Time resolved x-ray diffraction studies of prospective crystalline materials under dynamic ultrasonic loads

I.A. Eliovich[1,2], **A.V. Targonskiy**[1,2], **A.E. Blagov**[1,2], **Yu.V. Pisarevsky**[1,2], **V.I. Akkuratov**[1,2], **A.I. Protsenko**[1,2], **M.V. Kovalchuk**[1,2]

[1]*FSRC "Crystallography and photonics" RAS*

[2]*NRC "Kurchatov institute"*

Yan.eliovich@gmail.com

At present report time resolved methods and measurements of rocking curves (RC) and reciprocal space maps (RSM) under external dynamic ultrasonic loads are described. These measurements were made by using adaptive X-Ray optic (ABXO) elements.

Conducting experiments with time resolution using x-ray and synchrotron radiation is one of the advanced modern scientific problems. Today, there are three main directions in the development of such experiments - the creation of new sources (synchrotrons and XFELs), the development of detecting equipment, and the rapid tuning of experimental parameters. The first two directions have gained significant development in recent years, and the last direction rests on the impossibility of quickly adjusting experimental parameters using existing goniometric systems. As a result, the existing hardware and methodological base practically does not cover the range of time resolutions from seconds to microseconds, in which many interesting physical processes occur.

One of possibilities to overcome these limitations of traditional approach is using of non-mechanical adaptive X-ray optic elements, such as X-ray acoustic resonators of longitudinal oscillations or bimorph piezo-actuators [1]. It allows fast and precise variation of X-ray diffraction parameters, varying the angular position of the X-ray beam and controlling its wavelength. An important feature of the method is the possibility of conducting experiments not only in laboratory conditions, but also at synchrotron stations.

The method has been successfully applied to the study of processes occurring in crystals under dynamic ultrasonic loads. Using this method, studies of a silicon crystal subjected to quasistatic mechanical load were carried out [2]. The studies of the evolution of the defective structure of lithium fluoride (LiF) and TeO_2 single crystals under the conditions of dynamic ultrasonic loading in a wide range of amplitudes have also been studied [3]. It is shown that the diffraction pattern (shape and FWHM of rocking curves) under the action of ultrasound can differ significantly from the original, and the proposed method allows monitoring its changes with a temporal resolution of up to 10 μs, inaccessible when using mechanical goniometric systems. Studies of the evolution of the defective structure using the new method showed its significant (at least 3 orders of magnitude on a laboratory source) superiority in speed over existing methods.

The technique was also successfully applied for conducting experiments in a threecrystal X-ray diffraction scheme. It was shown that with its help it is possible to carry out fast (several minutes even with laboratory X-ray source) measurements of the reciprocal space maps from the studied samples under dynamic ultrasonic loads, as well as studying the distribution of ultrasonic vibrations in resonator crystals.

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Keywords: X-ray diffraction, time-resolved experiments, crystals under dynamic loads

The reported study was funded by RFBR and DFG 19-52-12029 and by RFBR according to the research project №18-32-20108.