Department of Electrical, Electronic and Computer Engineering | **Key words** | Power laser application, laser-produced plasma, laser ablation, laser fusion diagnostics

Doctor of Engineering/Professor

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Education

Osaka University, Faculty of Engineering, Department of Electrical Engineering
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Professional Background

Researcher, Institute for Laser Technology
Professor, Institute of Laser Engineering (ILE), Osaka University

Consultations, Lectures, and Collaborative Research Themes

Commentary and technical consultation on basic technology and applications of high-power lasers, consultation on applications of laser-generated plasmas (inertial confinement fusion, laser-driven quantum sources, laser ablation

Main research themes and their characteristics

「Development of laser-driven quantum beam sources」

The 21st century is called as “the age of light”, and there have been remarkable developments in laser application technology, in vast range of output energy. By focusing a high-power laser, it is possible to achieve a high-density energy state that has not been possible until now. A new academic realm called "high energy density science" is established. One direct application of “high-density energy states'' using high-power lasers is “laser-driven quantum (beam) sources''. The “plasma'' produced by irradiating matter with a high-power laser becomes an extremely bright source of radiation of high-energy electromagnetic waves and charged particles, which itself and/or whose secondary radiation can be used for various applications.

In the Leading Project of the Ministry of Education, Culture, Sports, Science and Technology (2003-2007), by optimizing irradiation laser conditions and irradiation materials, we succeeded in efficiently generating extreme ultraviolet light of 13.5 nm, which is necessary for semiconductor processes and is giving prospects for industrialization of a laser-driven EUV light source.

In recent years, it has become possible to achieve extremely high-intensity laser irradiation by means of the chirped pulse amplification method, which was awarded the Nobel Prize. As a result, it has become possible to easily generate a bright relativistic electron beam. By utilizing this high-energy electron beam, high-energy charged particle (proton or deuteron) beams and high-energy x-rays in the γ-ray energy region can be generated. In the Research Optimal Deployment Support Program (JST/A-STEP 2016-2019) "Compact neutron source and construction of basic technology for its industrial application", the possibility of laser-driven neutron source and its industrial application was clearly shown. Currently, improvement of the efficiency of the system is under investigation.

In joint research with the Lawrence Livermore National Laboratory in the United States, scaling law of electron-positron generation by high-energy X-rays was experimentally obtained. This result will serve as a basis for astrophysical experiments on electron-positron plasmas in future experiments using large-scale lasers and will provide a new bright radiation source for the study of condensed matter properties using positrons. Currently, a capture and storage system for the generated positrons is under development.

Fig.1 Various quantum beam generation by a ultra-high intensity laser beam.

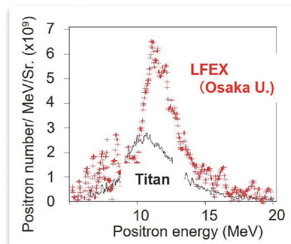

Fig.2 Spectra of a positron beam generated by an ultra-high intensity laser (LFEX: Osaka University, Titan: LLNL, USA)

Fig.3 Photonuclear reaction X-ray spectrometer The amount of photonuclear reaction neutrons in each spectral bin is measured with a bubble neutron detector.

「Engineering research for laser fusion」

In the inertial confinement fusion research using high-power lasers, it is important to measure the energy and spatial distribution of fusion neutrons generated in verification experiments. For this purpose, we were developing various detection systems, and are currently working on the development of an image detector with low sensitivity to background gamma rays. Also, in nuclear fusion, the nuclear polarized fuel (whose nuclear spins are aligned) improves the efficiency and decreases the difficulty of realization. With the aid of the Grant-in-Aid for Scientific Research, a new method for maintaining polarization and a new polarized fuel system using a high-power laser could be proposed. Designing the desired laser system is under development.

Major academic publications

M. Nakai, Y. Arikawa, M. Utsugi, H. Nishimura, N. Miyanaga, H. Azechi and H. Chen,
“Neutron Generation by Laser-Driven Photonuclear Reaction”, Rev. Laser Rng. 44, pp.595-601(2016).

M. Nakai, Y. Arikawa, H. Nishimura and H. Chen,
“Present Status of Creating Relativistic Electron-Positron Plasmas”, Rev. Laser Rng. 44, pp.595-601(2016).

M. Utsuro, M. Nakai, H. Kohri, T. Ohta, T. Kondo, A. Igarashira, M. Fujiwara,
"NMR Spectroscopy for Proof-of-Concept Experimentation on a Polarized Laser Fusion Process"
Fusion Science and Technology 78, 513(2022).