# High-Speed Visualization of Temperature Field in Diode-Rectified Multiphase AC Arc with Bipolar Electrode

Manabu Tanaka*[1], Tsugio Matsuura[2], and Takayuki Watanabe[1]

[1]Department of Chemical Engineering, Kyushu University – Japon
[2]Taso Arc Corp. – Japon

**Résumé**

An innovative multiphase AC arc (MPA) was drastically improved by diode rectification technique with bipolar electrodes. Temperature fields of the diode-rectified MPA (DRMPA) were successfully visualized on the basis of a high-speed camera with appropriate band-pass filters.
The MPA is expected to be utilized in massive powder processing as novel heat source because MPA possesses many advantages; high energy efficiency, large plasma volume, low gas velocity, and low cost. However, a few issues remain to be solved. In particular, electrode erosion is one of the important issues to be solved.

Electrode erosion mechanism in the MPA had been investigated by high-speed visualization technique. Erosion due to larger droplet ejection than 100 $\mu$m in diameter is dominant at cathodic period while evaporation at anodic period is dominant mechanism. The droplet ejection at cathodic period is caused by the electrode melting due to high heat flux to electrode at anodic period. Therefore, the DRMPA was successfully established based on the diode-separation of AC electrode into a pair of cathode and anode to solve the electrode erosion. However, fundamental phenomena in the DRMPA are still poorly understood because of its novelty, although spatiotemporal characteristics of the arc and/or electrode temperature are necessary to develop the DRMPA for industrial applications. The purpose of the present study is to clarify temperature fluctuation of arc and the electrodes in DRMPA by high-speed visualization technique.

Twelve-diodes were placed between the electrodes and the transformer. Thus, the electrodes were divided into pairs of cathode and anode, namely bipolar electrodes. Each electrode consisted of cathode made of indirect water-cooled oxide-doped tungsten with 3.2 mm in diameter and anode made of water-cooled copper rod with 20 mm in diameter. Six pairs of electrodes were symmetrically arranged at the angles of 60 deg. DRMPA were generated among these parallel rod electrodes in argon atmosphere. Arc temperature field and electrode temperature fluctuation were visualized by high-speed camera with appropriate band-pass filters. Transmission wavelengths for arc temperature visualization were 794 nm and 675 nm, while these for electrode temperature measurement were 785 nm and 880 nm. Remarks obtained from the high-speed visualization are as follows;

*Intervenant

(1) Temporal and spatial characteristics of the DRMPA was investigated. Anode jet in the DRMPA was weaker than that in the conventional MPA due to the negligible metal vapor in the DRMPA system. In contrast, strong cathode jet was confirmed in both the DRMPA and the conventional MPA due to the high current density near the tungsten-based electrode. Arc region in the DRMPA was widely distributed compared with the MPA. Therefore, arc region in the DRMPA is more suitable for nanomaterial synthesis and/or waste treatment at a high processing rate.
(2) Erosion rate of the electrode in the innovative DRMPA was drastically improved. Anode erosion in the DRMPA was reduced due to higher thermal conductivity of copper in the DRMPA than that of tungsten in the MPA. Moreover, cathode erosion in the DRMPA was also reduced because of the absence of the anodic heat transfer to the tungsten-based electrode. Temperature of tungsten-based electrode in the MPA was higher than the melting point of tungsten, while that in the DRMPA was significantly lower than the its melting point, resulting in negligible erosion.