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Influence of Aluminum Content on the Microstructural, Mechanical and Tribological Properties of TiAlN Coatings for Using in Dental and Surgical Instrumentation

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Abstract : 420 steel is normally used in the manufacture of dental and surgical instrumentation, as well as parts in the chemical, pharmaceutical, and food industries, among others, where they must withstand heavy loads and often be in contact with corrosive environments, which leads to wear and deterioration of these steels in relatively short times. In the case of medical applications, the instruments made of this steel also suffer wear and corrosion during the repetitive sterilization processes due to the relatively low achievable hardness of just 50 HRC and its hardly acceptable resistance to corrosion. In order to improve the wear resistance of 420 steel, TiAlN coatings were deposited, increasing the aluminum content in the alloy by varying the power applied to the aluminum target of 900, 1100, and 1300 W. Evaluations using XRD, Micro Raman, XPS, AFM, SEM, and TEM showed a columnar growth crystal structure with an average thickness of 2 microns and consisting of the TiN and TiAlN phases, whose roughness and grain size decrease with a higher Al content. The AlN phase also appears in the sample deposited at 1300W. The hardness, determined by nanoindentation, initially increases with the aluminum content from 9.7 GPa to 17.1 GPa, but then decreases to 15.4 GPa for the sample with the highest aluminum content due to the appearance of hexagonal AlN and a decrease of harder TiN and TiAlN phases. It was observed that the wear coefficient had a contrary behavior, which took values of 2.7; 1.7 and $6.6x10^{-6}$ $mm^3/N.m$, respectively. All the coated samples significantly improved the wear resistance of the uncoated 420 steel.

Keywords : hard coatings, magnetron sputtering, TiAlN coatings, surgical instruments, wear resistance
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