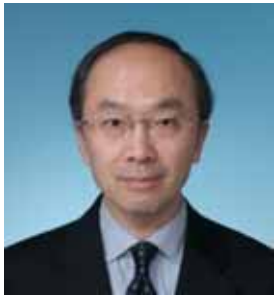
Ubiquitous Power Laser for Achieving a Safe, Secure and Longevity Society

Yuji Sano – Program Manager (PM)



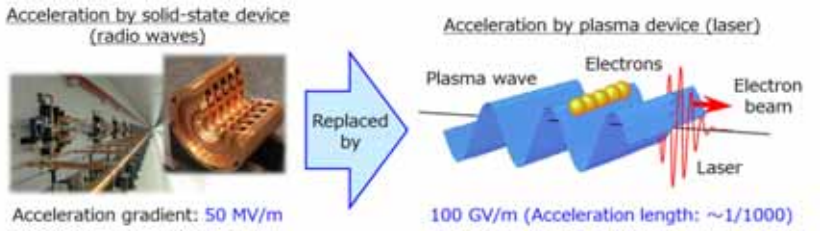
1977 Received Master's degree from the Graduate School of Science and Engineering, Tokyo Tech (majoring in nuclear engineering)
1977 Joined Toshiba Corporation
2006 Senior Fellow, Power and Industrial Systems R&D Center
2014 – present ImPACT Program Manager

Profile
For 20 years, supervised technical development relating to laser applications, and promoted development and commercial application of laser peening technology. From 2008 to 2014, served concurrently as Program Officer for the "Photon Frontier Network" of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Received the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology (FY 2008) and many other awards. Ph.D in engineering.

Disruptive Innovation

✓ Keys to Breakthrough

・Using plasma waves with a precipitous electrical field created by laser to accelerate electrons will reduce the acceleration length to 1/1000. The functions of an XFEL can be achieved at the tabletop level.



・Laser ultra-miniaturization will be made possible through the use of unique Japanese microchip laser and ceramic laser media technologies. The gymnasium size can be reduced to a desktop size, and the desktop size can be reduced to one fitting in the palm of the hand. Applications in industry and medical settings will be pursued.

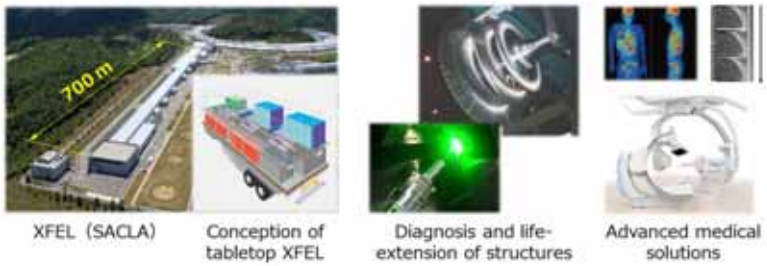
The Challenges for the PM and the Impact of Success

✓ Overview and Background

・Laser, plasma and accelerator technologies will be integrated to achieve a compact, high-output, ubiquitous quantum beam technologies and units. The units will have applications in equipment diagnosis, security, advanced medicine and other fields, and will help to achieve a safe, secure and longevity society.

✓ Impact on Industry and Society in the Event of Achievement

・Will bring the use of an XFEL* (a National Critical Technology) close at hand. Atomic level analysis will revolutionize industry and will find applications in ubiquitous equipment diagnosis and repair, biological imaging, and quantum beam radiotherapy, anytime, anywhere.



* XFEL: X-ray Free Electron Laser, a marvelous laser enabling atomic level analysis. Currently requires a kilometer-order accelerator facility.

Scenario for Success and Achievement Targets

✓ Methods of Resolution Leading to Achievement (approach)

・A platform with electron accelerator using laser plasma (a field in which Japan is a leader) at its core, which will combine laser, plasma and accelerator technologies, will be built.
・With this platform, a co-creation organization where specialists from various technical fields including industry can conduct complementary research and development will be established to accelerate the development.
・The study of user needs and evaluation of development systems will be contracted to a third party to shape potential market needs and development specifications will be formulated with the participation of end users.

✓ Achievement Targets

・Development of an ultra-compact electron accelerator using lasers (> 1 GeV, < 10 m)
・Generation of X-ray beam from accelerated electrons with a microundulator (1 keV)
・Development of a compact, lightweight, high-output microchip laser (> 20 mJ, < 1 kg)

✓ Risks

・Europe and the U. S. are pursuing research and development with abundant funding. The ImPACT Program is working to integrate fields of laser, plasma and accelerator, and specialized for stable low-energy electron acceleration to generate X-ray beam, and to develop industrial applications.

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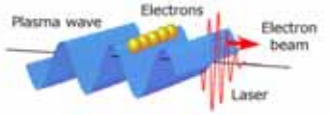
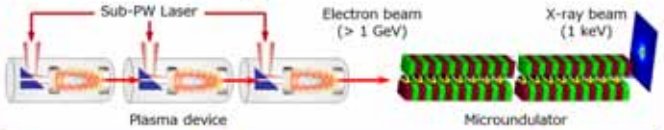
Overall R&D Program Structure Created by the PM

Project 1
Laser acceleration & XFEL demonstration

Laser acceleration elemental technologies
Issue: Electron acceleration exceeding 1 GeV and modularize it as a plasma device



Integrated platform for laser acceleration
Issue: Multi-stage acceleration and generation of 1 keV X-ray beam by a microundulator with a length of 10 m or less



Plasma device power source
Issue: Power source with large current (kA), 10 ns rise time and jitter of 100 ps or less

Beam measurement and control
Issue: Control of laser and electrons, and injection of electrons to undulator

Microundulator
Issue: Ultra-compact undulator generating 1 keV X-ray beam

Project 3
Study of user needs and systemization assessment

Study of user needs and systemization assessment
Issue: Trend studies on "X-ray beam by laser-accelerated electrons" and "ultra-compact power lasers"

Project 2
Ultra-compact power laser

Microchip laser
Issue: Pulse energy exceeding 20 mJ with a weight of 1 kg

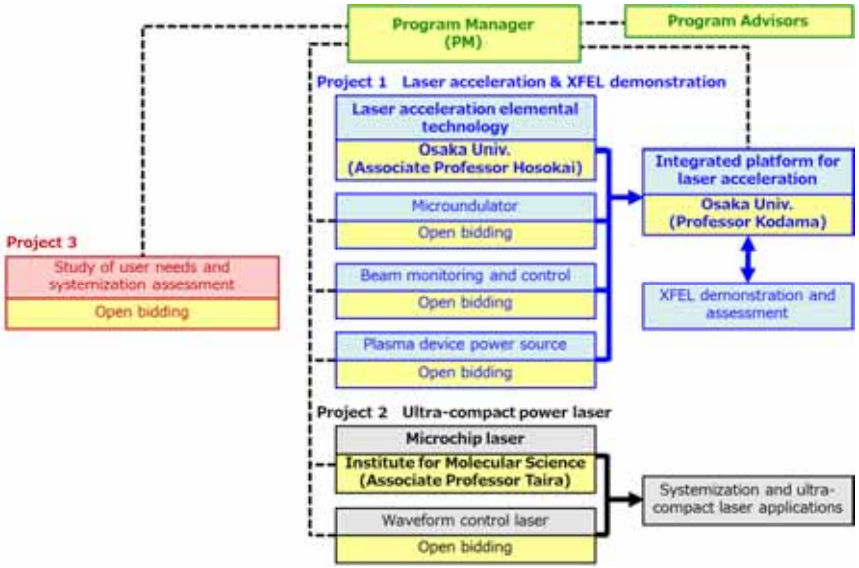
Waveform control laser
Issue: Pulse energy of 600 J by a tabletop-sized unit

Expansion to industrial applications (peening, forming, flaw detection etc.) and basic science applications (material behavior under extreme environments, etc.)

Total R&D Program Cost
JPY3.0 billion

* May increase/decrease depending on development progress
* Expenses required for PM activities and support will be provided as a separate allowance.

Implementation Structure as Assembled by the PM



✓ Key Points for Implementing Organization

・Advisors from industry, academia and government will be invited. An outside study will be commissioned to quickly respond to potential market needs.

・In the latter half of the project period, the achievements of each institution will be assembled into the platform.

✓ Approach to Institution Selection

・Global top-level institutions will be selected. If implementation by other institutions is difficult, the institution should be designated. For other technologies, a wide variety of ideas can be attracted through an open bidding process.

Project 1 Laser acceleration elemental technology: Osaka Univ.

Project 1 Integrated platform for laser acceleration: Osaka Univ.

・Osaka Univ. has achieved the world's most stable laser electron acceleration in "Development of ultrafast atomic-scale imaging device using laser-plasma-driven single electron bunch" project conducted as a CREST team type research. It has the achievements and equipment needed for research and development in this field, and to establish an integrated platform for laser acceleration of electrons.

Project 2 Microchip laser: Institute for Molecular Science

・The Institute for Molecular Science was the first institution in the world to successfully achieve megawatt laser pulses using a microchip structure, and it is a world leader in this field.