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Hybrid HIPIMS and DC magnetron sputtering deposition of TiN coatings: deposition rate, structure and tribological properties

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Abstract: High power impulse magnetron sputtering (HIPIMS) has the advantage of ultra-dense plasma deposition environment although the resultant deposition rate is significantly low. By using a closed field unbalanced magnetron sputtering system, a hybrid process consisting of one HIPIMS powered magnetron and three DC magnetrons has been introduced in the reactive sputtering deposition of a TiN hard coating on a hardened steel substrate, to investigate the effect of HIPIMS incorporation on the deposition rate and on the microstructure and mechanical and tribological properties of the deposited coating. Various characterizations and tests have been applied in the study, including XRD, FEG-SEM, cross-sectional TEM, Knoop hardness, adhesion tests and un-lubricated ball-on-disk tribo-tests. The results revealed that, both the DC magnetron and hybrid-sputtered TiN coatings exhibited dense columnar morphology, a single NaCl-type cubic crystalline phase with strong (220) texture, and good adhesion property. The two coatings showed similar dry sliding friction coefficient of 0.8 – 0.9 and comparable wear coefficient in the range of $1 - 2 \times 10^{-15} \text{ m}^3 \text{N}^{-1} \text{m}^{-1}$. The overall deposition rate of the hybrid sputtering, being 0.047 $\mu\text{m}/\text{min}$ as measured in this study, was governed predominantly by the three DC magnetrons whereas the HIPIMS only made a marginal contribution. However, the incorporated HIPIMS has been found to lead to remarkable reduction of the compressive residual stress from -6.0 to -3.5 GPa and a slight increase in the coating hardness from 34.8 to 38.0 GPa.

Key Words: Magnetron sputtering deposition; HIPIMS; TiN; TEM; Friction and wear

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