Depth-resolved Strain Measurements by Energy-variable X-ray Diffraction

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Characterization of the microstructure of materials with spatial resolution is one of key issues in materials related fields from nano-technology to non-destructive testing of manufactured articles. Depth resolved strain/stress measurements by diffraction methods are of particular interest. In order to improve depth resolution of x-ray diffraction, we are developing novel technique for synchrotron beam lines – energy-variable diffraction (EVD) [1]. The method is based on our ability to precisely change energy of synchrotron radiation and, in a result, to accurately control the x-ray penetration depth. Comprehensive analysis of x-ray trajectories, taking into account the instrument misalignment, change of the height of an incident x-ray beam with energy, and variable penetration of x-rays into the sample depth, allowed us to receive analytic expression for the diffraction profile measured by EVD and to show that the maximum diffraction intensity registered in the detector is coming from certain depth, which is energy-dependent [2]. This finding opens a way for measuring residual strains with high depth resolution by changing the x-ray energy in small enough steps.

Experimental examples taken with differently scaled metal/metal and metal/ceramic multilayers as well as structures from nature (seashells) demonstrate the capabilities of the method.

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