Research area in the Strategic Objective "pioneering next-generation photonics through the discovery and application of novel optical functions and properties"

6.1.9 Advanced core technology for creation and practical utilization of innovative properties and functions based upon optics and photonics

Research Supervisor: Ken-ichi Kitayama (Professor, The Graduate School for the Creation of New Photonics Industries)

Overview

The goal of this research area is to produce disruptive innovation (innovation producing technologies under an entirely different standard of value that displaces existing values) in new fields of photonics that will meet future demands of society and industry through cross-disciplinary, multilayered integration and development of conventional optical sciences, while simultaneously working to clarify the fundamental principles sustaining the creation of new technological ideas. These efforts are aimed at the synthesis of new optical functional materials, the development of communication and network technologies using innovative techniques for controlling light, the visualization of microstructures with high temporal and spatial resolutions, and the creation of basic technologies and systems for complex light through integration with advanced mathematical sciences. This cross-disciplinary and coordinated approach toward further supporting a broad range of fields that includes the environment, energy, manufacturing, telecommunications, medical care, and security through the clarification, control, and application of such new optical physics and functions will lead to the formation of a higher-order social and industrial infrastructure capable of meeting various aspects of social demands, including precision, sensitivity, capacity, power consumption, and cost.

We will not limit ourselves to in-depth studies on technologies in a single field in this research area, but will keep a broad perspective that encompasses related fields of technology in an effort to conduct R&D that can create a new paradigm for merging dissimilar fields.

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

(1) Background

Photonics has potential as a basic technology capable of resolving issues that people face in their daily lives, such as security, health, and food safety, strengthening our competitiveness at the national level through improvements in industrial productivity and the creation of new industries, and creating diverse systems that can effect disruptive innovation in any of various fields on a global scale, including global warming countermeasures and space development. For example, innovative optical communication and networking technologies and sensing

technologies could spur the rapid development of the Internet of Things (IoT), while biophotonics, which has made great strides in recent years, is expected to contribute to the realization of advanced medical care and diagnostic systems utilizing noninvasive observation and analysis. Moreover, the use of optical sciences to synthesize unexpoited optical functional materials and substances is anticipated to help create a foundation for new materials industries.

For the current fiscal year, we invite proposals in this research area on the following topics.

(2) Desired research topics

In this research area, we are targeting use-inspired basic research involving photonics, rather than pure basic research or pure applied research as described hereinbelow. Research directors should have the ability and preparedness to lead the charge across the “valley of death” spannning between basic research and viable products and technologies. In this research area, we are looking to conduct R&D focused on expanding the applications of photonics into such diverse fields as the environment, energy, manufacturing, telecommunications, medical care, and security by radicalizing photonics technologies and integrating them through a cross-disciplinary, multilayered approach, and we want to be able to verify the construction of a world-leading system approximately eight years following the completion of this project.

The systems mentioned here are not simply standalone measuring and data processing equipment, transceivers, and manufacturing equipment, but are intended to be the collective integration of these devices, capable of processing and visualizing data and providing applications and services. Accordingly, when submitting a proposal for this research area, the applicant must present an image of the system they envision for the future. In other words, we would like applicants to tell us in a tangible and convincing manner what sort of contribution, direction, and vision the achievement of their research concept, backed by their own experience and knowledge, will have on society and industry. Proposals that do not answer these questions sufficiently or that are viewed as being pure basic research or pure applied research will not be selected. Some specific examples could be an ultrafast optical communication system having a single-photon source employing metamaterials (enhancing convenience in people’s lives and contributing to global warming measures through the establishment of an ultrafast, low-power communication technology in response to the dramatic increase in data processing and power consumption accompanying the popularity of cloud computing, etc.), a 3D machining system employing an attosecond laser (contributing to the creation of new manufacturing industries through applications to low-cost, high-precision microfabrication of diverse target materials), and a deep tissue imaging system employing ultra-sensitive photodetectors (pioneering new diagnostic and therapeutic techniques by establishing technologies for the visualization of cells and tissues that was previously not possible). However, please present your vision and future direction based on your own research concept without getting caught up on these examples.

In addition to the above information, we are looking for proposals on challenging and innovative R&D in a variety of fields. When describing your research proposal, we would like you to clearly establish a direction and vision for the system you wish to develop, without limiting yourself to the above examples, and explain in detail

what this system will eventually look like, including the anticipated progress and results along the way and at the end of the project and what gives this system clear superiority over existing technology. When necessary, please provide any numerical targets needed to support your proposal. As the end result of this research project, it would be optimal to be able to verify the underlying technology required to implement the system you have proposed and to be able to demonstrate its potential as a viable product. However, proposals that are focused on suitable goals and that detail the underlying technologies to be researched and the course of development to be continued for some years following the completion of this project are in line with the intention of this research area.

For your reference, the following are some examples of photonics technologies and fields we ourselves would like to address in this research area. However, please bear in mind that these are merely examples.

1) Development of nanoscale laser micromachining and measuring technologies and creation of new materials

• Design new substances and materials from a theoretical approach

• Develop optical control and sensing technologies to study inherent structures of organisms

2) Improvement of noninvasive *in vivo* sensing and imaging techniques

• Establish high-precision, high-security biometrics technologies

• Elucidate mechanisms of interaction occurring under light irradiation between a biologically relevant substance and a non-biological substance, such as a photoprobe

3) Development of techniques for observing electronic states at high resolutions

• Observe and control ultra-fast dynamic processes, such as electrons emitted from a solid

• Develop nano-optical devices, such as surface plasmon-based circuits and interferometers

• Establish control technologies for coherent light with an extremely short pulse duration and for photoresponses and photochemical reactions

4) Development of an optical frequency comb for ultimate measurements of time and space and a laser acceleration technology

• Develop technologies for manipulating electrons in matter with attosecond precision

• Develop advanced optical sciences for use under extreme environments and conditions, such as a laser acceleration technology

(3) Research project organization

In order to implement the research concept, the research leader should be willing to share his or her vision with researchers and engineers in different but complementary technological fields and to conduct collaborative research with a team-based approach to identifying needs and encouraging dialog. Please keep this point in mind when putting together a team best suited for your purposes and indicate the specific approach to be adopted by the team and individual groups therein. It is preferable that the implementation of this research not be confined to a framework involving only universities and national R&D agencies, but makes use of the technical skills and knowledge on the application side (industry, medical personal, etc.).

This research area is soliciting proposals with an upper limit for research expenses of three hundred million yen

per research project.

(4) Collaboration with other research areas

Administration of this research project will include collaboration with the PRESTO (Sakigake) research area "Fully-controlled photons and their proactive usage for new era creation (FRONTIER)," and the joint holding of area conferences and workshops when needed. We will also promote collaboration with related academic societies and research institutes and will occasionally hold symposiums and integrate studies for the purpose of actively expanding into new research areas.

Briefings on the call for proposals in this research area will be held according to the following schedule. We hope to see many interested parties in attendance. Both briefings listed below will be held jointly for the CREST research area "Pioneering next-generation photonics through the discovery and application of novel optical functions and properties", the PRESTO research area "Fully-controlled photons and their proactive usage for new era creation.", the CREST research area "The creation of innovative quantum technology platform based on the advanced control of the quantum state," and the PRESTO research area "Quantum state control and functionalization."

Date & Time	Venue
April 26 (Wed) 13:30-16:00	< Kanto-Area> TKP Ichigaya Conference Center 3F, Hall 3C. 8 Ichigaya-Hachimanchō, Shinjuku-ku, Tokyo
April 27 (Thu) 13:30-16:00	< Kansai-Area> Campus Plaza Kyoto Nishino-Toin-dori Shiokoji Sagaru, Shimogyo-ku, Kyoto

For more information, please visit the following site: http://senryaku.jst.go.jp/teian-en.html.