【Flagship Project】 “ Next generation laser ”

Project Name **Advanced Laser Innovation Center (ALICe)**

Project Leader **The Univ. of Tokyo Teruo Fujii, Executive Director / Vice President;**
(acting) The Univ. of Tokyo Professor Kenichi Ishikawa

(Joint research institute) ① "Science and theory enabling intelligent laser manufacturing (STELLA)"
Keio Univ., RIKEN, Univ. of Electro-Communications,
National Institutes for Quantum and Radiological Science and Technology(QST), Osaka Univ.
② "Attosecond lasers for next frontiers in science and technology (ATTO)"
RIKEN, QST, National Institute for Materials, Science, KEK, Institute for Molecular Science,
SIGMA KOKI Co., Ltd, Tokai Optical Co., Ltd, Toyama Co., Ltd etc.

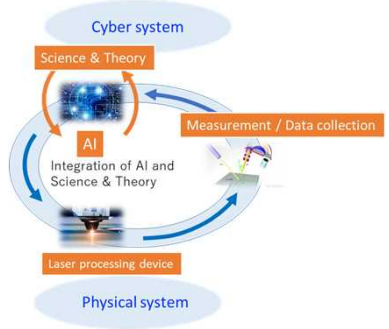
Overview **Integrated** development of both **CPS laser manufacturing (simulator)** capable of proposing the optimal processing parameters based only on simulation in cyberspace and **attosecond (10^{-18}) pulse lasers** needed for clarification of ultrafast responses of electrons in materials and laser-based **advanced measurement systems**.

Goals of R&D

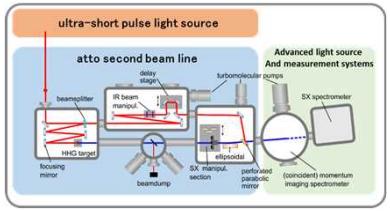
① "Science and theory enabling intelligent laser manufacturing (STELLA)"
Development of CPS laser manufacturing (simulator) capable of proposing the optimal processing parameters based only on simulation in cyberspace.
② "Attosecond lasers for next frontiers in science and technology (ATTO)"
Development of high-repetition and high-intensity attosecond-pulse lasers and laser-based advanced measurement systems.

Milestones

① "Science and theory enabling intelligent laser manufacturing (STELLA)"
5th Year: Develop AI-CPS laser manufacturing (simulator) that predicts processing parameters using AI
10th Year: Development of science-and-theory CPS laser processing (simulator) that predicts processing parameters using simulations based on the science and theory of laser processing
② "Attosecond lasers for next frontiers in science and technology (ATTO)"
5th Year: Development of high-repetition (10kHz) & high-intensity (1GW) isolated attosecond-pulse lasers
10th Year: Development of prototypes of advanced measurement systems etc. for fundamental and applied researches



Concept of CPS laser manufacturing (simulator) development (image)



Prototypes of an advanced light source and a measurement system

Future strategy

- **Promotion of a sustainable industry-academic collaboration ecosystem** in cooperation with other related projects, consortiums etc.
- **Timely implementation of R&D achievements** for the benefit of society.

Strengthening of the research infrastructure & development of human resources of the next generation

- **Construction of** an all-Japan **collaborative network system, creation of new science & Technology originating from Japan and strengthening of basic & fundamental researches** based on the established Advanced Photon Science Alliance (APSA) etc.
- Creation of new research areas representing the strength of Japan’s research activities and **fostering outstanding young researchers becoming leaders of the next generation** in the course of the 10-year research project.
- **Establishment of a new scheme for supporting financially** top-level PhD students **as professional researchers**.
- Implementation of a new scheme for **hiring graduate students etc. involved in research cooperation with industries as researchers**.

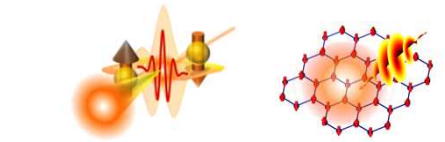
【Basic Foundation Research】 “ Next generation laser ” ①

Project Name **Development of attosecond light functions in strongly correlated quantum materials**

Project Leader **Prof. Shinichiro Iwai, Graduate School of Science, Tohoku University**

Overview **Elucidate** the non-linear **attosecond (10^{-18} s) dynamics** in strongly correlated quantum materials (organic superconductors, high-temperature superconducting cuprates, Kitaev quantum spin liquids etc.) and develop their petahertz (10^{15}) light functions.

Complementary & synergistic effects with the flagship project:
Propose strategies for making use of the potential of strongly correlated quantum materials as attosecond functional materials.



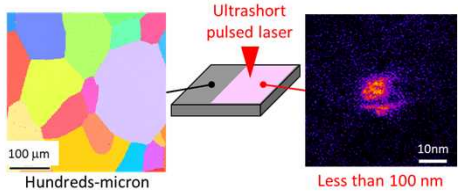
Schematic image of attosecond electron dynamics in strongly correlated quantum materials

Project Name **Developing guidelines on materials strengthening and toughening based on mechanism of atomic scale damaging under ultrashort pulsed laser processing**

Project Leader **Associate Prof. Tomokazu Sano, Graduate School of Engineering, Osaka University**

Overview By clarifying mechanism of atomic scale damaging during ultrashort pulsed laser processing of materials, develop guidelines on materials strengthening and toughening that treat atomic scale damaging as a more advanced materials processing rather than as a inducing defects.

Complementary & synergistic effects with the flagship project:
Development of CPS-based laser processing (simulator) for deriving laser processing parameters to obtain desired material & mechanical properties.



Grain ultra-refinement using ultrashort pulsed laser-shock wave

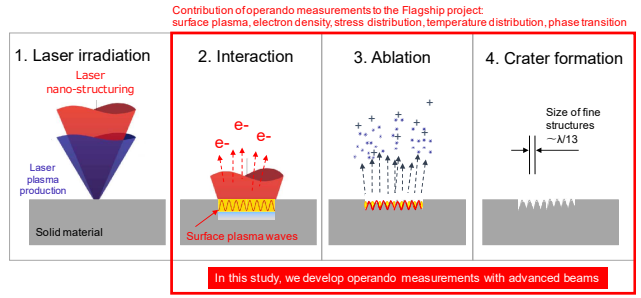
【Basic Foundation Research】 “ Next generation laser ” ②

Project Name **Operando measurements using advanced beams to study the mechanism of fine structure formation**

Project Leader **Associate Prof. Masaki Hashida, Kyoto University Institute for Chemical Research**

Overview **Operando measurements** using advanced beams are demonstrated for studying the physical mechanism of laser–matter interactions that determine the size and density of fine structures formed on substrates and for constructing a laser processing platform to create new surface functionality.

Complementary & synergistic effects with the flagship project:
Knowledge of the fundamental physics of laser material processing to create new surface functionality enables advances in CPS (cyber-physical systems)-based laser processing (simulators).



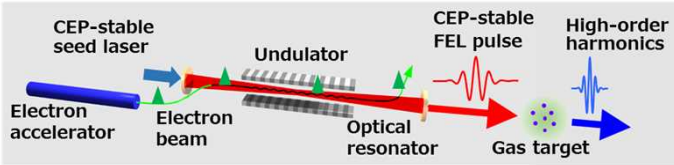
Scope of advanced beam operando measurements

Project Name **Research on basic technologies for a high-repetition attosecond pulse source driven by a free electron laser**

Project Leader **Senior Principal Researcher Ryoichi Hajima, National Institutes for Quantum and Radiological Science and Technology- Quantum Beam Science Research Division**

Overview Generate pulse in the mid-infrared wavelength region using a free electron laser and use this for **generating** a high-repetition (more than 10 MHz) **attosecond X-ray** that exceeds high-order harmonic sources by solid-state lasers.

Complementary & synergistic effects with the flagship project:
A technology approach different from the flagship project & realizing operations at 10 MHz or more.



Scheme of attosecond X-ray generation