Evolution of Surface Micro-Features on Titanium Nitride Thin Films Deposited Using Plasma Vacuum Arc Methods


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Titanium nitride (TIN) thin films possess excellent wear resistance, a golden color, and other desirable properties. They are therefore quite common in industrial parts and components. TIN films can be fabricated by many methods among which vacuum arc-plasma deposition is gaining popularity because of the ease to adjust the processing parameters and the high deposition rate. In order to retain the high efficiency in industrial applications, magnetic fields are not frequent; used and macro-particles emitted from the source can contaminate the sample. The macro-particles can reduce the wear resistance and increase the surface roughness of the deposited film as these particles tend to have lower hardness and frequently become the original failure points. A long deposition time, high ion energy, high deposition rate, high deposition temperature, and high sample bias can result in a rougher surface as well. The surface roughness is due to the presence of surface microstructures that stand out from the surface. These microfeatures are usually considered the result of macro-particles on the thin film deposited using vacuum arc methods, or TIN crystalline growth in the macro-particles. In this work, we aim to distinguish the intrinsic nature of the abnormal features. TIN films are deposited respectively using arc deposition with direct vacuum arc plasma source and with filtered vacuum arc plasma source. The surface microstructures resembling birds and seeds are caused by an ion/machining force microscopy (AFM). Using transmission electron microscopy (TEM) and diffraction, the nature of the columnar structure is investigated.


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Metal vacuum arc discharge is an effective technique for thin film deposition or ion implantation. Coatings materials such as Fe, Al, Ti, Cr and W are commonly used to produce plasma. The vacuum arc is ignited by a high-voltage trigger near the end of the cathode and the main arc builds up between the cathode and anode. Non-uniform burning has been observed on the cathode surface, and it is particularly severe for materials with low conductivity such as Si and Cu. As an arc source, non-regular cathode erosion can cause unintentional increase of the arc voltage and critically impact the arc ignition stability. In this work, the surface erosion of poorly conducting cathode materials is investigated using a variety of operation parameters and cathode to anode geometry. Our results show that adjusting the arc pulse duration and the configuration of the extraction hole of the anode can optimize surface erosion and stabilize the arc performance.

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