Dependence of electrode materials and gaseous in serpentine plasma for nano particles preparation

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Gliding arc discharge is attractive discharge system that can control electrical consumption power under atmospheric pressure. Regarding this discharge, we named serpentine plasma. This plasma does not satisfy thermionic emission condition, but there is much characteristic. This plasma generates particles in atmospheric pressure environment. We investigated preparation of nano particle using various gas and electrode materials on atmospheric serpentine plasma system.

1. Introduction

Gliding arc discharge is attractive discharge system that can control consumption power under atmospheric pressure [1]. In our previous study, we showed that gliding arc discharge did not satisfy the requirements of normal arc discharge condition. In other words, the conditions of gliding arc discharge are not low voltage, high current. The gliding arc does not have thermionic emission condition in a fixed point on electrode. Depending on a shape of electrodes, gliding arc discharge may satisfy normal arc condition, but many cases are not so. In addition, it has been understood that the discharge strongly depended on a velocity of supplied gas. Therefore we named it 'serpentine plasma' as a name to distinguish from a normal arc discharge. Nano particles preparation using this atmospheric plasma was carried out. Also emission spectroscopy observation of plasma was carried out. We already confirmed that particles were generated in a vapour phase between the electrodes by a high-speed Infrared thermography. An image same as a visible region was got in an infrared region by the measurement of the interval that plasma maintained. Usually thermography does not enable plasma diagnoses because thermography observes the wavelength from 1μm to 1mm. Plasma does not often emit the infrared radiation of this wavelength area. This thing means that there were particles in the space between electrodes. We confirmed nano particles based on the electrode metallic element were generated in particular easily when only argon (Ar) was used for feeding gas in serpentine plasma.

2. Experiment

We used for serpentine plasma system with UV assistance and equipment for observation of electrical properties and dynamic behaviour. Two electrodes, which are made of iron, graphite or aluminium, are 100 mm height knife edge-shaped and their shortest gap was 5 mm. The electrodes were set inside an acrylic chamber that has an outlet on the top for gas exhaust. An inlet for gas supply to the chamber was placed at the bottom and at the centre between two electrodes. Ar, He, CH_4, CO_2 was used. The definition of discharge starting voltage in this work is the amplitude of applied voltage just before the start of discharge. Waveforms of applied voltage and discharge current were measured with a high-voltage probe and a current clamp, respectively. Both waveforms were captured with a digital oscilloscope. Time-resolved digital photographs for plasmas were recorded by a high-speed digital camera (Nobby Tech. Ltd., Phantom V.1210) with 10,000-100,000 fps with external trigger signal from a pulsed signal generator. Sampling of the particle to silicon substrate or stainless mesh which was installed in the gas exhaust aperture was carried out. The nano particles were analysed by Electron Beam 3D surface roughness analyzer (Elionix, ERA-8900FE).

3. Summary

Nano and micro size particles were confirmed on stainless steel mesh. However positive confirmation was not possible with silicon substrate. Flow rate of the gas was more than 10 l/min (maximum rate 50 l/min) therefore substrate heating will be necessary with a flat and smooth silicon substrate. Because gliding arc discharge system is extremely simple structure, and a power supply can apply it with a commercial power supply, low-cost nano particles preparation is enabled.

4. References

[1] J. Sperka et al. Materials Research Bulletin 54 (2014) 61–65