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

Recent remarkable progress of ultra-intense ultra-shot lasers has opened the new field of intense laser science. 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, x-ray, ions, THz, and so on), which have the features of point, pulse, intense, compact, and perfect synchronized sources with different radiations. The radiations 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 of soft matter, molecules, nano-scale matter, and so on 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.

Research Activities (Year 2009)

Publications

Sakabe S, Hashida M, Tokita S, Namba S, Okamuro K: Mechanism for Self-Formation of Periodic Grating Structures on a Metal Surface by a Femtosecond Laser Pulse, *Phys. Rev. B*, **79**, 033409 (2009).

Nagashima T, Hirayama H, Shibuya K, Hangyo M, Hashida M, Tokita S, Sakabe S: Terahertz Pulse Radiation from Argon Clusters Irradiated with Intense Femtosecond Laser Pulses, *Optics Express*, **17**, 8907-8912 (2009).

Hashida M, Mishima H, Tokita S, Sakabe S: Non-Thermal Ablation of Expanded Polytetrafluoroethylene with an Intense Femtosecond-Pulse Laser, *Optics Express*, **17**, 13116-13121 (2009).

Sakabe S, Hashida M, Tokita S, Otani K: Laser Energy Scaling Law for the Yield of Neutrons Generated by Intense Femtosecond Laser-Cluster Interactions, *Plasma and Fusion Research*, **4**, 041 (2009).

Tokita S, Inoue S, Masuno S, Hashida M, Sakabe S: Single-Shot Ultrafast Electron Diffraction with a Laser-Accelerated Sub-MeV Electron Pulse, *Applied Physics Letters*, **95**, 111911 (2009).

Tokita S, Murakami M, Shimizu S, Hashida M, Sakabe S: Liquid-Cooled 24 W Mid-Infrared Er:ZBLAN Fiber Laser, *Optics Letters*, **34**, 3062-3064 (2009).

Presentations

Mechanism for Self-Organization of Periodic Structures on a Metal Surface by Femtosecond Laser Pulses, Sakabe S, Hashida M, Tokita S, Namba S, Okamuro K, The European Conference on Laser and Electro-Optics 2009, Munich, Germany, 18 June 2009 (invited).

Long-Term Stabilization of Pulse-to-Pulse Energy of a High-Energy Multipass Ti:Sapphire CPA System, Tokita S, Hashida M, Masuno S, Namba S, Sakabe S, The European Conference on Laser and Electro-Optics 2009, Munich, Germany, 17 June 2009.

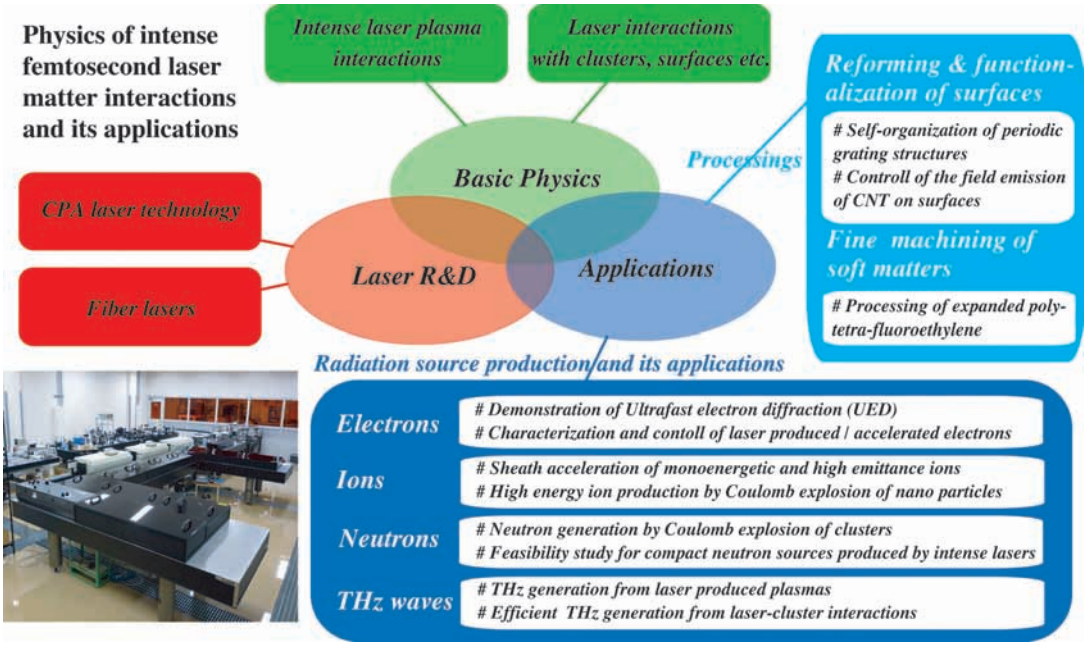
High Energy Ion Emission from a Copper Surface Irradiated by a Femtosecond Laser Pulse with the Laser Fluence of Ablation Threshold, Hashida M, Namba S, Okamuro K, Tokita S, Sakabe S, The 8th Pacific Rim Conference on

Ion Emission from Metal Surface Irradiated by Femtosecond Laser Pulses

Femtosecond laser ablation of Cu by short-pulse laser irradiation (800 nm, 130 fs) was studied in the laser energy fluence range of 0.028–14.4 J/cm^2. In order to elucidate the dynamics of the ejected particles, the energy distribution of ions emitted from the metal with femtosecond laser ablation was measured by time-of-flight mass spectrometry. Three thresholds for ion emission were identified. The lowest laser fluence at which ions are emitted, $F_{th,L}$ is 0.028 J/cm^2, and two higher emission thresholds were identified at fluences of $F_{th,M}$ = 0.195 J/cm^2 and $F_{th,H}$ = 0.470 J/cm^2. The number of emitted ions per laser pulse N_i was dependent on laser fluence and was in good agreement with $N_i \propto F^4$ for laser fluence of $F_{th,L} - F_{th,M}$, $N_i \propto F^3$ for laser fluence of $F_{th,M} - F_{th,H}$, and $N_i \propto F^2$ for $\geq F_{th,H}$. The process of ion production is well explained by multi-photon absorption and optical field effects. High-energy Cu ions of 30 eV were produced at a low laser fluence of 0.136 J/cm^2. The most probable energy of Cu ions increased as the laser energy fluence increased. The experimental results were analyzed within the framework of the Coulomb explosion of ions that were localized to the metal surface, which could satisfactorily and qualitatively explain the obtained results.

Ultrafast Electron Diffraction with a Laser-Accelerated Electron Pulse

Ultrafast electron diffraction (UED) is a very sensitive and useful method for investigating the transient structures and dynamics of atomic and molecular systems on femtosecond to picosecond time scales. We have demonstrated single-shot measurement of electron diffraction patterns for a single-crystal gold foil using 340-keV electron pulses accelerated by intense femtosecond laser pulses with an intensity of 2 × 10^{18} W/cm^2. The measured electron beam profile is faithfully reproduced by the numerical simulation of the electron trajectory, providing evidence that the electron pulse spontaneously expands in time owing to the velocity spread produced in the acceleration process, but is not distorted in an irreversible nonlinear manner. This study shows that the laser acceleration is promising for the development of pulse compression methods for single-shot femtosecond electron diffraction.



Lasers and Electro-Optics, Shanghai, China, 31 August 2009.

Grants

Sakabe S, et al., Time Resolved Electron Microscope with Intense Femtosecond Laser Produced Electrons, Grant-in-Aid for Scientific Research (A), 1 April 2006–31 March 2010.

Tokita S, Development of Mid-Infrared High-Power Ultrashort-Pulse Fiber Laser, Grant-in-Aid for Young Scientists (B), 1 April 2008–31 March 2010.

Tokita S, Development of Mid-Infrared Femtosecond Fiber Laser Using Fluoride Grass Fibers, Amada Foundation for Metal Work Technology, 15 December 2008–31 March 2011.