Photoluminescence imaging of YAG:Ce particles generated by laser ablation in liquid PDMS

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We have observed the phenomena of laser ablation in liquid to investigate the particle generation processes. In liquid PDMS, a laser-induced bubble generated on the target surface interestingly retains its shape more than 10 min after laser ablation [1-2]. YAG:Ce is a yellow-emitting phosphor under blue excitation. We used it as a target and observed photoluminescence from YAG:Ce particles generated in single-shot laser ablation of a sintered YAG:Ce in liquid PDMS under 447nm CW laser excitation. Behavior of laser induced bubble was recorded by a high-speed video camera. Photoluminescence was observed in entire bubble area at 60 fps recording rate and 20μs shutter speed. The bubble expanded to several tens of micrometers over a few minutes after irradiation, then a crack appeared in the light emitting bubble surface, and the gas bubble finally floated through the crack while the shell-like emitting region remained on the target. With comparison to our previous shadowgraph observations, we thought that the laser-induced bubble was covered with a thin film of polymerized PDMS with YAG:Ce nanoparticles attached on it and this polymerized bubble surface layer was the reason why the laser-induced bubble remains on the target surface for more than 10 min [2]. Reflections of excitation light from the bubble surface were also captured in the video. To avoid this reflection and make the observations clearer, a filter which can cut the excitation light at 447 nm was placed in front of the camera. It was found that, without the filter, the camera captured not only the reflections but also the scattered light on the bubble surface. Although photoluminescence brightness became much weaker than that without the filter, the time evolution in the photoluminescence area was the same as that without the filter. From the 1st image at 16 ms observed at 60 fps recording rate, it seemed that particles were already attached on the polymerized film on the bubble surface. Therefore, observations at 54 kfps with shutter speed of 18 μs were carried out to elucidate faster stage of bubble generation. In the image indicated as 0.4 μs in Fig.1, path of particles from 0.4 μs after irradiation to 18 μs were observed as photoluminescence tracks. These tracks were observed only inside the bubble, and photoluminescence regions were observed clearly on the entire bubble after several tens of μs. These observations indicate that particles were dispersed by the ablation and adhered to the polymerized film on the bubble surface.

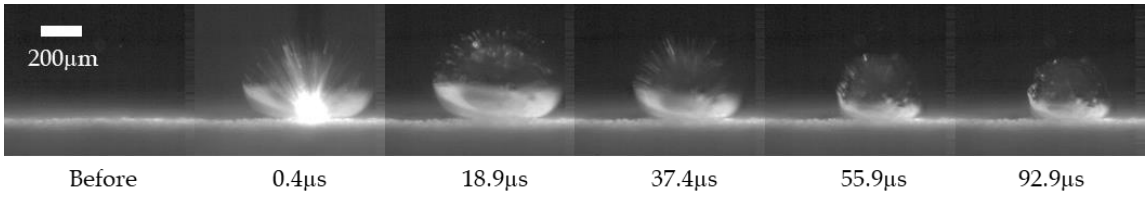

Figure 1. Photoluminescence images from YAG:Ce in laser ablation in liquid PDMS obtained by 54 kfps and shutter speed of 18μs. Brightness and contrast of these images are adjusted. Luminescence from the solid target contributed brighter images in lower part.

[1] T. Naruse and Y. Hanada, Rapid, high-quality microfabrication of thermoset polymer PDMS using laser-induced bubbles, Opt. Express, **27**, 7, pp.9429-9438 (2019)
[2] R. Tanabe-Yamagishi, S. Komatsu, Y. Ito and Y. Hanada, Laser Ablation of Copper and YAG:Ce Targets in Liquid PDMS, Studied by Shadowgraph and Photoluminescence Imaging, J. Laser Micro/Nanoeng., **17**, 2, pp.89-93 (2022)