Advanced Research Center for Beam Science
– Laser Matter Interaction Science –

http://laser.kuicr.kyoto-u.ac.jp/e-index.html

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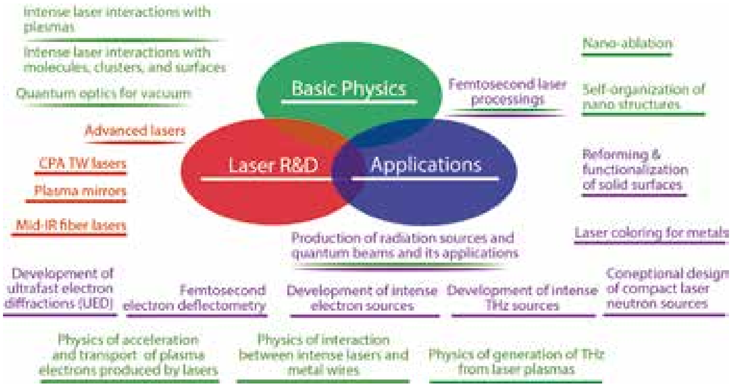
Scope of Research

The interaction of femtosecond laser pulses with matter involves interesting physics not seen with nanosecond laser pulses. Through investigation of the interaction physics, the potential of intense femtosecond lasers for new applications is being developed (e.g., laser-produced radiation and laser processing). Ultra-intense lasers can produce intense radiations (e.g., electrons, ions, and THz), which are promising as next-generation radiation sources. Ultra-short lasers can process any matter without thermal dissociation. Femtosecond laser processing is also the next-generation of laser processing. Our laboratory is equipped with an ultra-intense femtosecond laser named T6, to study the physics of intense laser–matter interactions and its applications.

KEYWORDS

Intense Laser Science
Laser Plasma Radiations (electrons, ions, and THz)
Ultrafast Electron Diffraction (UED)
Laser Nano-ablation Physics
Femtosecond Laser Processing



Selected Publications

Miyasaka, Y.; Hashida, M.; Nishii, T.; Inoue, S.; Sakabe, S., *Appl. Phys. Lett.*, **106,** 013101 (2015).
Inoue, S.; Tokita, S.; Hashida, M.; Sakabe, S., *Phys. Rev. E*, **91,** 043101 (2015).
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Hashida, M.; Miyasaka, Y.; Inoue, S.; Nishii, T.; Shimizu, M.; Inoue, S.; Sakabe, S., *IEEJ Trans. FM*, **135,** 575-580 (2015).
Hasebe, T.; Homma, K.; Nakamiya, Y.; Matsuura, K.; Otani, K.; Hashida, M.; Inoue, S.; Sakabe, S., *Prog. Theor. Exp. Phys.*, **2015,** 073C01 (2015).

Intense Laser Interaction with a Thin Foil and Its Induced Surface Wave along a Neighbor Metal Wire

In recent years, generation of intense terahertz pulses has been achieved by intense femtosecond laser pulses, opening up prospects for studying non-linear optics of material at frequencies in the terahertz range. To generate intense terahertz pulses, an essential subject is to understand the optical damage of the wavelength conversion element that converts femtosecond laser pulses into terahertz pulses, such as nonlinear crystal. Laser plasmas, with no optical damage limitation, are an attractive terahertz radiation source. Recently, we demonstrated the generation of strong sub-terahertz surface waves by irradiating a metal wire directly with intense laser pulses. The amplitude and pulse width of the surface wave were evaluated to be 200 MV/m and 7 ps, respectively. It is considered that the sub-terahertz surface waves are driven by mass movement of laser-accelerated electrons and the waves are transmitted along the laser-irradiated wire. To separate the generation and transmission parts of the sub-terahertz surface waves is significant from an application standpoint, because it would improve the repetition rate and ease-of-use of the transmission part. We provide a new technique to separate the generation and transmission parts of strong terahertz waves. By placing the metal wire (i.e., the transmission part) near the intense laser plasma (i.e., the generation part), we succeeded in measuring the sub-terahertz surface waves propagated along the metal wire.

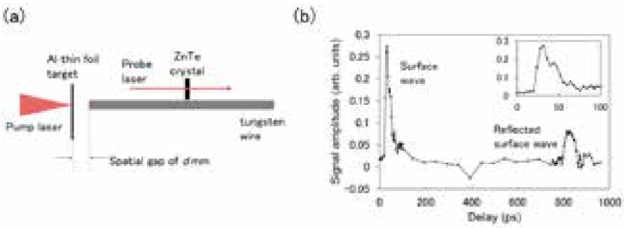

Figure 1. (a) Schematic of the experimental setup; (b) Surface wave measured by electro-optical sampling.

Orientation of Periodic Grating Structures Controlled by Double-pulse Irradiations

The experiment for the formation of laser induced periodic surface structures (LIPSS) has been demonstrated on a titanium surface irradiated by a double-pulse beam cross-polarized in a time delay of $\Delta\tau$ = 0 to 40ps. The first pulse fluence F_1 and the delayed pulse fluence F_2 were always kept below the formation threshold F_{TH} = 65mJ/cm^2 of the periodic grating structure on Ti. We found that the periodic grating structures with a LIPSS orientation of 45° relative to both polarizations were produced with a time delay of 0–120 fs. To control the LIPSS orientation, the experiment of double pulse beam with a time delay of 0 fs has been demonstrated, in which a beam composed of a first pulse with constant fluence of F_1 = 70 mJ/cm^2 and a delayed pulse varying from F_2 = 0 to 70 mJ/cm^2. The LIPSS orientations were in the range of 0–45° and decreasing as the normalized fluence F_2/F_1 decreases. We found that the orientation of LIPSS produced by double pulse irradiations was in relatively good agreement with the direction obtained by the vector sum of laser fields, E_1^4 and E_2^4. The tendency suggests that the orientation of LIPSS might be characterized by multi-photon process at the metal surface.

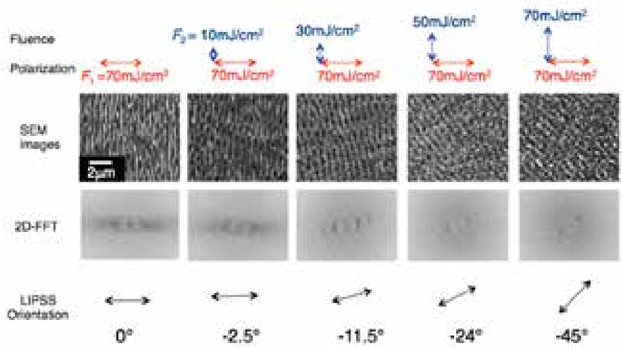

Figure 2. The dependence of periodic structure interspaces on the laser fluence of first pulse F_1 for the delayed pulse fluence of F_2 = 70 mJ/cm^2.

Intense THz Emission from Cluster Plasma Produced by Two-color Laser Pulse

Terahertz (THz) waves are expected to have use in great variety of applications, such as information and communication technology, safety and security, bio-sensing, and medicine. To make these applications practicable, more intense THz pulses are desired. Some concepts and techniques to generate intense THz pulses have been proposed. However, incidental laser energy is limited by the damage threshold of the materials used for the THz source. Laser plasmas have the benefit of being damage-free as a THz-wave source. Therefore, THz radiation from plasmas produced by intense femtosecond laser pulses has been studied to explore the potential of future intense THz sources. We have studied THz radiation from argon cluster plasmas produced by an intense two-color laser pulse. The angular distribution of THz radiation has been measured for laser energy of 10 mJ and laser pulse durations of 200 fs. The THz emission generated from argon cluster plasma is enhanced by irradiation with fundamental and second harmonic pulses.