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TiAlN film preparation by Y-shape filtered-arc-deposition system

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Abstract

A Y-shape filtered-arc-deposition system, which has two arc sources and a common plasma-transport-duct, was operated under nitrogen gas, and a titanium aluminum nitride (TiAlN) thin film was prepared with Ti and Al cathodes. Two filtered-arc plasma beams were not completely combined into one beam even at the exit of the common duct. Thus, TiAlN film with composition-uniform distribution was not obtained at the fixed substrate position. However, different composition films were easily obtained at one time. Then various-composition films of TiAlN with different arc currents were prepared and film properties were measured. The surface roughness in arithmetical mean roughness was less than 3 nm on a 1.5-nm roughness substrate. The density of TiAlN increased with the Ti-content ratio, and its hardness tended to weakly increase with Al-content ratio. The maximum hardness was 36 GPa. Ti-rich film has internal compression stress and Al-rich film has internal tensile stress.

Keywords: Y-FAD; TiAlN; Composition distribution; Film properties

1. Introduction

Cathodic arc deposition (CAD) using cathodic vacuum arc-discharge plasma, sometimes called vacuum arc deposition, arc ion plating, and arc PVD (physical vapor deposition), is one of the very important technologies to prepare thin solid films. Currently, CAD is mostly utilized to obtain the wear-resistant protection coating on cutting tools, dies, metal molds, and sliding parts. However, it is well-known that micron and/or sub-micron macroparticles, so-called droplets, are emitted by vacuum arc discharge from the cathode spot as well as electrons, neutrals and ions. The incorporation of droplets in the film under preparation causes a very rough surface, porous film, pinhole defects, and poor composition-uniformity. One of the promising methods to remove the droplets from the cathodic vacuum arc plasma and to make the droplet-free film is filtered arc deposition (FAD), sometimes known as filtered cathodic vacuum arc (FCVA) or filtered vacuum arc (FVA). After the first filtered arc system developed by Aksenov [1], many other types of filtered arc systems have been developed and reported in various reviews [2–5].

Recently, multi-element nitride film has been attracting increasing attention [6–8]. One of the useful multi-element nitride films for high-speed cutting tools is titanium aluminum nitride (TiAlN) [9]. TiAlN has the great advantages of better oxidization resistance and high hot hardness, compared with conventional metal nitride and carbide films of TiN, CrN, and TiC [10,11]. The preparation of TiAlN in CAD usually requires a composition-controlled TiAl alloy target (=cathode of arc discharge). However, if pure Ti and Al cathodes are used instead of expensive TiAl alloy, the running cost is able to be reduced. Furthermore, a filtered system is necessary to obtain higher quality TiAlN film. Thus, we have developed a Y-shape filtered arc deposition system (Y-FAD) with two vacuum arc evaporators and a Y-shape filter duct. This system has a partial-common duct for plasma transportation, which is different from the previously developed system with a partitioned duct [12]. Y-FAD has been demonstrated to be able to prepare composition-controlled TiAl film [13].

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