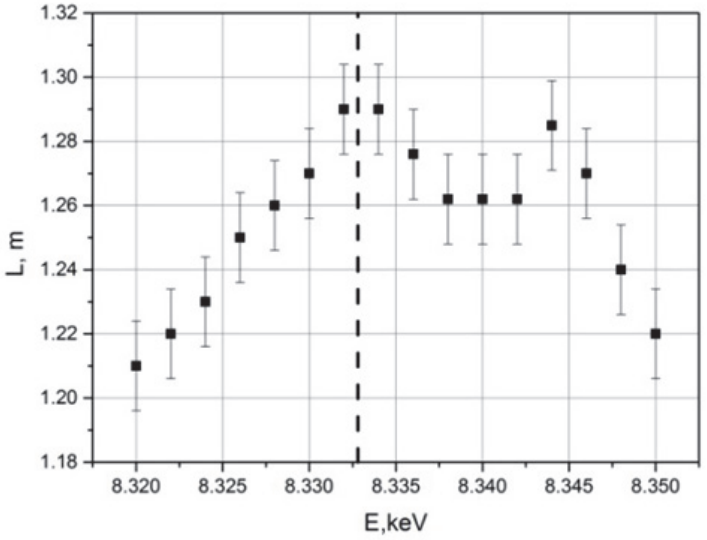

Fig. 1. Absorption spectrum, which shows the dependence of the distance between the refractive refractive nickel lens and the image of the source (L, m) on the energy of the focused beam (E, KeV)

The first maximum occurs in the region of K-edge absorption of nickel, from which this lens is made. According to tabular data, the position of this region of K-edge absorption is 8.3328 eV (the position is marked by a dashed line) within the accuracy determined by the monochromatization degree of the focused beam. It coincides with the left edge of the second maxima. The second

maxima is located in the EXAFS area and, accordingly, carries information about the structural features of the lens material, which are currently under study.

Measurements of the beam vertical size at the focal position at 1,4 meters (full width at half-height (FWHM) of the intensity distribution) were also made as well as the enhancement at the center of the focused spot (Fig. 2).

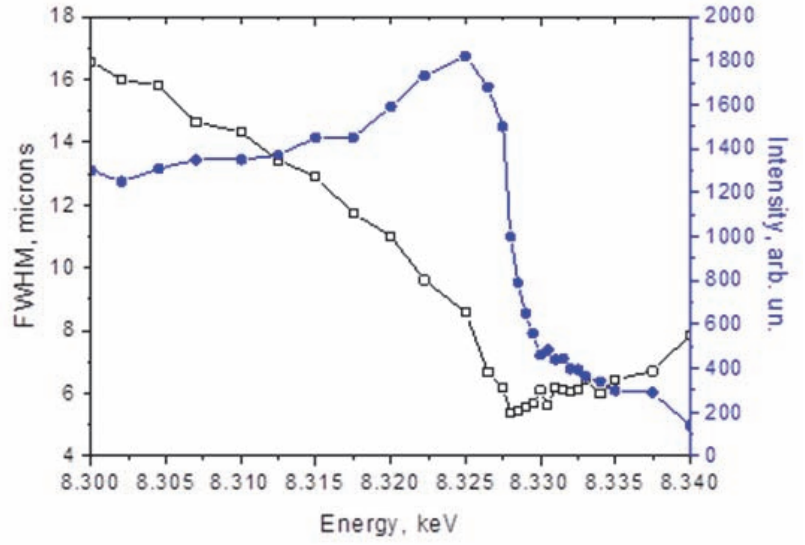

Fig. 2. X-ray energy dependence of the beam vertical size at the focal position (L=1,4m) and intensity at the center of the beam in the region of K-edge absorption of the lens material, which is 8.3328 keV.

All these measurements were carried out in the energy range of the incident radiation near the region of K-edge absorption of nickel. The dimensions of the focused beam size (FWHM) at 8.325 keV were 8.5 μm, at 8.3295 keV were 5.35 μm respectively, which demonstrates abrupt change of the focal length in the order of 30% near the nickel absorption K-edge. The lens parameters such as the lens effective aperture and the size of the focal spot was changed discontinuously.

According to the theoretical studies and the first calculations, this change in the focal length correlates with the nature of the

change in the refractive index and the associated form factor, which is in energy range 8330 — 8345 eV, makes it possible to obtain the parameters of the material under study by direct refraction measurements. So far, such a possibility of determining these parameters with respect to the x-ray energy range has not been discussed.

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X-RAY POLYMER REFRACTIVE LENSES NANOFABRICATED BY TWO-PHOTON ABSORPTION LITHOGRAPHY

The inner structure diagnostics methods based on X-ray have very high resolution and sensitivity and do not need metallisation or vacuum, which make them very attractive for nondestructive investigation of fragile biological samples on nanometer scales [1]. To implement these methods one should develop effective ways of producing, guiding, focusing and collecting X-ray radiation. The