**Transient-reflection spectroscopy of laser-plasma formation on solid and liquid surfaces**

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**Abstract**

When material is irradiated with an intense ultrashort laser pulse, plasma is formed through highly dense electronic excitation, leading to ablation and particle acceleration. On a surface irradiated with an intense laser pulse, a plasma mirror (PM) is formed. A self-induced PM is indispensable for achieving an extremely high prepulse contrast of a peta-watt laser system. We investigate ultrafast dynamics of laser-plasma formation by measuring transient reflection from a PM formed by an intense laser pulse.

In our experiment, transparent solid plates and a liquid-sheet water jet are adopted as target samples. These target surfaces are excited by an intense near-infrared laser pulse from a Ti:Sapphire laser and probed with a fundamental, second-harmonic, or fifth harmonic pulse. The transient reflection of the probe pulse from the surfaces is monitored.

Transient reflectivity measurement enables us to visualize spatial dynamics of ablating surfaces. The spallation in excited fused silica (FS) and organic polymers is clearly identified from a temporal oscillation lasting for longer than 500 ps with a period of several tens of picoseconds [1, 2]. The surface expansion and densification in the outer region of an ablating hole are also suggested by the spatial dependence of the transient reflectivity measurement [3].

The plasma resonance frequency *w*p is proportional to the square root of carrier density. When the carrier density is in the order of 1022 cm-3 which is as high as the atomic density, the wavelength resonant to *w*p becomes in the ultraviolet (UV) and vacuum ultraviolet (VUV) range. Using UV and VUV pulses, we measure the increase in reflectivity of the excited FS and water liquid sheet surfaces [3, 4]. On the basis of the Drude model, it is suggested that the electron density increases to the level of 1022 cm-3.

The spectrum measurement of the transient reflection provides more exact time-dependent reflectivity including phase. The time-resolved reflection spectra *I*(*w*, *t*) are described as

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where *E*(*t*) and *r*(*t*) are the waveform of a probe pulse and the time-dependent reflection coefficient, respectively. We retrieve *E*(*t*) of the UV and VUV pulses and *r*(*t*) of excited FS and wafer surfaces through the cross-correlation type frequency-resolve optical gating analysis. The phase measurement of *E*(*t*) and *r*(*t*) would be valuable to discussion on ultrafast dynamics.

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