DS 3 Thin film analysis I

Time: Monday 09:30–11:00 Room: GER 38

Invited Talk

DS 3.1 Mon 09:30 GER 38

X-ray diffraction analysis of residual stress fields in thin films - basic aspects and applications — •Christoph Genzel — Hahn-Meitner-Institut (c/o BESSY), Albert-Einstein-Straße 15, D-12489 Berlin

Thin films grown by physical or chemical vapour deposition have to meet various demands. The fields of application extend from wear protection of cutting tools to rather sophisticated superlattice structures used in microelectronics. At any rate, thin film deposition induces more or less high residual stresses in the growing layer, which influence the material properties to a great extent and therefore, have to be analysed carefully. In this connection X-ray diffraction takes up a key position, because it allows for a nondestructive and phase-selective investigation of the residual stress state. The application of well-established X-ray stress analysis (XSA) techniques to thin film systems, however, leads to a series of problems which are mainly due to the small layer thickness and the pronounced texture. Different approaches in thin film XSA are discussed with respect to their ability to a depth resolved evaluation of in-plane residual stress gradients within the layer (system). A useful criterion for classifying the individual methods is given by the way used to assign the measured diffraction signal to a certain information depth within the film. It will be shown, that both the so-called Laplace space methods, the depth resolution of which is based on the exponential beam attenuation, and the real space methods using a small volume gauge defined by narrow slits in the primary and the diffracted beam can be applied successfully to special cases in thin film stress gradient analysis.

DS 3.2 Mon 10:15 GER 38

In-situ Study of the Thermal Stability of Fe-Pt Multilayers — •Nikolay Zotov, Jürgen Feydt, Alan Savan, and Alfred Ludwig — Forschungszentrum Caesar, Ludwig-Erhard-Allee 2, D-53175 Bonn

Annealing of Fe-Pt multilayers has attracted attention as a promising reaction pathway for the synthesis of FePt hard-magnetic thin films. Such nanostructures are possible candidates for high-density magnetic recording devices or exchange-spring magnets due to the very large magnetocrystalline anisotropy of the fct FePt phase. Fe-Pt multilayers with modulation periods 2.42 and 3.75 nm were fabricated by magnetron sputtering. Simulations of the high-angle satellites at room temperature revealed the presence of strong (111) texture, some Fe-Pt intermixing during the deposition and vertical grain sizes of about 16-24 nm. The structural evolution of the multilayers with temperature was studied by in-situ X-ray diffraction between 300 and 603 K. Two temperature regimes are established. Below 534 K a slow diffusion with coherent interfaces, no change of the texture and minor decrease of the lateral grain size of the multilayers is observed. Above 534 K, a fast diffusion causes incoherent variations of the modulation periods, increase of the vertical misorientations of the grains and significant changes of the lateral grain sizes, which might suggest the presence of grain boundary diffusion in the multilayers with small modulation period. Both multilayers transform at about 583 K into the fcc FePt phase. The phase transition is of first-order and a power law describes the order parameter with a critical exponent equal to 0.97(2), which is practically independent of the modulation period.

DS 3.3 Mon 10:30 GER 38

Growth and roughness evolution of sputtered aluminum oxide films on organic and inorganic substrates — •S. Sellner[1,2,3], A. Gerlach[3,4], S. Kowarik[3,4], F. Schreiber[3,4], N. Kasper[1,5], H. Dosch[1,2], S. Meyer[6], J. Pflaum[6], and G. Ulbricht[7] — [1]MPI für Metallforschung, Stuttgart — [2]Institut für Theoretische und Angewandte Physik, Universität Stuttgart — [3]Institut für Angewandte Physik, Universität Tübingen — [4]Physical and Theoretical Chemistry Laboratory, Oxford University — [5]ANKA, FZ Karlsruhe — [6]III. Physikalisches Institut, Universität Stuttgart — [7]MPI für Festkörperforschung, Stuttgart

Aluminum oxide is an important material in thin film technology. One critical parameter in thin film growth is the roughness evolution of a growing film with film thickness (σ = L^{β}). We present a comparative study of the growth of sputtered aluminum oxide films on silicon oxide and on organic films of diindenoperylene (DIP). From X-ray diffraction measurements we extract the scaling exponent β of aluminum oxide growth on both substrates. By renormalising the aluminum oxide roughness by the roughness of the underlying organic film we find good agreement with β as obtained from the aluminum oxide on silicon oxide (β=0.37), suggesting a remarkable similarity of the aluminum oxide growth on the two substrates under the conditions employed. We emphasize that aluminum oxide layers deposited on top of organic films have shown the potential to serve as encapsulation material in organic devices and to strongly enhance the thermal stability of the organic films.
[1] Sellner et al., Adv. Mater. 16 (2004)
[2] Sellner et al., J. Mat. Res., in print

DS 3.4 Mon 10:45 GER 38

Residual stress analysis in multilayer systems with synchrotron radiation - complementary investigations using angle and energy dispersive diffraction methods — •Manuela Klaus, Ingwer Denks, and Christoph Genzel — Hahn-Meitner-Institut (c/o BESSY), Albert-Einstein-Straße 15, D-12489 Berlin

Residual stress analysis in multilayer systems consisting of stacks of alternating sublayers poses a special challenge for the measuring as well as the evaluation procedures to be applied. So neighbouring sublayers in the stack may be of similar composition leading to strongly overlapping diffraction lines, or sublayers of identical structure contributing to the same diffraction line are separated by small sublayers of other structure. In both cases problems arise, when the measured diffraction signal should be assigned to some information depth within the multilayer. To overcome these difficulties, different approaches are possible. In any case, they require the use of highly parallel synchrotron radiation being available within a broad energy range that extends from about 5 keV to about 150 keV. It will be shown that both, angle and energy dispersive diffraction yield results which complement one another. So wavelength tuning at absorption edges, for example, allows for the separated analysis of adjoining near surface sublayers being similarly composed, whereas high resolution white beam strain scanning yields depth resolved information even on burried sublayers close to the interface as well on the residual stress distribution in the substrate itself.