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Workshop »Coatings for Tools & Components«

Cross-sectional characterization of stress gradients in nanocrystalline thin films

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Resolving the microstructure and residual stress gradients within thin films and uncovering their origin as well as their influence on functional and mechanical properties still remains a challenging task. The recent development of a synchrotron setup based on multi-layer Laue lenses, which enables focusing of synchtrotron X-ray beams down to ~30 nm, provides unprecedented insights into the cross-sectional variation of microstructure and stress development throughout individual sublayers of multilayered thin films [1]. Currently, cross-sectional X-ray nanodiffraction (CSnanoXRD) experiments focus on the application of 30 nm X-ray beams to reveal nanoscale microstructure and stress gradients in films deposited on (i) nonplanar substrates and (ii) multilayered structures subjected to severe deformation. In detail, the nanoscale residual stress and microstructure distributions evaluated from (i) a 2 µm thick TiN thin film deposited on a WC-Co cutting edge [2] and (ii) a Cr-CrN bilayer thin film subjected to scratch testing at 200 and 400 mN load [3] are presented. Moreover, small-angle X-ray scattering microscopy [2] and FWHM microscopy [3] will be introduced and used to identify unique cross-sectional and lateral inter- and intracrystalline stress-induced microstructural changes. These new X-ray investigation tools are verified by complementary scanning and transmission electron microscopy. The experimental results give unprecedented insight into the formation of microstructure and residual stress gradients during deposition of thin films, as well as the mechanical response of functional thin films upon severe deformation, thus significantly enhancing the understanding of the complex interaction between residual and applied stresses during thin film deformation.

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