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

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

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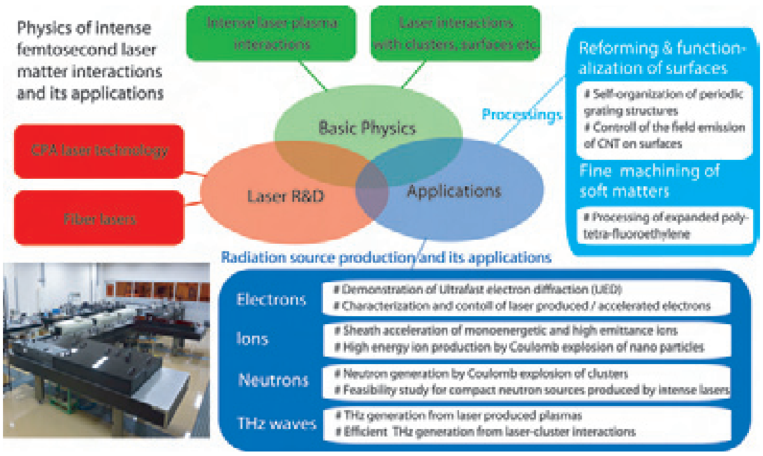
Scope of Research

The interaction of femtosecond laser pulses with matters involves interesting physics, which does not appear in that of nanosecond laser pulses. Investigating the interaction physics, potential of intense femtosecond lasers for new applications is being developed (such as laser produced radiations and laser processing). Ultra-intense lasers can produce intense radiations (electrons, ions, THz, and so on), which can be expected as the next-generation radiation sources. Ultra-short lasers are available to process any matters without thermal dissociation. The femtosecond laser processing is also the next-generation laser processing. In our laboratory ultra intense femtosecond laser named T^6-laser is equipped, and the physics of intense laser matter interactions and its applications are researched.

KEYWORDS

Intense Laser Science
Laser Plasma Radiations
(Electrons, Ions, and THz)
Ultrafast Electron Diffraction (UED)
Laser Nano-ablation Physics
Femtosecond Laser Processing
Mid-infrared Fiber Lasers



Selected Publications

Inoue S, Tokita S, Nishoji T, Masuno S, Otani K, Hashida M, Sakabe S: Single-shot Microscopic Electron Imaging of Intense Femtosecond Laser-produced Plasmas, *Rev. Sci. Instrum.*, **81,** 123302 (2010).

Tokita S, Hirokane M, Murakami M, Shimizu S, Hashida M, Sakabe S: Stable 10 W Er:ZBLAN Fiber Laser Operating at 2.71–2.88 μm, *Opt. Lett.*, **35,** 3943 (2010).

Tokita S, Hashida M, Inoue S, Nishoji T, Otani K, Sakabe S: Single-Shot Femtosecond Electron Diffraction with Laser-Accelerated Electrons: Experimental Demonstration of Electron Pulse Compression, *Phys. Rev. Lett.*, **105,** 215004 (2010).

Okamuro K, Hashida M, Miyasaka Y, Ikuta Y, Tokita S, Sakabe S: Laser Fluence Dependence of Periodic Grating Structures Formed on Metal Surfaces under Femtosecond Laser Pulse Irradiation, *Phys. Rev. B*, **82,** 165417 (2010).

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Periodic Grating Structures Self-formed on Metal Surfaces under Femtosecond Laser Pulse Irradiation

Periodic structures self-formed on the surface of several metals by femtosecond laser pulses are investigated by electron microscopy. For the self-formation of periodic gratings on metal surfaces, the interspaces of the periodic structures depend on laser fluence. This dependence is the same for all metals, although the range of laser fluence in which the structures are formed differs between metals (Figure 1). The laser fluence dependence can be explained by the generation of a plasma wave through the parametric decay of laser light [Phys. Rev. B 79, 033409(2009)]. This indicates that the formation of periodic structures depends not on metal properties, but only on the electron density of plasma produced on a surface by femtosecond laser pulses.

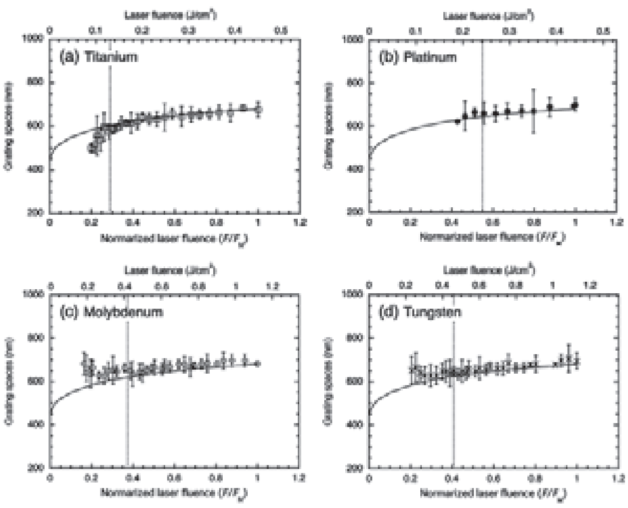

Figure 1. Laser fluence dependence of the periodic structure interspaces produced by femtosecond laser pulses for (a) Ti, (b) Pt, (c) Mo, and (d) W (pulse duration: 160 fs). The interspace of the grating structure was determined by analyzing a set of 10 irradiated spots on the metal surface. Error bars show the standard deviation of the interspaces. Laser fluence is normalized by the upper limit on laser fluence for producing periodic structures, F_M. Solid lines show calculation results according to the parametric decay model proposed by Sakabe *et al.*, and dotted lines show the laser fluence for the ablation rate of 10 nm/pulse.

Femtosecond Pulse Compression of Laser-accelerated Electron Pulses

Time-resolved electron diffraction and microscopy using femtosecond electron pulses is a powerful method for observing atomic-scale ultrafast structural changes. Such an advanced method is crucial for the study of ultrafast phenomena in a broad range of scientific fields, including physics, chemistry, materials science, and biology, because the method enables the direct observation of atomic processes. However, due to the space-charge effect, the brightness of probe electron pulses is low and insufficient in most cases using conventional electron guns.

We have developed a new method for solving the space-charge problem in ultrafast electron diffraction. This unique method involves compression an intense laser-accelerated electron pulse. Figure 2 shows the femtosecond electron-pulse generation system. Accelerated by a femtosecond laser pulse with an intensity of 10^{18} W/cm^2, an electron pulse with an energy of around 350 keV and a relative momentum spread of about 1% was compressed to a 500-fs pulse at a distance of about 50 cm from the electron source by using a magnetic pulse compressor. Furthermore, the electron pulse was used to generate a clear diffraction pattern of a gold crystal in a single shot. This technique has great potential for the generation of extremely high-charge femtosecond pulses in the sub-MeV range, because the space-charge effect does not limit the charge in a pulse. We expect that this development will fundamentally change the observation of ultrafast phenomena by electron pulses in the near future.

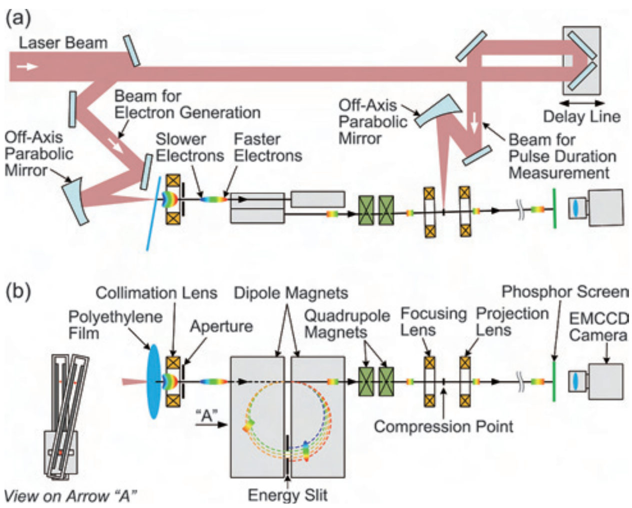

Figure 2. Schematic diagram of the experimental setup of electron pulse compression and pulse duration measurement: (a) top view and (b) side view. Everything except the EMCCD camera is operated in a vacuum at 10^{-2} Pa.