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Thin film stress and microstructure analysis by energy-dispersive diffraction

C. Genzel[1]

[1] *Helmholtz-Zentrum Berlin für Materialien und Energie, Department of Microstructure and Residual Stress Analysis, Berlin, Germany*

The most important advantage of energy dispersive (ED) diffraction compared with angle dispersive methods is that the former provides complete diffraction patterns in fixed but arbitrarily selectable scattering directions. Furthermore, in experiments that are carried out in reflection geometry, the different photon energies E(hkl) of the diffraction lines in an ED diffraction pattern can be taken as an additional parameter to analyze depth gradients of structural properties in the materials near surface region. For data evaluation advantageous use can be made of whole pattern methods such as the Rietveld method, which allows for line profile analysis to study size and strain broadening [1] or for the refinement of models that describe the residual stress depth distribution [2]. Concerning polycrystalline thin films, the features of ED diffraction mentioned above can be applied to study residual stresses, texture and the microstructure either in ex-situ experiments or in-situ to monitor, for example, the chemical reaction pathway during film growth [3]. The main objective of this talk is to demonstrate that (contrary to a widespread opinion) high energy synchrotron radiation and thin film analysis may fit together. The corresponding experiments were performed on the materials science beamline EDDI at BESSY II which is one of the very few instruments worldwide that is especially dedicated to ED diffraction. On the basis of selected examples it will be shown that specially tailored experimental setups allow for residual stress depth profiling even in thin films and multilayer coatings as well as for fast in situ studies of film stress and microstructure evolution during film growth.

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