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Full Length Article

Effect of nitrogen flow ratio on microstructure, mechanical and tribological properties of $TiWSiN_x$ thin film deposited by magnetron co-sputtering

H.A. Macías [a], L. Yate [b], L.E. Coy [c], J.J. Olaya [a], W. Aperador [d]

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Highlights

- Thin films of $TiWSiN_x$ ($4.8\% \leq X \leq 33.3\%$) deposited by mean of reactive magnetron co-sputtering.
- Low nitrogen content favors amorphous coatings with low hardness and low wear resistance.
- High nitrogen content favors a FCC-NaCl structure composed of W_2N and/or TiN immersed in amorphous Si_3N_4.
- An increase in nitrogen results in an increase in compressive residual stress and improvement in the mechanical and tribological properties.

Abstract

We investigate the deposition of $TiWSiN_x$ thin films by means of the method of reactive magnetron co-sputtering, setting the nitrogen flow ratios N2/(Ar+N_2) at 4.8%, 9.1%,16.7 and 33.3%. The crystallographic structure of the films was established through X-ray diffraction (XRD), the morphology and topography were evaluated through scanning electron microscopy (SEM) and atomic force microscopy (AFM), the chemical composition was evaluated through X-ray diffraction and X-ray photoelectron spectroscopy, the mechanical properties were evaluated by nanoindentation, and the wear resistance was studied via nanowear and pin-on-disk. It was found that films deposited between 4.8% and 16.7% nitrogen flow ratio exhibited an amorphous phase. As the nitrogen was increased, the films evolved into a mixture of amorphous Si_3N_4 and crystalline TiWN phase. Moreover, the film morphology changed to fine columnar as the nitrogen flow ratio increased. As a general observation, the hardness, resistance to plastic deformation (H^3/E^2), and residual stress of the samples increased as the nitrogen flow ratio increased. The maximum hardness, resistance to plastic deformation, and residual stress were 22 ± 0.4 GPa, 213 ± 20 MPa, and 1.4 ± 0.01, respectively. The lowest nanowear volume (0.47 μm^3) and wear rate (11 ± 8 10^{-9} mm^3/N mm) were obtained for films deposited at high nitrogen flow ratios. The lowest friction coefficient (0.15) was recorded for films deposited at 16.7% nitrogen flow ratio.

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Keywords

Co-sputtering; Mechanical properties; $TiWSiN_x$ films; Wear

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