5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Planar thermal plasma jet in diode-rectified AC arc system under atmospheric pressure

Manabu Tanaka[1], Takuya Suenaga[1], Aika Tamae[1], Takafumi Okuma[1], Takayuki Watanabe[1], Tsugio Matsuura[2], Juan Pablo Trelles[3], Masaya Shigeta[4]
[1]Department of Chemical Engineering, Kyushu University, [2]TasoArc Corp.,
[3]Department of Mechanical Engineering, UMASS Lowell,
[4]Department of Mechanical and Aerospace Engineering, Tohoku University
e-mail (speaker): mtanaka@chem-eng.kyushu-u.ac.jp

A new thermal plasma source achieves planar thermal plasma jet, has been successfully developed by diode-rectified AC arc under atmospheric pressure. The purpose of the present study is to understand the fundamental phenomena such as plasma jet fluctuation and interaction between plasma jet and treated surface.

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 [1] or DC arc discharge [2] 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 configured by AC electrodes, diode-rectified electrodes, cathodes, and anodes. **Figure 1** shows the schematics 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. Planar-shaped thermal plasma jet was successfully generated owing to this unique configuration of electrodes with diode-rectification technique. Operating conditions for plasma generation are as follows; arc current: 120 A, arc voltage: 20-30 V, power: 30 kW, argon flow rate as electrode shield gas: 0.5 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.

Figure 2 shows the of arc current waveforms for each electrode. Results indicated that all of the electrodes from location 1 to 4 followed each role as designed, e.g. location 1 electrode worked as AC electrode from negative to positive and 2 only worked as anode.

Figure 3 shows the representative snapshots of the plasma jet for (a) front view and (b) side view. 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.

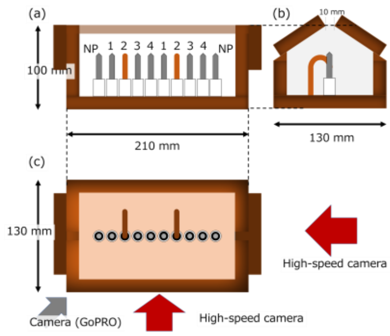

Fig. 1 Schematic of planar thermal plasma source.

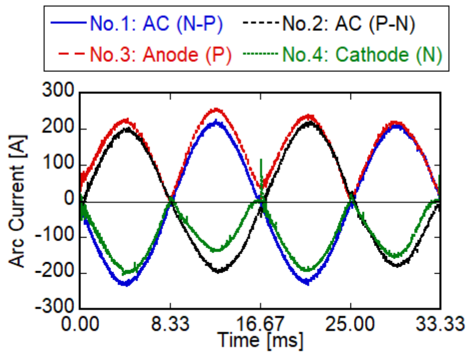

Fig. 2 Arc current waveforms for each electrode.

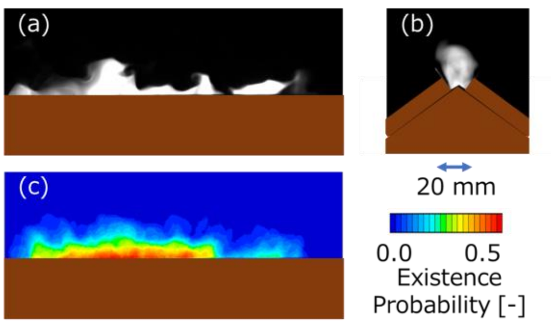

Fig. 3 High-speed snapshots of the planar thermal plasma jet for (a) front view and (b) side view. (c) Distribution of plasma jet existence probability.

Acknowledgements
This work is partially supported by JSPS KAKENHI (Grant No. JP19K03808).

References

[1] T. Tsuchiya, et al., Plasma Chem Plasma Process., **38**, 599-620 (2018).
[2] M. Szulc, et al., J. Phys.: Conf. Seri., **825**, 012017 (2017).