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Application News

No.V20

High-Speed Video Camera

High-Speed Imaging of Laser Ablation Process

Introduction

Laser ablation is the process of removing material from a solid (or occasionally liquid) surface by irradiating it with a laser beam. At high irradiation intensities, material on the solid surface is vaporized and converted to plasma. Laser ablation is utilized in a wide range of fields, including product processing, medical, material manufacturing, and more.

Examples of product processing include electronic component processing by Q-switched Nd: YAG laser and microfabrication of plastics and ceramics by excimer laser. An example in the medical field is refractive surgery of the cornea using an ArF laser. In material production, it is notably used in thin film production apparatuses. Although this application of laser ablation is not suitable for mass production of thin films, the ability to easily create a thin film having the same composition ratio as a target (solid surface) and the ease with which the thickness can be changed, have led to its wide use in specialized applications. Observation of the substances discharged (plume) during ablation and elucidation of the behavior of the laser ablation plume make it possible to optimize the film-forming conditions and enhance development of thin films. It is believed that observation of the ablation plume using a high-speed video camera is important. Using the Shimadzu Hyper Vision HPV-X2 high-speed video camera, we were able to observe and document the laser ablation plume generated using AZO (transparent electrode material) as the target.

Experimental Method

The thin film production apparatus consisted of a laser device and a vacuum chamber for ablation. The laser was applied to the target, and film was formed on the substrate above. Fig. 1 shows the state of the experimental apparatus, the vacuum chamber, the Shimadzu HPV-X2, and the target. A target rotation accessory was installed to prevent repeated ablation at the same site on the target. Laser oscillation timing was used as the trigger for recording. Table 1 lists the imaging components.

Measurement Results

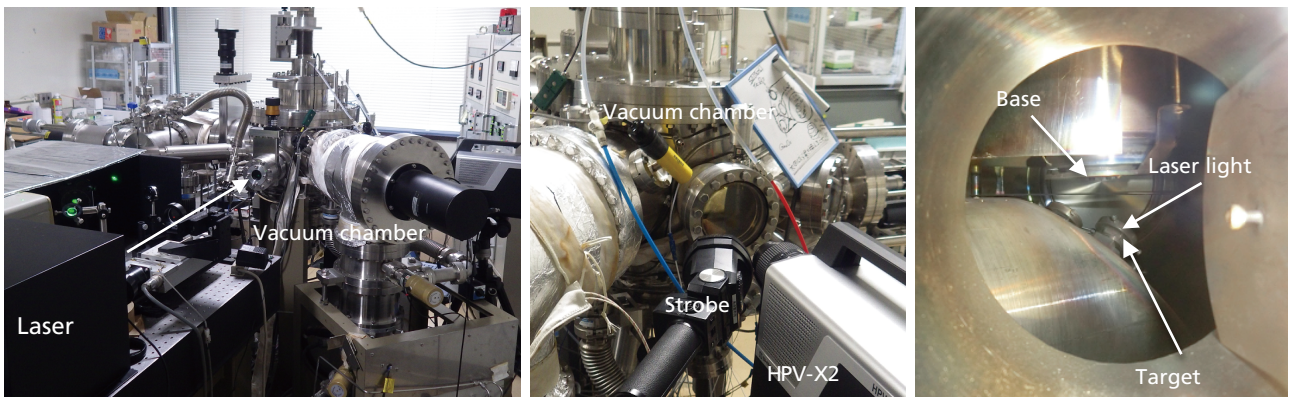
As indicated in Table 2, imaging was conducted at a speed of 10 million frames per second. Frame 2 of Fig. 2 shows that laser irradiation has occurred (indicated by white arrow). Ablation occurs in subsequent frames. The intensity of the ablation plume's emission gradually deteriorates as it spreads in a perpendicular direction to the target.

Table 1 Imaging Equipment

High-Speed Video Camera	: Shimadzu Hyper Vision HPV-X2
Lens	: 105 mm macro lens
Lighting	: Strobe

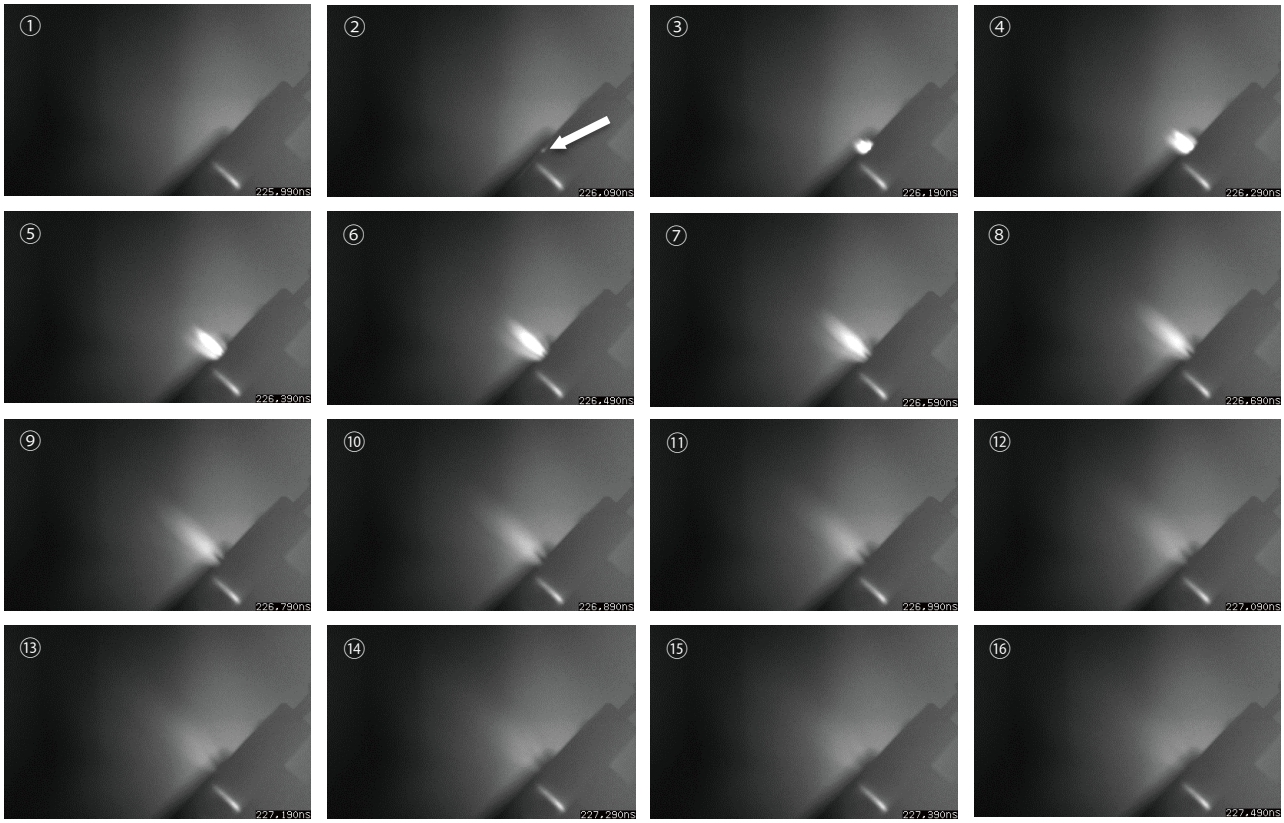
Table 2 Measurement

Recording speed	: 10 million frames per second



View of entire experimental apparatus (left), vacuum chamber, Shimadzu HPV-X2 (center), and target (right).

Fig. 1 Experiment Equipment



Data provided by Kyoto University, Tabe Laboratory

Fig. 2 High-Speed Images (framing interval: 100 nanoseconds)

Fig. 3 shows the relationship between distance from and brightness of the target vertically. Brightness corresponds to the brightness values obtained by subtracting the brightness of frame 1 (before laser irradiation) from each of the brightness values of frames 2 through 16, respectively. The spreading characteristics of the ablation plume can be comprehended from the graph. The speed of the laser ablation plume can be determined based on the 100-nanosecond frame interval.

Note: As the aperture was opened to record the entire ablation, some halation is evident in frames 3 through 7.

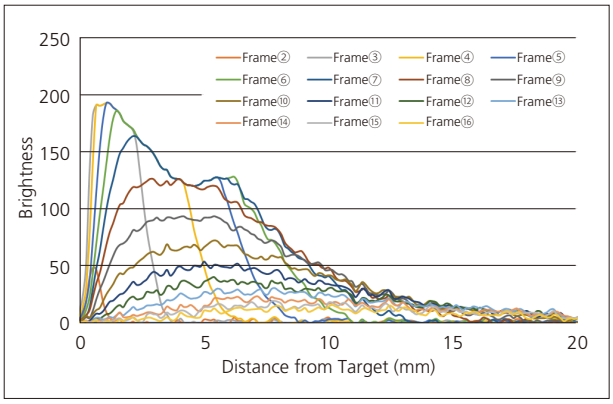


Fig. 3 Brightness of Laser Ablation Plume

Conclusion

Laser ablation is an ultra high-speed phenomenon and can be captured in exquisite detail with the newly developed Shimadzu Hyper Vision HPV-X2 high-speed video camera — featuring recording speeds up to 10 million frames per second and six times higher sensitivity compared to conventional video cameras. Video recording of this type has not been possible using conventional video cameras due to the difficulty of light reaching the target inside the vacuum chamber. The Shimadzu Hyper Vision HPV-X2 high-speed video camera is the best in its class, providing excellent video documentation of the laser ablation process.

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