Research area in Strategic Objective "*Opening up technological frontiers by synergy between photonics and informatics, materials science, etc., to support a sustainable society*"

Frontier exploration via the synergy of photonics/optics with information, communication, sensing, and material technologies

Research supervisor: Yoshiaki Nakano (Professor, Graduate School of Engineering, The University of Tokyo)

Overview

Optics and photonics have greatly contributed to information and communication technologies so far, supporting today's society. Meanwhile, as DX and AI progress, there is an emerging need for significantly lower power consumption in information systems and advanced interfaces that connect the real world with the cyber world. In this research area, we aim to create the foundational technologies necessary for the realization of green information systems that are integrated with the real world and support a sustainable society. Focusing on the fundamental differences in nature between light/photons and electrons, we aim to develop innovative information processing, communication, and sensing systems that make the most of the advantages of photons over electrons. We will also work on developing new materials and process technologies necessary for this purpose. To achieve our goals, we must break away from conventional wisdom, and in doing so we anticipate synergy from the fusion of fields such as information systems, devices, and material researchers.

Specifically, we will cover research and development in fields including the following: (1) creating principles and fundamental technologies that demonstrate the true value of light, (2) developing hybrid technologies of optics/photonics with other fields, and (3) pioneering innovative utilization technologies of optics/photonics for a sustainable information society.

Research Supervisor's Policy on Call for Application, Selection, and Management of the Research Area

1. Background

In line with the strategic objectives for the fiscal year 2024, "Opening up technological frontiers by synergy between photonics and informatics, materials science, etc., to support a sustainable society," this CREST area will create the foundational technologies necessary for the realization of green information systems that are integrated with the real world to support a sustainable society. By merging our country's strengths in optics/photonics with information and material sciences, we aim to break through the conventional limits and pioneer a new frontier of science and technology. In this process, we will develop technologies related to devices and systems based on cross-disciplinary ideas, and explore uncharted phenomena, properties, materials, and theories, organically combining both to create a foundational system of knowledge and technology.

2. Principle of invitation project and selection

In this research area, we are primarily seeking research proposals that aim to realize information systems capable of information processing, communication, and sensing using light waves/photons, through the synergy across fields such as photonics/electronics, optical science, information science, and material science. In addition to proposals based on groundbreaking ideas by interdisciplinary synergy that lead to innovations in information systems, we also expect research proposals that target the collaboration between layers from basic research to the development of applied technologies. We desire original proposals that leverage the unique strengths of the proposers, not just trendy keywords or their combinations. Below are examples of specific research topics, but we also welcome proposals based on free thinking that do not fit into these categories.

(1) Creation of principles and fundamental technologies that demonstrate the true value of light

A proposal to create ultimate photonic conversion and control technologies that maximize the potential of light, introducing new theories and materials. One to delve into the basic principles and new phenomena of light, stepping into its deep physical properties and quantum nature. For example, creating theories and technologies to enhance the scalability, controllability, and efficiency of photonic devices and circuits to the limit by utilizing various degrees of freedom of light such as amplitude, phase, space, polarization, frequency, etc.

(2) Development of hybrid technologies of optics/photonics with other fields

A proposal to develop hybrid technologies that combine optics/photonics with other sciences such as electronics and quantum physics, surpassing the traditional performance limits that could not be broken through by light or electrons alone. This includes an attempt to complementarily integrate material-science-based photonic devices research and information-science-based research on mathematical models, architectures, and software. A proposal, through such a scientific fusion, to create design theories and implementation methods that can uniformly handle hybrid systems of photons, electrons, and quantum, and to demonstrate systems that can break through conventional limits. For example, technologies that overwhelmingly improve the efficiency and speed of traditional computers through the coordination of photons with other type of computational resources, technologies that seamlessly connect wired and wireless optical communications through the free conversion of photons and electrons, and the development of sensing technologies that combine new devices and algorithms to utilize previously unused properties and wavelengths of light.

(3) Pioneering innovative utilization technologies of optics/photonics for a sustainable information society

A proposal to develop innovative light utilization technologies for strengthening the collaboration between elements such as computers, communications, IoT devices, and the linkage between cyberspace and the real world, which will be a key in future information systems. One to present concepts for solving various social issues in fields such as the environment, food, healthcare, and manufacturing through light-empowered information systems. For the former, for example, a proposal to develop technologies that increase system efficiency, by appropriately utilizing light, in very large systems where cloud and edge computing, sensing, and the networks that connect them, are unified. For the latter, a proposal to present solutions to social problems through the combination of synergized photonics-based information systems of various sizes with social science studies on diverse issues.

3. Research periods and research funds

The proposal should be structured with an appropriate number of researchers according to the goals of the proposed project, with a research period of no more than five and a half years. The budget scale will be of the following two types:

(1) Budget Scale Type I: from 300 million to 500 million yen (Expected adoption: about 1 to 2 projects)
(2) Budget Scale Type II: from 150 million to less than 300 million yen (Expected adoption: about 3 to 4 projects)

4. Principle of research-area management

We will facilitate active exchange and collaboration among the selected CREST teams in this research area, and researchers from the newly launched PRESTO program "Pioneering the synergy of information and physics connected by optics and photonics," by organizing joint meetings and symposia, among other initiatives to promote interaction. Through these efforts, we strive to form a network of researchers that transcends generations and fields. Additionally, the selected teams are expected to engage in exchanges and collaborations with related research areas within JST, including the CREST program "Creating innovative optics and photonics based on creative principles," started in fiscal year 2019, as well as joint research with leading researchers in Japan and overseas.