Review of Cathodic Arc Deposition for Preparing Droplet-Free Thin Films

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***Abstract*—Cathodic arc plasma is one of the potential ion plating physical vapor deposition methods to prepare protective coatings on cutting tools, metal mold, etc. In particular, TiN, CrN, and TiAlN films are coated on industrial cutting tools using cathodic arc plasma. However, the cathode spot of the vacuum arc generates macrodroplets as coproducts of cathodic arc plasma containing high-energy ions. These macrodroplets may pose problems with smooth-surface films that are used for advanced high-precision applications. This paper reviews cathode phenomena particularly for a graphite cathode, the techniques for reduction of macrodroplet generation, and the techniques for macrodroplet removal from the processing plasma. The reduction technique includes steered arc, pulsed arcs, etc. The removal technique includes shielded arcs and filtered arcs. Recent filtered arc deposition systems are referred.**

***Index Terms*—Cathodic arc, droplet suppression, filtered arc, macrodroplet, thin film deposition.**

I. Introduction

ONE INDUSTRIAL application of vacuum arc discharge is coating technology. When an arc discharge is generated under medium and higher vacuum, in general, a cathode spot is formed, but no anode spot is formed. The cathode spot is very active with high temperature and evaporates the cathode material. At the cathode spot region, very dense plasma is generated, and the evaporated cathode material is ionized and the ions deposit solid film upon reaching the solid surface. Such vacuum arc deposition is a major method in physical vapor depositions (PVDs) and has the advantage of higher ion energy, compared to the other PVD methods. The ion source of the arc cathode is generally solid. Therefore, no crucible is needed, and the sources can be freely mounted on the wall of the process chamber. In principle, no gas introduction is necessary. However, vacuum arc deposition is suitable for reactive deposition because the ions generated in the vacuum are highly reactive with the gases due to their high energy.

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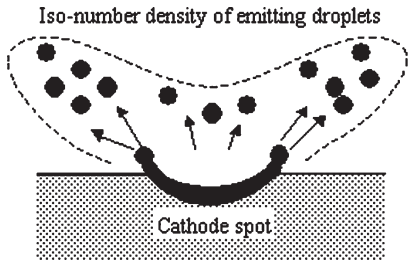

Fig. 1. Image of droplet emission from metal cathode spot.

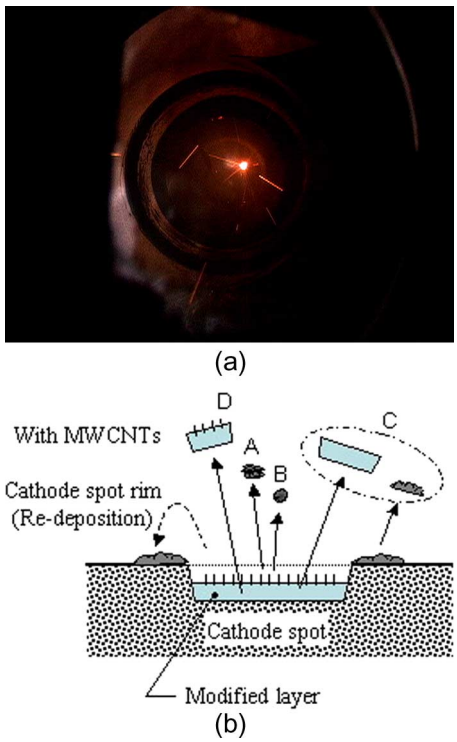

Fig. 2. Graphite cathode spot and image of droplet emission. (a) Graphite cathode spot (dc 50 A, no gas introduction). (b) Image of droplet emission of graphite cathode.

Vacuum arc deposition is also called cathodic arc deposition or arc ion plating, and various types of industrial systems are in widespread use around the world. Its major use is to make protective coatings on cutting/machining tools and sliding materials. Examples of film materials are TiN, TiC, CrN, and TiAlN. Such technology has long been investigated, and the relevant information is available in books and the literature [1]–[5]. Nowadays, the introduction of basic-type vacuum arc deposition apparatus (namely, nonfiltered arc deposition apparatus) has almost reached the saturation point, and the