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窒素直流アークにおける電極添加酸化物種のアーク温度分布への影響
Influence of doped oxide on arc temperature distribution in nitrogen DC arc

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1. Introduction

DC arc plasma is a powerful tool for synthesis of nanoparticles due to many advantages, such as high enthalpy, rapid quenching, and high chemical reactivity. Decreasing cathode erosion is important for avoiding the pollution of products from cathode material. Kinds of rare earth oxides with low work function are usually doped into tungsten cathodes to improve arc stability and reduce cathode erosion [1].

Nitrogen is a prospective gas that is safe and low cost. Research about temperature measurement of N_2 DC arc have been published in the past few decades. However, the understanding about the effect of rare earth metal oxide on arc temperature in N_2 atmosphere is insufficient.

The purpose of present work is to explain the arc temperature distributions in N_2 atmosphere with different cathode materials with emission intensity ratio method.

2. Experimental setup

Figure 1 is schematic illustration of DC arc plasma system. Water-cooled copper plate was set as the anode. W-2wt%ThO_2, W-2wt%Y_2O_3, W-2wt%La_2O_3, and W-2wt%Ce_2O_3 cathodes were used. Cathode diameters were 6 mm. The electrode gap distance was 10 mm. Arc current was 200 A. Gas composition was 50vol%N_2-Ar. High-speed camera with appropriate band-pass filters at 480±5 nm and 500±5 nm was utilized to visualize Ar^+ and N^+. Abel inversion [2] was applied to arc images. Arc temperatures were calculated by emission intensity ratio method with consideration of line emissions, bremsstrahlung, and recombination radiation.

3. Result and discussion

Figure 2 shows the high-speed camera images measured with 500±5 nm band-pass filter and arc temperature distributions at different cathode materials in 50vol%N_2-Ar atmosphere with 200 A. The arc temperature of W-2wt%Y_2O_3 was higher. In Ar atmosphere, the arc temperature is higher for cathode doped metal oxides with high melting points [3]. This is because additive metal oxides with high melting points decrease the size of the cathode spot and increase the current density of the arc. However, this tendency was not obtained in the nitrogen atmosphere in this study. The reaction of nitrogen with the doped metal oxide and the recombination heat of nitrogen affected the size of the cathode spot.

4. Conclusion

The effect of doped metal oxides on arc temperature was investigated in N_2 DC plasma. Reactivity of nitrogen with the doped metal oxide and the recombination heat of nitrogen affect the arc temperature.

Reference

[1] Sadek A A., Ushio M., Matsuda F., Metallurgical Transactions A, 21(12), 3221-3236 (1990).
[2] O. H. Nestor and H. N. Olsen, SIAM Rev. 2, 200 (1960).
[3] S. Tashiro and M. Tanaka, J. Plasma Fusion Res. 88(7), 383-388 (2012).

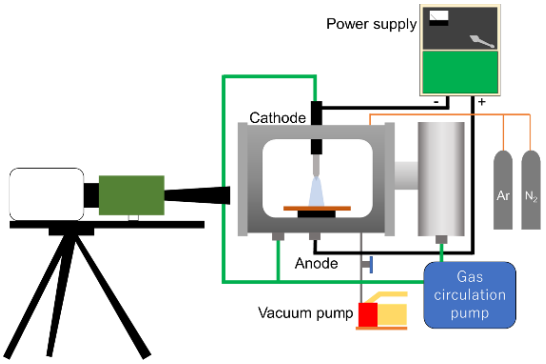

Fig. 1 Schematic diagram of DC arc system.

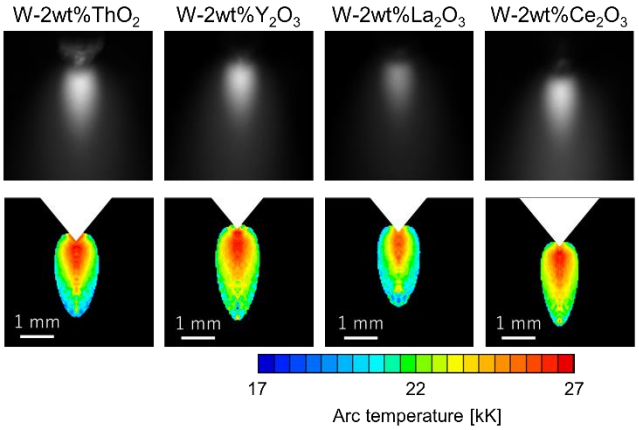

Fig. 2 Arc images of 500 nm and arc temperature distributions measured at different cathodes.