Cathode Spot Motion in Vacuum Arc of Zinc Cathode Under Oxygen Gas Flow

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***Abstract*—Magnetically steered cathode spot(s) of a vacuum arc with a zinc (Zn) cathode was(were) observed using a high-speed video camera. The camera can take 4500 frames per second of 256 × 256 pixels. The transverse magnetic flux density for steering the cathode spot was 1.0 and 5.5 mT at the bottom of the cathode (64 mm in diameter) shoulder. The arc was operated at an arc current of dc 30 A and O_2 flow rate of 40 ml/min. The pressure was varied from 0.1 Pa to 5.0 Pa. The principal results obtained in the present study were as follows. The cathode spots were driven in the retrograde direction. When a strong magnet was used, the number of the cathode spots was smaller, the cathode spots revolved at the outer region of the cathode surface more of the time, and the velocity of the cathode spots was higher than when a weak magnet was used. The velocity of the cathode spots increased as the pressure increased.**

***Index Terms*—Ambient oxygen, cathode spot, distribution of magnetic flux density, multiplicity, pressure dependence, retrograde velocity, zinc cathode.**

I. Introduction

Cathodic arc plasma exhibits a potential use in preparing thin solid films of metal and nitride, oxide, and carbide ceramics, since the cathode spot(s) in vacuum arcs emit(s) highly energized metallic ions [1]. In such applications, the cathode spot(s) is(are) usually steered by applying a magnetic field on the cathode surface [2], [3]. Therefore, it is important to investigate cathode spot dynamics under a magnetic field. To date, intensive study of cathode spot dynamics in a vacuum has been performed by Jüttner, *et al.* [4], [5]. However, it is also important that such dynamics should be understood in a practical apparatus in order to advance vacuum arc technology to the stage of industrial applications.

In the present study, the cathode spot(s) of the vacuum arc for preparing zinc oxide (ZnO) film [6], [7] was(were) observed using a high-speed video camera, under different magnetic field strengths and various pressures. The properties of the spots were revealed in terms of the tracking zone, multiplicity, and velocity.

II. Experimental

The steered-type cathodic vacuum arc apparatus and video camera arrangement used in the experiment are depicted in Fig. 1. A zinc (Zn) cathode of 64 mm in diameter with a barrier wall shoulder at the edge, which prevents the arc spot from running off the cathode surface, was placed in a cylindrical vacuum chamber (SUS304, 600 mm long, 400 mm in diameter). The chamber was the grounded anode. The permanent magnet was placed behind the cathode, and a magnetic field-guide plate of mild-steel (80 mm in inner diameter, 120 mm in outer diameter, 5 mm thick) was arranged parallel to the cathode surface. In the present study, two different magnets were used. Fig. 2 shows the normal and transverse components of magnetic flux density

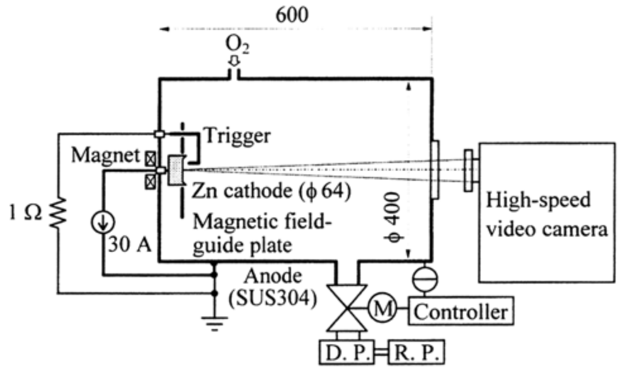

Fig. 1. Schematic diagram of steered vacuum arc and arrangement of high-speed video camera.

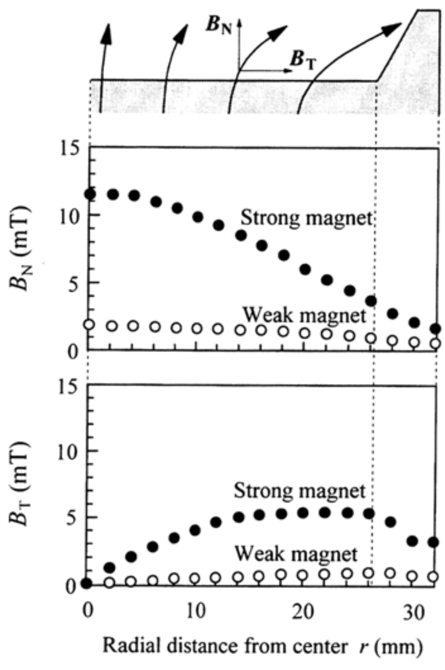

Fig. 2. Distribution of magnetic flux density on cathode surface. B_N and B_T refer to normal and transverse components, respectively.

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