X-Ray Scattering Studies of Nanocrystalline and Amorphous Materials Using High-Energy X-Rays on a Laboratory System

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The increased interest in recent years regarding the properties and applications of nanomaterials has also created the need to characterize the structures of these materials. However, due to the lack of long-range atomic ordering, the structures of nanostructured and amorphous materials are not accessible by conventional diffraction methods used to study crystalline materials. One of the most promising techniques to study nanostructures using X-ray diffraction is by using the total scattering (Bragg peaks and diffuse scattering) from the samples and the pair distribution function (PDF) analysis. The pair distribution function provides the probability of finding atoms separated by a certain distance. This function is not direction-dependent; it gives information about the absolute value of the distance between atoms in the material. The method can therefore be used to analyze also non-crystalline materials. From experimental point of view a typical PDF analysis requires the use of intense high-energy X-ray radiation ($E \geq 15$ KeV) and a wide 2θ range.

After the initial feasibility studies regarding the use of standard laboratory diffraction equipment for PDF analysis [1-3] this application has been further developed to achieve improved data quality and to extend the range of materials, environmental conditions and geometrical configurations that can be used for PDF experiments. The recent introduction of detectors with improved efficiency for high-energy X-rays [4] has further enhanced the capabilities of laboratory diffractometers for total scattering experiments. This contribution presents several examples of laboratory PDF studies performed on different nanocrystalline and amorphous materials of scientific and technological interest and demonstrates that PDF analysis with a laboratory diffractometer can be a valuable tool for structural characterization of nanomaterials.

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