Laser-Induced Crystallization Process of an Anthracene Observed by High-Speed Shadowgraphy

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Crystallization is an important process in a wide range of industries. We have applied ultra-short pulsed laser to triggering crystallization of various proteins and organic compounds, and realized the effective crystallization [1,2]. The laser pulse focused into a supersaturated solution induces generations of cavitation bubble, shockwave and stresswave. We previously proposed that these physical phenomena increase the local concentration in the supersaturated solution, leading to the promotion of the crystallization [3]. To confirm the mechanism, the visualization of the concentration distribution is essential. In this study, we challenged to visualize the concentration distribution using an anthracene as a model material, which is easily crystallized by single pulse laser irradiation. The microsecond time scale dynamics was observed by high-speed shadowgraph imaging. The shadowgraph method allows to visualize the refractive index gradients in the solution as a light contrast.

Solution of an anthracene in cyclohexane was prepared at concentration of 30 mM and dispensed into 4 mL cuvettes. After the solutions were cooled to 20°C (solubility of anthracene is 12 mM), a Ti:Sapphire laser pulse (central wavelength: 800 nm, pulse duration: 300 fs, pulse energy: 210 μJ/pulse) was focused into the solution trough an objective lens (10×, NA. 0.25). Observation of the laser focal point was captured by a high-speed camera (CRYSTA PI-1P, Photonic Lattice; flame rate: 525 kfps) combined with the shadowgraph system. As the result, a cavitation bubble expanded into an elliptical shape extending in the laser propagation direction within about 13 μs after laser irradiation, and the high-brightness area was observed with the shrinkage of the cavitation bubble. After the cavitation bubble collapsed, many long-lasting bubbles were formed. The brightness area was diffused with the bubbles' moment for a few hundred microseconds. Such clear high contrast areas were not observed in pure cyclohexane. Thus, we suggest that the clear contrast change in the anthracene solution indicated the visualization of local concentration distribution caused by laser irradiation. As reconstructing the concentration distribution by analysis of the light contrast, we found that the concentration locally fluctuated. This concentration fluctuation should trigger the crystal nucleation of an anthracene.

References

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