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Advances in coating characterization: Towards a comprehensive understanding of microstructure-property-performance relations of hard coatings

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Advanced coatings and thin films providing multi-functional properties like wear and oxidation resistance combined with high toughness or diffusion barrier functions require sophisticated design of materials and architectures. For a knowledge-based development of such coatings, advanced characterization techniques to investigate their microstructure and properties from the micro- to the atomic scale are needed. Within this contribution, recent progress in coating characterization techniques is highlighted. Examples included are three-dimensional atom probe tomography to study the efficiency of diffusion barrier layers and cross-sectional nanodiffraction using focused X-ray synchrotron beams to illuminate microstructure evolution during coating growth or stress-depth profiles established by post-deposition treatments. The acquired detailed knowledge about composition and microstructure enables to establish correlations to coating properties, where recently new approaches for determination of hot-hardness based on high-temperature nanoindentation as well as fracture strength and fracture toughness determined by micromechanical tests have been suggested. Combining such techniques with failure analysis of coatings during application or during micromechanical tests enables to understand their degradation mechanisms, thus providing the basis for further optimization of coating materials and architectures.

Keywords

hard coatings

diffusion barriers

microstructure evolution

mechanical properties

local characterization