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Microstructure and properties of magnetron-sputtered multifunctional FeCo/TiN nanolaminated thin films with combined wear resistance and ferromagnetic properties for real-time wear control

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In many applications, the wear and damage state of technical surfaces covered by wear protective coatings is not accessible for real-time optical inspection during operation of a coated part or tool. To enable such an in-situ monitoring of the surface conditions it was recently suggested to incorporate a magnetoelastic ferromagnetic sensor phase into a wear resistant coating and, thus, combining simultaneously wear protection and wear sensing functions in a new thin film design. Using an appropriate read-out instrumentation, such a smart, multifunctional coating would be ready for online monitoring of its current state (e. g. volume loss, strain, temperature).
As a model system, we have grown FeCo/TiN nanoscaled multilayer films with 1 µm total thickness by sequential non-reactive magnetron sputter deposition of both TiN and FeCo layers, followed by post-deposition annealing (60 min at 600 °C in vacuum) in a static magnetic field (50 mT) in order to induce a uniaxial magnetic anisotropy. It was demonstrated that there is a critical bilayer period of about 5 nm below that the multilayer films simultaneously exhibit higher hardness (up to 29 GPa) and improved soft ferromagnetic behaviour (coercive field < 0.30 mT, initial permeability ~ 130, cut-off frequency ~ 1 GHz) compared to the multilayer films with bilayer periods > 5 nm.
In this presentation, the focus is on the correlation between coating architecture, growth conditions and the microstructure of the multilayer films with the aim to obtain a thorough understanding of their macroscopic properties. Detailed results on the thin film constitution, obtained by X-ray based techniques (X-Ray Diffraction, and X-Ray Reflection) and by electron microscopy (High Resolution Transmission Electron Microscopy, and Selected Area Electron Diffraction), will be discussed. In particular, it will be shown that by decreasing the critical bilayer period below a threshold value a change in the crystalline structure arises which can be correlated with the macroscopic properties.

Keywords
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