

Enhancement of shielded cathodic arc deposition

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Abstract

A shielded-cathodic-arc-deposition (SCAD) technique was modified and enhanced to improve the deposition rate of droplet-free thin solid film. The technique was based on plasma transportation using the external magnetic field of a permanent magnet or electromagnetic coil. The deposition rate distribution of the titanium nitride (TiN) film was measured. A higher deposition rate at the substrate center was obtained by using a focusing magnet behind the substrate (enhanced shielded-cathodic arc deposition: E-SCAD). A higher and wider deposition rate was realized by using a focusing electromagnetic coil (improved E-SCAD: IE-SCAD).

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1. Introduction

The cathodic vacuum arc has a promising potential for preparing thin solid films for wear-resistant hard coatings, optical coatings and transparent conducting coatings [1]. However, the cathodic arc discharge involves the emission of macrodroplets from the cathode spot. In most cases, the adhesion of the macrodroplets results in poor film. To date, several techniques have been presented to solve this droplet problem. The techniques can be roughly classified into two types, one in which the generation of the droplets is suppressed, and other by which the process is carried out in the region where the droplets are absent. The former includes steering arc [2,3], distributed arc [4], and pulsed arc [5,6]. The latter includes magnetically filtered arc [7,8], shielded arc [9,10], and coaxial arc [11]. The shielded arc is one of the simplest, high-efficiency methods to prevent the adhesion of the droplets [12]. However, the shielded arc has a disadvantage in that the deposition rate is considerably decreased since many ions are simultaneously shielded [13].

The improved shielded-arc device based on plasma transportation by the magnetic field has been developed by I.I. Aksenv et al. [14] and H. Bolt et al. [15]. They

have used several electromagnetic coils and an electromagnetic island shield. In the present study, the shielded arc apparatus with simpler magnetic field configuration using one or two permanent magnets and/or an electromagnetic coil was tested in order to realize an energy-saving system. A comparison among a conventional non-shield cathodic-arc-deposition (CAD), a normal shielded cathodic-arc-deposition (SCAD) without applying the magnetic field around the substrate, an enhanced shielded-cathodic-arc-deposition (E-SCAD) with a permanent magnet behind the substrate, and improved E-SCAD (IE-SCAD) with an electromagnetic coil around the substrate is provided in terms of the deposition rate of the titanium nitride (TiN) film.

2. Experimental set-up and procedure

The E-SCAD apparatus is depicted in Fig. 1. A titanium (Ti) cathode target 64 mm in diameter was placed in the vacuum chamber (stainless steel-made), which served as the anode. Magnetic disks were placed behind the cathode, in order to steer the cathode spot. A protection plate (mild steel, 68 mm in inner diameter and 170 mm in outer diameter, 4 mm thick) prevented the plasma from expanding backward and also guided the radial component of the magnetic flux density on the cathode surface in order to steer the cathode spot. The normal component of the magnetic field density at the center of cathode surface was 1.8 mT. The distribu-

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