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

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Scope of Research

By making the physics of interaction between femto-second laser and matters clear, possibility for new applications is being developed in such as laser processing and laser nuclear science. The interaction of femto-second laser and matter differs from that of nanosecond laser in physics such as ionization and ablation process. Soft-ionization and ablation by the femto-second laser (we named it nano-ablation) can be applied to mass spectrometry and nano-scale structural formation and matter reforming, respectively. In addition, with the progress of short pulse lasers, even a small-sized equipment can create ultra-high optical field. In this strong electromagnetic field the motion of an electron becomes relativistic, and the electron is accelerated easily above MeV, emitting high energy pulse x-rays and ions. Laser produced radiation has the feature such as impulse, a point source and high intensity, and its potential to the new radiation source is expected. In our laboratory physics of intense laser matter interactions and its application are researched.

Research Activities (Year 2005)

Presentations

Energetic Ion Generation by Coulomb-explosion in Cluster Gas and a Low-density Plastic Foam with an Intense Femtosecond Laser, Sakabe S, International Symposium on Atoms, Molecules, and Clusters in Intense Laser Fields 2, 24 - 25 January 2005.

Desorption/ionization of Coronene and C_{60} Molecules Irradiated by an Intense Short-pulse Laser, Shimizu S, Hashida M, Sakabe S, International Symposium on Atoms, Molecules, and Clusters in Intense Laser Fields 2, 23 - 24 January 2005.

Intense Short-pulse Laser Application Research at Institute for Chemical Research, Kyoto University, Sakabe S, Korea-China-Japan Workshop on Ultrashort High-Intensity Laser Development and Their Applications, 21 - 22 March 2005.

Energetic Ion Generation by Coulomb-explosion in Cluster Gas and a Low-density Plastic Foam with an Intense Femtosecond Laser, Sakabe S, Hashida M, and Shimizu S, Advanced Lasers and their Applications, 12 - 14 May 2005.

Study of Fast Electron Transport in Hot Dense Matter Using X-ray Spectroscopy, Nishimura H, Inubushi Y, Ochiai M, Fujioka S, Kawamura T, Hashida M, Simizu S, Sakabe S, et. al., 32nd EPS Plasma Physics Conference and 8th International Workshop on Fast Ignition of Fusion Targets, 27 June - 1 July, 2005.

Nanostructure Formation on Metals by Femtosecond Laser Pulses, Hashida M, Shimizu S, and Sakabe S, 14th International Laser Physics Workshop, 4 - 8 July 2005 (Invited).

Energetic Ion Generation by Coulomb-explosion in Cluster Gas and a Low-density Plastic Foam with an Intense Femtosecond Laser, Sakabe S, Hashida M, and Shimizu S, 14th International Laser Physics Workshop, 4 - 8 July 2005 (Invited).

Periodic Nano Structure Formation on Metals by Femtosecond Laser Pulses, Hashida M, Shimizu S, and Sakabe S, International Workshop on Intense Laser-Matter Interaction and Pulse Propagation, 15 - 19 August 2005.

Desorption/ionization of Organic Molecules Irradiated by an Intense Laser, Shimizu S, International Workshop on Intense Laser-Matter Interaction and Pulse Propagation, 15 - 19 August 2005.

Carbon Nanotubes Cathode Modified by Femtosecond Laser Ablation, Hashida M, Shimizu S, and Sakabe S, 8th Conference on Laser Ablation, 11-16 September 2005.

Grants

Sakabe S, Research on Coulomb Explosion Dynamics of Cluster Molecules with Intense Lasers, Grant-in-Aid for Scientific Research (B)(2), 1 April 2003 - 31 March 2006.

Hashida M, Advanced Material Processing with Femtosecond Lasers, Grant-in-Aid for Young Scientists (B), 1 April 2005 - 31 March 2007.

Completion of Intense Femto-second Laser System T⁶-laser for the Research of Laser-matter Interaction and Its Applications

Ultra intense femtosecond laser system T⁶ (the acronym of Table-top Ten TW Ten Hz Tunable Ti:sapphire) laser has been installed in the new laser building, which was completed in 2004, adjacent to the building of accelerator facility. The system is a Ti:sapphire chirped-pulse amplifier laser, delivering 1J (at maximum), 100fs pulses at a center wavelength of 800nm and repetition rate variable from single shot to 10Hz at maximum. The laser has been successfully operated in the laser building constructed for less mechanical vibration on the floor against earthquake and high stability of temperature and humidity controls. Since the first experiment for laser nano-ablation, we have been doing the experiments of laser processing, soft ionization, laser produced radiations, and collaboration research with ICR, another university. The laser and irradiation systems are continuously improved for more efficient collaboration research, and will be opened for the researcher with our common interests.

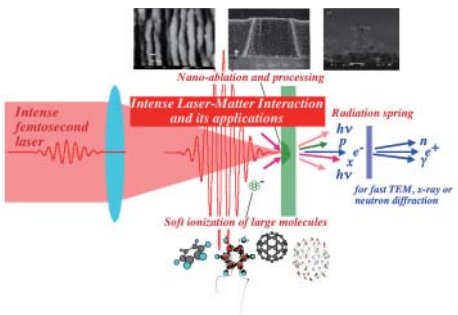

Figure 1. Intense femtosecond laser-matter interaction physics and its applications.

Ultrashort-Pulse Laser Ablation of Fluoropolymer

Laser -ablation experiments were performed on polytetrafluoroethyhlene (PTFE) with femtosecond Ti:sapphire pulse laser. The released ions upon ablation were detected by time of flight mass spectrometer (TOF-MS) with 130fs and 400ps pulse laser. The difference was shown in detected ions and laser fluence dependence of them between two pulses. The ablation threshold of PTFE was also investigated from the crater surface diameter dependence on the laser fluence. It was found that the ablation threshold was approximately proportional to pulse duration to the power 0.39 in the range of 130fs-400ps. It was suggested that the ablation of organic polymer material such as PTFE might be controlled by the mechanism different from multiphoton absorption.

Carbon-nanotubes Cathode Modified by Femtsecond Laser Ablation

Femtosecond laser ablation of the carbon nanotubes (CNTs) cathode was demonstrated in the laser fluence range of 0.05-2J/cm^2. It was shown that the CNTs were aligned perpendicular to the cathode surface by the laser ablation. The emission characteristics of the CNTs cathode were measured by a diode system. The modified CNTs cathode turned on electron emission at the electric field of 1.8V/μm, which was approximately half of original CNTs cathode and the 10% lower than that of nanosecond laser ablation. As the laser fluence decreased, the electric field of turn-on had the tendency to be lower.

Elements and Their Transitions Feasible for NEET

Electron and nuclear transitions in the nuclear excitation by electron transition (NEET) process have been investigated. The NEET transitions for nuclei are presented in a table in which the electron and nuclear transitions, their transition energies, transition multipoles, and nuclear spin angular momentum are given. The elements are listed for which the difference between the electron and nuclear transition energy is <5 keV, because the NEET probability will be appreciable if the electron transition energy is close to the nuclear transition one. As both the experimental and theoretical studies for NEET are at an early stage, only the elements and their parameters related to NEET are listed here. The present compilation, however, provides a useful direction for future studies of NEET and its applications to nuclear science.

Desorption/ionization of Bio-molecules with Intense Femtosecond Laser

Desorption/ionization of bio-molecules with intense femtosecond laser (800nm wavelength, 130 fs pulse duration) was studied by-means-of time-of-flight mass spectrometry. The molecular ions of some lipid molecules were observed at the laser intensity around the ionization thresholds. The signal intensity of the molecular ion and fragment ions increase with increasing the laser intensity. The laser intensity dependence of the signal intensity for the observed ions suggested that ionization mechanism might be non-resonant multiphoton ionization. The desorption/ionization by non-resonant multiphoton ionization will have a great possibility as a new soft-ionization method.