## Nanocomposites and nanomaterials

# Quantum-mechanical model of phase-contrast images for nanoscale non-crystalline objects

**K.V. Fuzik, V.B. Molodkin, G.O. Velikhovskyi, S.V. Lizunova,**

**B.V. Sheludchenko, N.G. Tolmachev, V.V. Lizunov, S.V. Dmitriev**

*G.V. Kurdyumov Institute for Metal Physics, National Academy of Sciences of Ukraine, 36 Academician Vernadsky Boulevard, UA-03142 Kyiv, Ukraine.*
*E-mail: fuzik_katerina@gmail.com*

The obtaining of phase-contrast images of non-crystalline objects, due to the X-ray refraction phenomenon, allows significantly increasing the contrast of images, and hence the sensitivity in determining of characteristics of the non-crystalline object. Among the different ways of obtaining phase-contrast images, the method based on the triple-axes scheme with an analyzer (ABI — analyser-based imaging) is worthy of note because of relative simplicity and ease of realization. Although many methods to restore the characteristics of the object using its phase-contrast images have been proposed for today, all of them have some difficulties in obtaining stable solutions.

In this paper, the approach based on the development of the quantum-mechanical theory of multiple scattering in both the object and the single-crystals of the monochromator and the analyzer have been proposed. The generalized theoretical model of phase contrast formation of inhomogeneous non-crystalline objects with arbitrary shape by triple-axes method have been developed by authors. The dispersion mechanism of the mutually consistent effect of the structure under study not only on absorption, but also on refraction, diffraction and extinction of radiation, due to multiple scattering, was taken into account analytically for the first time. The model takes into account self-consistently and analytically the effects of total X-ray multiple scattering at both on the homogeneous on average components of potential of the objects, and, for the first time, on the fluctuation one. The complete multiplicity have been taken into account in both the single-crystal of the monochromator and the analyzer, and in the object under study. The interrelation between the properties of the object under study (shape, size, refraction and absorption coefficients) and the experimentally observed parameters of the distribution of the rays intensities was analytically established for the first time. It is shown that the use of the developed model allows increasing the sensitivity and expanding the informative possibilities of diagnostics using the ABI method for nanoscale non-crystalline objects.