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Water Thermal Plasma Characteristics with Mist Generation for Waste Treatment

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Water plasma is in favor of generation of a large amount of H, O, and OH radicals. These radicals play important roles on control of by-products formation. Therefore, water plasmas are expected to be utilized for decomposition of harmful materials.

In water plasma, liquid water in the reservoir is directly injected into discharge region through stainless steel felt by capillary phenomena. The arc stability in this plasma torch is not sufficient due to the unstable water feeding by the stainless steel felt. Therefore, improved water plasma torch with mist generation has been developed to achieve the stable feeding of liquid water into discharge region for an improvement of the arc stability.

The purpose of this paper is to investigate the discharge characteristics of the innovative water plasma with mist injection. High-speed camera observation with synchronized voltage measurements was carried out to understand arc fluctuation in the non-transferred water plasma torch with mist injection.

The plasma torch shown in Fig. 1 is a DC non-transferred arc generator of coaxial design with a cathode of hafnium embedded into a copper rod and a nozzle type copper anode. The diameter of hafnium was 1.0 mm. Using hafnium as a cathode material can prevent the erosion and perform a longer operating time in an oxidative atmosphere.

An ultrasonic atomizer at the bottom of the torch atomizes the liquid at a frequency of 2.5MHz. The generated water mist is directly introduced into the discharge region. Water plasma was generated at discharge region by heating and ionization of the mist. Simultaneously, the anode is cooled by the water evaporation, thus the torch can be operated in the absence of carrier gases or air injection, cooling-controlled system, and pressure-controlled devices. Therefore, the presented system is a portable light weight system without additional gas supply system and has a higher energy efficiency than 90%.

A high-speed camera with an appropriate band-pass filter system was used to visualize the arc fluctuation and the temperature field. The wavelengths of the filters were 656 nm and 486 nm for H_α and H_β, respectively. Typical framerates were 3.8×10^5fps for temperature measurement.

The voltage waveform and the synchronized temperature distributions of the water plasma at different solutions are shown in Fig. 2. Arc temperature in most of the arc region was higher than 6,000 K at both conditions.

Temperature measurement on microsecond timescale was achieved by the high-speed camera system with appropriate band-pass filters. Obtained understandings enable to apply this system to waste treatment.

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References

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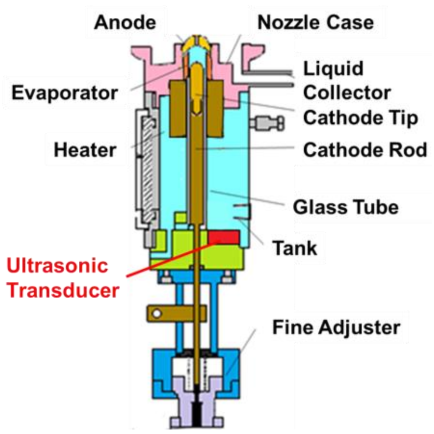

Fig.1. Schematics of water plasma torch with mist generation.

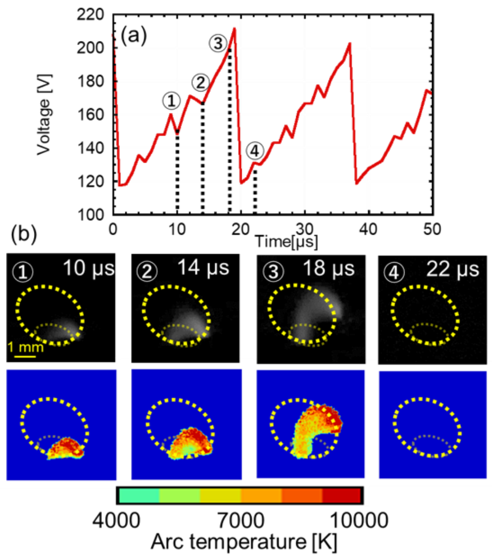

Fig. 2. (a) Waveform of arc voltage. (b): synchronized high-speed snapshots and corresponding temperature distribution.