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Thin Film Structures and Architectures for Mechanical Applications

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This work summarizes recent developments on applying thin film structure and architecture concepts to hard coatings for optimized performance in mechanical applications. Hard coatings deposited by plasma-assisted vapour deposition are widely used to reduce friction and wear of tools and engineering components. As surface temperatures of tools and engineering components can be as high as 1000°C, e.g., for dry cutting, the structure and property evolution with temperature is crucial.
With overstoichiometric TiB_{2+x} and TiN-TiB_2 coatings, the concepts of nanocolumnar and nanocomposite structures, respectively, will be discussed. Compositional modulations in TiB_{2+x}, where a B-rich tissue phase surrounds TiB_2 nanocolumns stabilize their nanostructure (d ~5 nm) and hardness (H ~48 GPa) up to 900°C. For the TiN-TiB_2 nanocomposite the hardness even increases from ~37 to 42 GPa upon annealing to 800°C, as their grain boundary phase becomes more compact and the cohesive strength increases. Additional strengthening at elevated temperatures can be provided by phase separation mechanisms, which originate from decomposition-processes of supersaturated phases to form small domains and/or precipitates. Hence, their structure and architecture changes during annealing. The model systems Ti-B-N, Cr-Al-N, and Ti-Al-N are used to study decomposition processes and structure evolutions of phases supersaturated in their non-metal or metal sub-lattice. Furthermore, the effect of specific alloying elements like B, Y, Zr, Hf, V, Nb, and Ta on the structure and mechanical evolution of Cr-Al-N and Ti-Al-N is discussed. The experimental investigations include simultaneous thermal analysis additional to x-ray diffraction, transmission electron microscopy, atom probe tomography, and nanoindentation tests. Complementary computational studies of phase stabilities, elastic constants, lattice parameters, and electronic configuration are provided by ab initio based methods.
The various thin film structures and architectures allow the utilization of multifunctional properties facilitating the development of next generation's hard coatings.

Keywords
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