High-speed imaging of laser ablation in supersaturated solutions towards understanding of laser-induced crystallization mechanism

Hiroshi Y. Yoshikwa[1], Yuka Tsuri[1,2], Hozumi Takahashi[1], Megumi Shiraiwa[3], Yusuke Takaoka[1], Satomi Ebihara[1,3], Katsuo Tsukamoto[1,4], Takashi Onuma[5], Ryutaro Shimada[5], Tomohiko Tateshima[5], Kazufumi Takano[6], Hiroaki Adachi[7], Masashi Yoshimura[8], Yoichiroh Hosokawa[2], Seiichiro Nakabayashi[3], Mihoko Maruyama[1,6], Yusuke Mori[1]*

1-Graduate School of Engineering, Osaka University, Japan, 2-Graduate School of Science and Technology, Nara Institute of Science and Technology, Japan, 3-Graduate School of Science and Engineering, Saitama University, Japan, 4-Graduate School of Science, Tohoku University, Japan, 5-Photonic Lattice Inc., Japan, 6-Graduate School of Life and Environmental Science, Kyoto Prefectural University, Japan., 7-SOSHO Inc., Japan, 8-Institute of Laser Engineering (ILE), Osaka University, Japan.

**hiroshi@ap.eng.osaka-u.ac.jp*

Crystallization (crystal nucleation and growth) is indispensable for various scientific and industrial fields such as X-ray crystallography, optoelectric devices, pharmaceutics. However, obtaining crystals of organic compounds and proteins with desired properties (e.g., quality, structure, size, shapes, etc) is not trivial due to their weak molecular interactions. To overcome this problem, we have been utilizing laser ablation as an external stimulus to nucleation and growth of organic crystals in supersaturated solutions [1, 2]. For instance, laser ablation of liquids by focused irradiation with a femtosecond laser can efficiently induce crystal nucleation at low supersaturation, which leads to the formation of crystals with higher quality and unique structures [1]. In addition, crystal defects and fragments that are generated by laser ablation of crystals can become new growth canters and seeds in supersaturated solutions, which lead to the generation of large, high-quality single crystals[1, 2]. As the next step, we have now also been investigating the underlying mechanism for the further improvement of the laser-induced crystallization techniques. In this presentation, we introduce the result of high-speed imaging of laser ablation of liquids and crystals in supersaturated solutions.

In this abstract, we just show a representative result about high-speed imaging of laser ablation of an opto-electric crystal (DAST crystal) in a supersaturated solution as Figure 1. The focused irradiation with a femtosecond laser pulse (λ = 800 nm, Δt ~250 fs) with the energy of 65 nJ/pulse (5 times larger than ablation threshold) induced the formation of a cavitation bubble at a focal point within a few microseconds. The cavitation bubble expanded and then collapsed together with a flow jet towards the crystal. Afterwards, the ejected fragments as crystal seeds grew independently from the original crystal. This result provides the fundamental insights into how laser ablation of crystals in supersaturated solutions influences the subsequent crystal growth behavior. In the presentation, we also show the result of laser ablation of liquids, which is involved in the laser-induced nucleation mechanism.

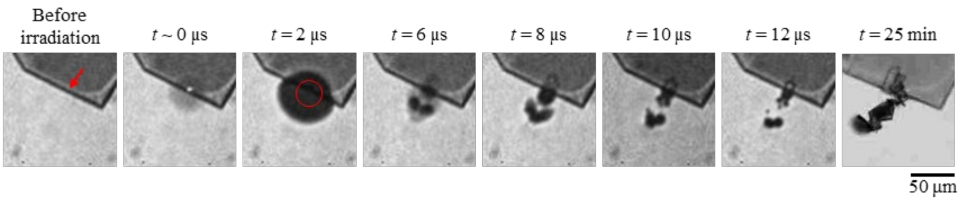

Figure 1 High-speed imaging of laser ablation of a DAST crystal in supersaturated solution

[1] H. Y. Yoshikawa et al., Laser ablation for protein crystal nucleation and seeding, Chem Soc Rev, vol. 43, pp.2147-2158 (2014).

[2] Y. Tominaga, M. Maruyama, H. Y. Yoshikawa et al., Promotion of protein crystal growth by actively switching crystal growth mode via femtosecond laser ablation, Nat Photon, Vol. 10, pp. 723-726 (2016).