4Cp07

窒素アークにおけるタングステン陰極の蒸発現象の可視化
Visualization of Tungsten Cathode Evaporation in Nitrogen Arc

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1 Introduction

DC arc has been used in a wide range of industrial fields. Cathode erosion is one of the most important issues to be solved because it determines electrode lifetime and purity of products. Low work function and high melting point are important properties for stable thermionic emission at negligible erosion. Tungsten with doped oxide as an emitter is generally utilized as cathode material.

Recent work based on high-speed visualization revealed that N_2 addition as plasma forming gas led to severer cathode erosion [1], although cathode erosion mechanism in N_2 arc has not been clarified. The purpose of the present study is to investigate erosion mechanism of metal-oxide doped W cathode in N_2 arc. Dynamic behavior of W vapor was visualized by a high-speed camera with an appropriate band-pass filter system.

2 Experimental

Figure 1 shows a schematic illustration of experimental setup. Metal oxide doped W with 6 mm in diameter was used as cathode, while a water cooled copper was used as anode. Different oxides of ThO_2, CeO_2, Y_2O_3, and Nd_2O_3 at around 2wt% of mass fraction were doped into each cathode to investigate the effect of doped oxide on cathode evaporation. Ar-N_2 gas mixture was filled at atmospheric pressure after several times of the evacuation by a rotary vacuum pump. Arc current was changed from 80 to 300 A.

High-speed camera system with band-pass filters were utilized to visualize W vapor from cathode during arc discharge. Transmission wavelength of band-pass filter was selected to be 430 nm, to visualize only W vapor without other emissions. Relative intensity of W to Ar was then calculated to estimate relative number density of W. Typical framerate of camera observation was 5×10^3fps.

3 Results and Discussion

Relative intensity distributions of W to Ar emission for different doped oxides are summarized in Fig. 2. Tungsten vapor was observed only at the periphery of the arc. This originates from the ionization of W vapor. First, W evaporates from the whole region of the high temperature cathode. However, most of W vapor returns back to the cathode due to the ionization of W at high temperature region of the arc. In contrast, W vapor which evaporates from the fringe of the cathode spot does not return back due to the lower temperature of periphery of the arc.

Obtained results also indicate that the different doped oxides lead to different behavior of W evaporation. This can be explained by two factors, thermal factor and chemical factor. Nitrogen reduction of doped oxide has important role on cathode evaporation.

4 Conclusion

Tungsten vapor from oxide-doped W cathode was visualized by the high-speed camera with appropriate band-pass filters. Characteristic evaporation of W from cathode was successfully observed. Understanding of cathode phenomena enable to realize the N_2 arc processes with negligible cathode erosion.

References

[1] M. Tanaka et al., Proc. 10th Conf. Trends Weld. Res., 393-396 (2016)

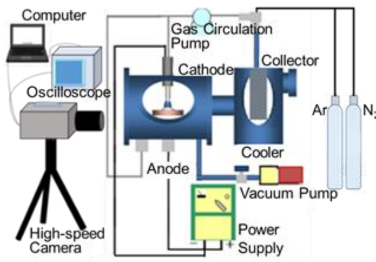

Fig. 1 Schematic diagram of DC arc system.

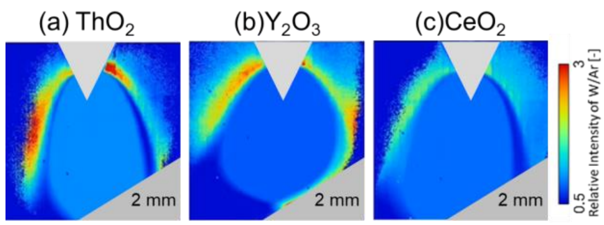

Fig. 2 Representative distributions of relative intensity of W to Ar emission for W cathode with different doped oxide. (a) ThO_2, (b) Y_2O_3, and (c) CeO_2.