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STUDY ON STRENGTH AND TOUGHNESS OF CrN COATING MODIFIED BY ATOMIC LAYER DEPOSITION

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Introduction

In this work, a kind of advanced technology that using atomic layer deposition method to modify the surface and properties of CrN hard coating was introduced. Due to the complementary of the advantages between atomic layer deposition and vacuum arc deposition, the hybrid technology that could decreasing the inner defects of coating, improving the surface density of coating, enhancing the mechanical properties of coating, and extending the service life of coating. This kind of hybrid technology provides a new method and idea to improve the properties of the tool coatings.

Methods

First, a VAD prepared CrN (labelled as $CrN_{\text{-VAD}}$) coating with a thickness of 2 μm was deposited on the surface of W6Mo5Cr4V2 high-speed steel, then a ALD prepared CrN coating with a thickness of 200 nm was deposited on the surface of the $CrN_{\text{-VAD}}$ coating (labelled as $CrN_{\text{-ALD}}$). The influence and mechanism of ALD technology on the phase structure, surface and section profile, adhesion, hardness and surface roughness of $CrN_{\text{-VAD}}$ coating were studied, respectively, through XRD phase analysis, SEM structure characterization, mechanical properties and roughness test.

Results

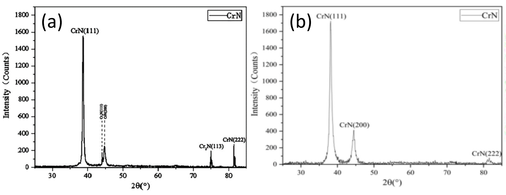

Fig.1. XRD pattern. (a) $CrN_{\text{-VAD}}$ coating; (b) $CrN_{\text{-ALD}}$ coating.

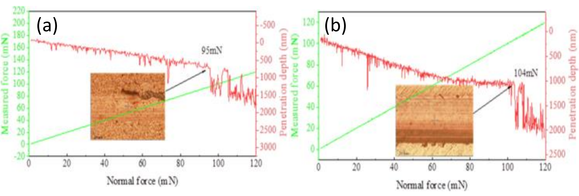

Fig.4. The adhesion test curve and scratch morphology of (a) $CrN_{\text{-VAD}}$ coating; (b) $CrN_{\text{-ALD}}$ coating.

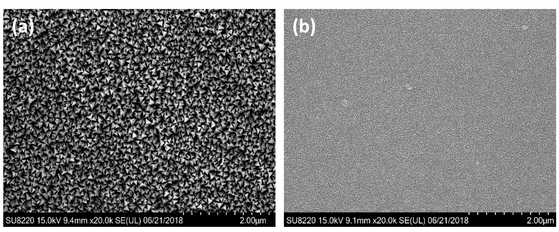

Fig.2. Surface morphology of (a) $CrN_{\text{-VAD}}$ coating; (b) $CrN_{\text{-ALD}}$ coating.

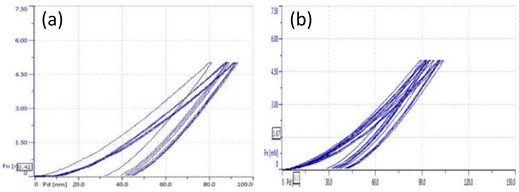

Fig.5. Nanoindentation hardness test curve of (a) $CrN_{\text{-VAD}}$ coating; (b) $CrN_{\text{-ALD}}$ coating.

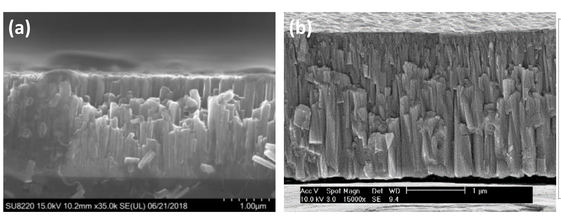

Fig.3. The cross-sectional morphology of (a) $CrN_{\text{-VAD}}$ coating; (b) $CrN_{\text{-ALD}}$ coating.

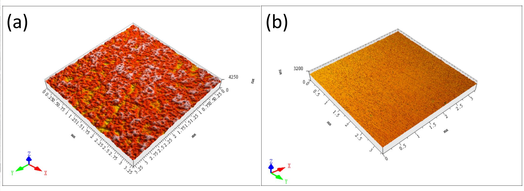

Fig.6. Surface morphology of (a) $CrN_{\text{-VAD}}$ coating; (b) $CrN_{\text{-ALD}}$ coating.

Conclusions

Compared with $CrN_{\text{-VAD}}$ coating, the grain size of $CrN_{\text{-ALD}}$ coating is significantly reduced and the defects of the coating are filled. the morphology of the cross-sectional shows an obvious gradient layered structure and the density is significantly improved. The surface roughness is reduced from 34.4 nm to 17.7 nm. Since the $CrN_{\text{-ALD}}$ coating grows in a mono-atomic layer, it has good coverage of the substrate, high bonding, and can fill the surface defects of the original substrate or coating. Besides, the coating material of ALD layer is the same as the $CrN_{\text{-VAD}}$ coating, so the coating material has good compatibility, and the bonding degree is high. The nanohardness of the ALD modified coating is increased from the unmodified 26.3 GPa to 34.4 GPa. In addition, the adhesion and surface roughness of the $CrN_{\text{-ALD}}$ coating are significantly better than the $CrN_{\text{-VAD}}$ coating. Therefore, the mechanical properties of the $CrN_{\text{-VAD}}$ coatings can be significantly enhanced by ALD technology, which is expected to further extend its service life, and provide a new method and idea for the improvement and optimization of the tool coatings in high-reliability and precision applications, which has certain theoretical and practical reference value.