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Innovative thermal plasma generation with diode-rectified AC arc system and its applications

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New thermal plasma sources have been successfully developed by diode-rectified AC arc under atmospheric pressure. Diode-rectification technique enables us to designe and control arc phenomena as well as electrode phenomena in high-intensity arc devices.

Planar thermal plasma jet has been successfully developed with diode-rectified AC arc system. Moreover, diode-rectified multiphase AC arc (DRMPA) has also been developed for the massive powder processing at high throughput [1]. These new sources of thermal plasmas and their applications will be presented in this topical plenary talk.

Generation of planar-shaped thermal plasma jet is one of the most important approaches to expand the applicability of thermal plasmas for materials processing, surface treatment, and waste treatment at high processing rate. A few approaches using radio frequency inductively-coupled plasma [2] or DC arc discharge [3] have achieved enlarged treatment area with plasma jets, although many limitations such as insufficient temperature or extent remain. Here, an innovative thermal plasma source based on the diode-rectified AC arc has been used to overcome the afore-mentioned difficulties.

Arc discharge was generated using 10 electrodes placed in a linear array. These 10 electrodes were configurated by AC electrodes, diode-rectified electrodes, cathodes, and anodes. **Figure 1** shows the conceptual illustrations of the plasma source. Electrode positioned at locations 1 and 3 have the role of AC electrode, corresponding to negative-positive cycle and positive-negative cycle, respectively. Diode-rectified electrodes are located at 2 and 4. Location 2 has the role of anode, while 4 works as cathode. Operating conditions for plasma generation are as follows; arc current: 100-160 A, arc voltage: 20-30 V, argon flow rate as electrode shield gas: 1.0-5.0 L/min, argon flow rate as chamber gas: 40 L/min, width of the slit for plasma jet: 10 mm, length of the slid: 200 mm.

Plasma jet existence probability was analyzed from the high-speed images for 5 AC periods. This existence probability was defined as the ratio of the time during which the plasma jet existed to total time. Therefore, “1” indicated that the plasma jet always existed and “0” does not exist. Obtained results suggested that the planar thermal plasma jet is a promising plasma source and will replace the conventional DC arc in many applications.

Figures 2 represents the diode-rectified multiphase AC arc (DRMPA). Stable thermal plasma has been successfully generated among twelve bipolar electrodes consisting copper anodes and tungsten-based cathodes. Degraded electrode erosion in the DRMPA system enabled to suppress contamination of electrode materials in produced nanomaterials, while large plasma area leads to high-throughput nanomaterial synthesis.

Acknowledgements
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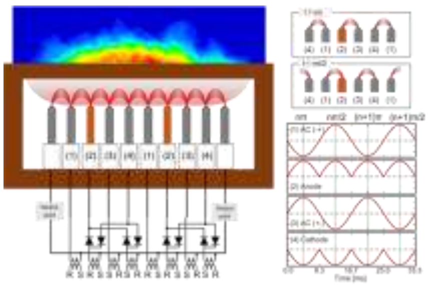

Fig. 1 Conceptual illustration of plasma torch for planer thermal plasma jet generation.

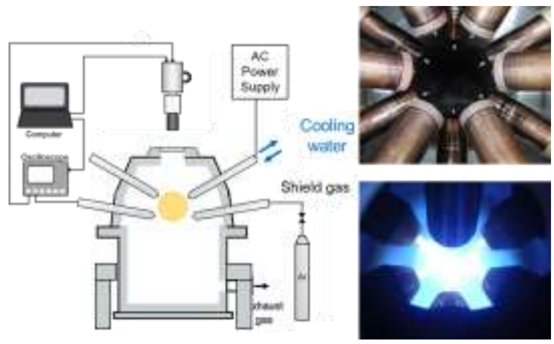

Fig. 2 Schematic of experimental setup for generation of diode-rectified multiphase AC arc (DRMPA) and its photographs.