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ナノ粒子生成用変調熱プラズマにおける原料粒子挙動のレーザストロボ観測
Laser Strobe Observation of Feedstock Particle Dynamics in Modulated Thermal Plasma for Nanoparticle Synthesis

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1. Introduction

Nanoparticles are expected as breakthrough elements in various fields of environment, energy, electronics, and so on. The authors have developed pulse modulated induction thermal plasma (PMITP) and time-controlled feedstock feeding (TCFF) method for synthesizing large amounts of nanoparticles. In the PMITP+TCFF method, complete synchronization between plasma modulation and feedstock feeding, and suppression of adhesion of the molten feedstock to torch wall are issues to be solved for further production rate. It is therefore necessary to understand the behavior of feedstock particles in the PMITP. In this report, a laser stroboscopic imaging system was adopted to observe dynamics of feedstock particles with mean size of about 20 μm in PMITP+TCFF method.

2. Observation system and experimental condition

It is required to suppress the strong emission from the thermal plasma for observation of feedstock particle behavior. Fig.1 shows a schematic diagram of a high-speed laser strobe imaging system adopted. A pulsed YAG laser beam with a wavelength of λ = 532 nm and power of 0.266 mJ was used as a light source for visualization of feedstock particles. This laser beam was converted to a vertical sheet-like collimated light beam by an optical system using a combination of concave and convex cylindrical lenses. This sheet laser beam incident to the plasma torch is partially reflected by feedstock particles. The reflected light and thermal plasma light are guided to a band pass filter with a wavelength width of λ = 532 ± 1 nm. As a result, almost only the strong reflected light of the laser beam is transmitted to a high-speed video camera, while attenuating the strong irradiation from the thermal plasma. Furthermore, synchronizing the repetition frequency of the YAG laser and the frame rate of the high-speed video camera enables us to measure the reflected light from the particles. The repetition frequency of YAG laser was 4000 Hz with a pulse width of 1-10 ns, which was synchronized with a high-speed video camera, whose frame rate was 4000 fps. Detailed plasma condition was the same as described in [1].

3. Observation results

Fig.2 shows observation results for PMITP+ TCFF condition at the timing of (a) plasma on-time at t=6 ms and (b) final state in on-time at t=12 ms, where on-time is realized from t=0 ms to 12 ms. Reflected light from feedstock was clearly detected near the central axis of the plasma torch. From Fig.2(b), feedstock particles with a smaller particle size by evaporation were seen to be diffused in radial direction because of gas flow originating from rapid temperature change in thermal plasma.

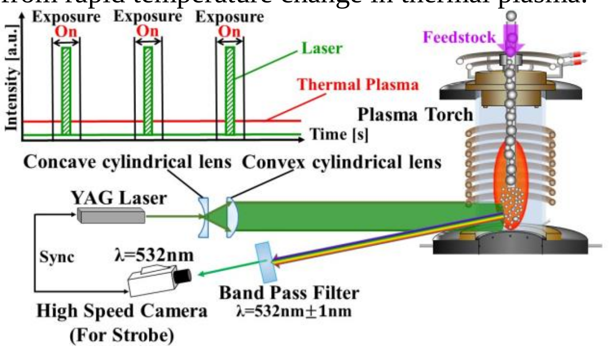
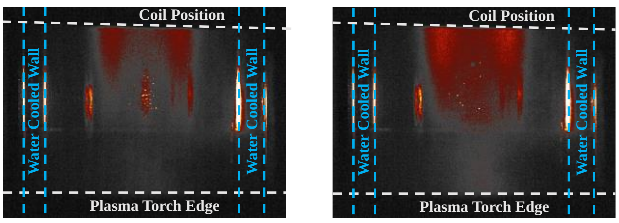


Fig.1 Observation system for feedstock particle behavior in induction thermal plasma.



(a) t = 6 ms (b) t = 12 ms

Fig.2 Observation results for PMITP + TCFF condition

4. Reference

[1] Y. Ishisaka, et al., *Applied Physics Express*, vol.10, **096201**, 2017