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TiN/Ti film formation by vacuum arc deposition with droplet shield plate

Hirofumi Takikawa*, Koji Shinsako, Tateki Sakakibara

Department of Electrical and Electronic Engineering, Toyohashi University of Technology, Toyohashi, Aichi, 441-8580, Japan

Abstract

Ti film was deposited on an Mo substrate, a TiN film was then deposited on it, using a reactive vacuum arc deposition with a droplet shield plate located between the Ti cathode and the substrate. Substrate temperature during the process was decreased as the shield plate was moved closer to the substrate. Deposition rates of Ti and TiN/Ti films with the shield plate were less than half to a quarter of those without the shield plate. The crystalline structure of the film prepared with the shield plate did not significantly differ from that prepared without the shield plate and was independent of the plate position. The number of droplets on the film was drastically reduced when the shield plate was located farther from the substrate, but an unacceptable number of droplets remained on the film when the shield plate was located closer to the substrate.

Keywords: Vacuum arc deposition; Droplet shield; Titanium nitride; Film characterization

1. Introduction

Titanium nitride (TiN) film has some excellent properties, i.e. high melting point, high hardness, and high thermal conductivity. Thus, it has practical uses as a hard and wear-resistant coating on cutting tools [1] and forming moulds. One TiN film formation method is reactive vacuum arc deposition, sometimes called reactive cathodic arc deposition [2]. This method exhibits a higher deposition rate and stronger adhesion, compared to CVD, sputter, and liquid-based coating methods. Moreover, the apparatus is relatively simple and can be easily scaled up for a large area coating, since many metallic ions can be obtained from the evaporation point of a vacuum arc cathode spot without any liquid pools or crucibles. The authors have produced TiN film [3] as well as AlN [4], diamond-like carbon [5,6], and TiO_2 [7] by this method.

However, the vacuum arc deposition method has a serious problem in so far as metallic macroparticles (so-called droplets) are emitted from the cathode spot as well as high energy ions, which adhere to the film. The diameter of such droplets is usually on the order of sub-microns to a few hundred microns [2]. The adhesion of droplets on the film presents a fatal disadvantage, i.e. the deposition of film at a micron level.

Several methods for overcoming the droplet problem have been reported such as a distributed discharge arc, a steered arc, or a magnetic field transport (an arc with a magnetic field filter). These are summarized by Swift [8]. A distributed discharge arc has been observed with a heated chromium cathode, and the arc emitted no droplets, though only a few relevant studies have been carried out. A steered arc is the most popular method though, even then droplets cannot be completely eliminated. Magnetic field transport is the most effective method though it has the disadvantage of an extremely slow deposition rate. Taki et al. have proposed a simple method using a

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* Corresponding author. Tel.: +81 532 446727; fax: +81 532 446757; e-mail: takikawa@eee.tut.ac.jp

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