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# From Alloy Design to Failure Mechanisms: Micromechanics of High-Entropy Nitride Refractory-metal-based Coatings

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## Abstract

Efforts to develop materials with properties surpassing those of conventional alloys have driven the emergence of high-entropy alloys, which consist of at least five principal elements. These materials are governed by core effects such as high entropy effect, cocktail effect, and lattice distortion. The high-entropy alloy concept has since been extended to ceramics, leading to the development of high-entropy nitrides, which have demonstrated hardness in the superhard region, high fracture toughness combined with wear resistance, and thermal stability at elevated temperatures. In this study, direct-current magnetron-sputtered high-entropy nitride coatings based on Cr, Mn, and Mo, with Si and Y added, introducing pronounced atomic size mismatch, are investigated. The composition is deliberately designed to combine elements with both strong and weak nitride-forming capabilities, as well as distinct nitrogen bonding characteristics, thereby probing the limits of entropy-driven phase stability. The micromechanical response of the coatings is evaluated using micropillar compression and micropillar splitting experiments performed over a broad temperature range to determine fracture toughness and deformation behaviour. By correlating these

mechanical measurements with temperature-induced structural evolution, the governing deformation and fracture mechanisms in Cr–Mn–Mo–Si–Y–N high-entropy nitride coatings are elucidated.

**Keywords:**

High-entropy nitride coatings Microstructure Mechanical properties Micropillar compression Micropillar splitting Fracture toughness