# Photonics Center
## Osaka University

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# Photonics for Human Friendly Community

Photonics is attracting increasing attention as one of the key technologies that will underpin the science, industry, and society of the 21st century following in the footsteps of 20th century electronics. Unlike an electron, which is a charged particle, a photon is a gentle messenger and probe that can travel freely through air, water, and even the human body. In 2005, Osaka University launched an in-school project, the "Nano-Photonics Initiative," with a view toward seeking state-of-the-art science related to light, opening up advanced scientific and industrial fields that utilize the photon, and developing researchers who will shape the future of photonics, As a follow-up to this pioneering project, in July 2007 the University established the Photonics Advanced Research Center (PARC), one of the programs for the "Creation of Innovation Centers for Advanced Interdisciplinary Research Areas" that are financed through Special Coordination Funds for Promoting Science and Technology.

Optics serves as the very basis of physics, and without optical research our historical developments in astronomy, mathematics, chemistry, and biology would be unthinkable. This discipline is expected to make even wider and deeper contributions in the key fields that emerged with the dawn of the 21st century, including nanotechnology, biotechnology, life science, information technology (IT), environmental science, and energy science, as it evolves into photonics, a cutting-edge science examining the interaction between photons and nanostructures that will play the role of innovator in this new era. At the vanguard of science, industry, and society in the 21st century, photonics creates fusion and stands as the fundamental technology for innovation. Breaking down the walls between conventional academic disciplines, photonics will go on to bring about the new mode of research described by Michael Gibbons as "transdisciplinarity."

A historical hub for science of light in Japan, Osaka University is home to the greatest number of optical researchers in the country, who represent the entire spectrum of subfields, including spectroscopy, photochemistry, bio-optics, and more. And now, under the keyword of "photonics," we have established a framework for accelerated innovation by organically setting up three projects within the Photonics Center: PARC aims to achieve industrial innovation through industry-academia collaboration, the Photonics-based Eco-Life-Technology Development Center promotes the development of environmental, energy, and healthcare technologies, and the Advanced Nano Photonics Research and Education Center in Asia conducts photonics research and education for the Asian region and the entire world. Going forward, at this Photonics Center we will create new photonics-based industries so that the hills of Senri might come to be known as "Photonics Hills," or a hub of photonics business.


## Satoshi Kawata

The Executive Director of PARC
Professor, Graduate School of Engineering, Osaka University

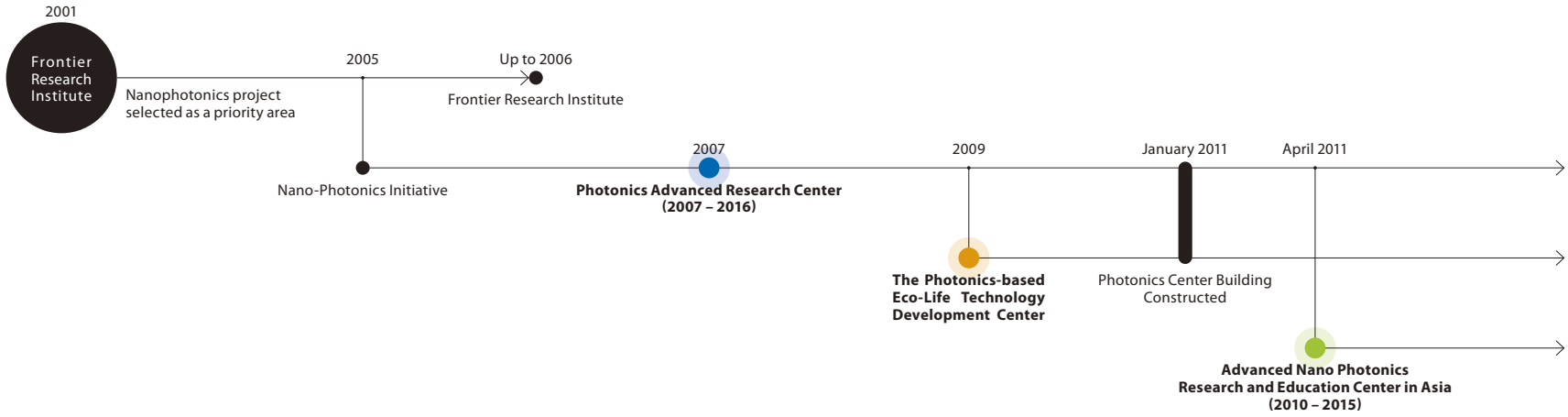
# History of Photonics Center, Osaka University



Osaka University is the key photonics research centers in the world, having hosted a number of photonics research projects with many of its faculties and schools conducting research and education from basic to applied levels and thereby producing numerous talented engineers. From 2001 to 2006, its Graduate School of Engineering pursued the "Frontier Research Institute," a program for "Fostering Strategic Centers of Excellence under the Special Coordination Funds for Promoting Science and Technology," in which a nanophotonics project was selected as one of the priority areas.

Under the framework of this program, aggressive efforts were made to establish photonics as an academic discipline and interconnect it with other disciplines, and also to promote industry-academia collaboration through, for example, joint research via matching funds with various businesses. It was in the spirit of such endeavors that in 2005 the Nano-Photonics Initiative was formed as an independent multidisciplinary research institution, gathering together researchers of electric and electronics engineering and applied physics. This research institution has since committed itself to the advancement of nanophotonics research, creation of new industries, and human resources development through a variety of initiatives, which include the startup of three venture businesses under the lead of the university, sponsorship of three rounds of the "International Nanophotonics Symposium Handai" convention, e-learning courses for working adults, and publication of an academic books (*Handai Nanophotonics Book Series Vol. 1, 2, 3, Elsevier*).

Originally a virtual organization within Osaka University, the Photonics Center is carrying on the mission of this Nano-Photonics Initiative, providing opportunities for researchers in this broad-based discipline to engage in education, research, and information sharing. With the completion of the Photonics Center Building in 2011, the Center has further consolidated its foundations. With the participation of over 20 laboratories from many different graduate schools and majors courses, as well as numerous businesses, the Photonics Center is currently promoting three projects. The details of these projects are as follows.



Osaka University's Photonics Center promotes in the following three projects.

## Photonics Advanced Research Center (PARC)

The Program for Realization of Innovation center for fusion of Advanced Technologies by Special Coordination Funds for Promoting Science and Technology / Special Grants for Projects Promoting Science and Technology through Regional Industry-Academia-Government Cooperation among Industrial, Academic and Governmental Organizations sponsored by Ministry of Education, Culture, Sports, Science and Technology (MEXT) (2007–2016)

**[Executive Supervisor]** Kiyokazu Washida, The President of Osaka University
Satoshi Kawata, The Executive Director of PARC

## The Photonics-based Eco-Life Technology Development Center

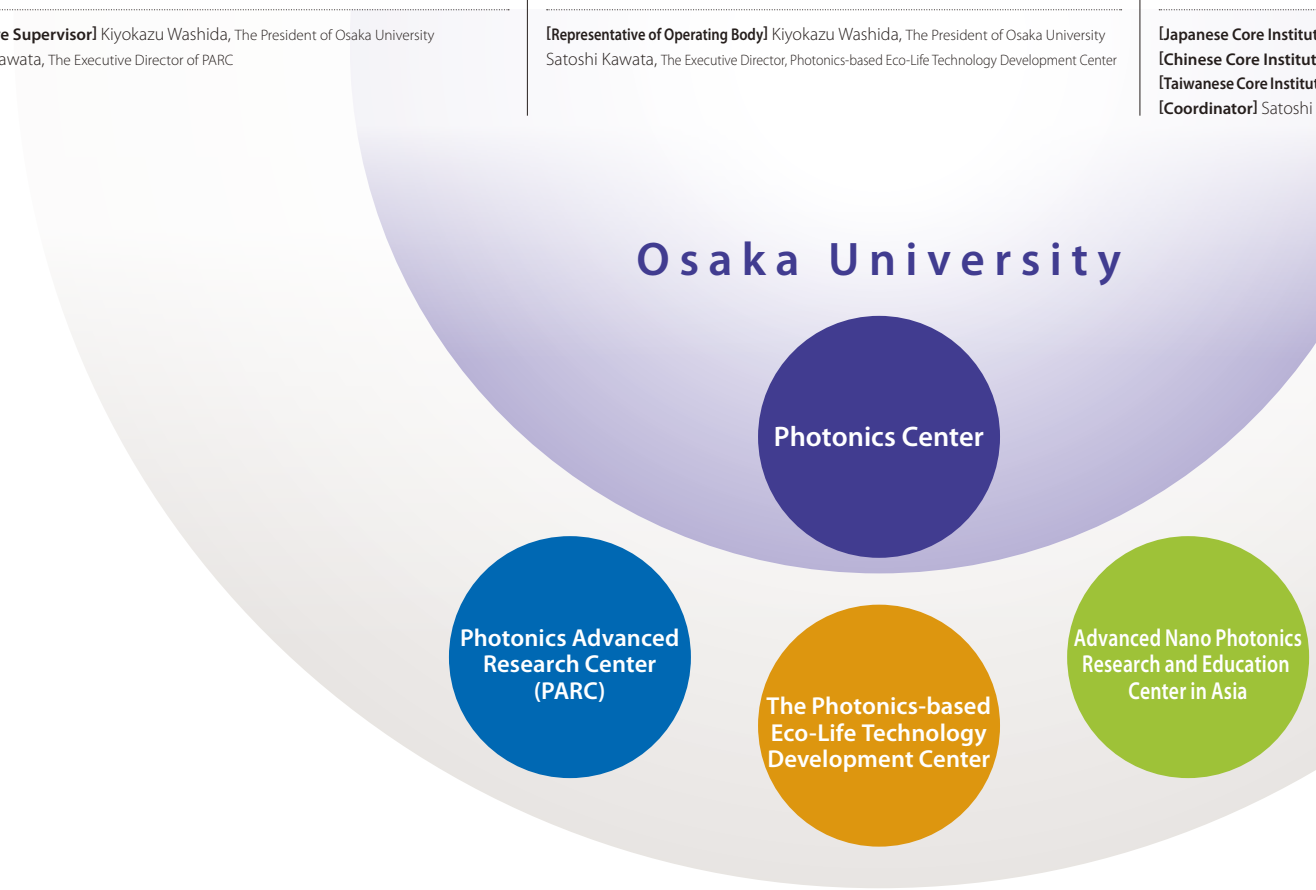
Special Grants to Improve Centers for Research and Development in the Field of Industrial Technology, FY 2009 sponsored by Japan's Ministry of Economy, Trade and Industry (METI)

**[Representative of Operating Body]** Kiyokazu Washida, The President of Osaka University
Satoshi Kawata, The Executive Director, Photonics-based Eco-Life Technology Development Center

## Advanced Nano Photonics Research and Education Center in Asia

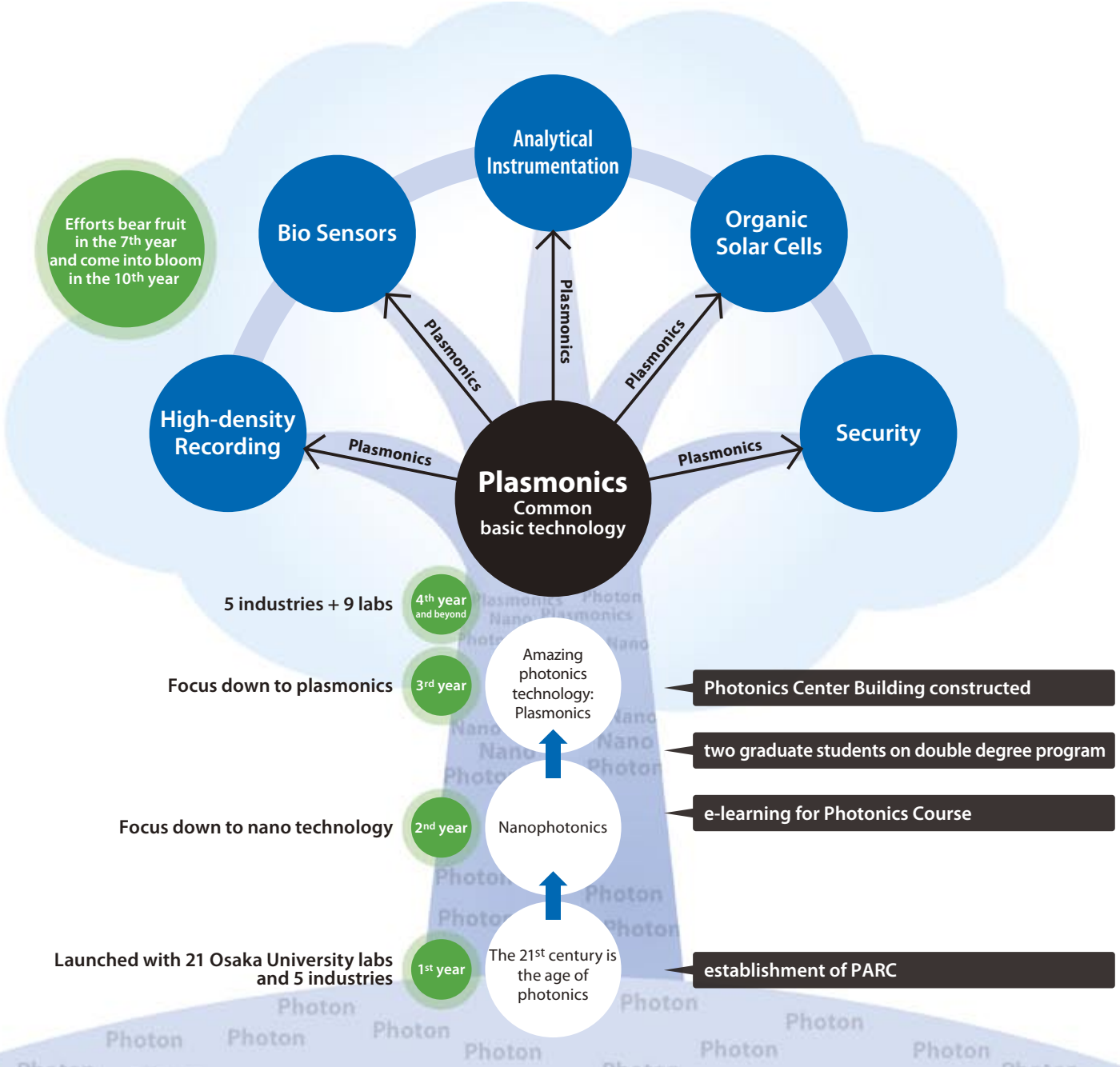
Japan Society for the Promotion of Science, Asian CORE Program (2010–2015)

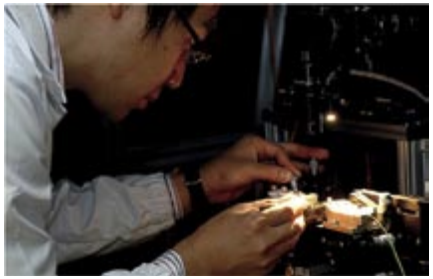
**[Japanese Core Institution]** Osaka University
**[Chinese Core Institution]** Technical Institute of Physics and Chemistry, Chinese Academy of Science
**[Taiwanese Core Institution]** Instrument Technology Research Center
**[Coordinator]** Satoshi Kawata, Photonics Center, Osaka University




Hosted by Osaka University, the Photonics Center is dedicated to the research and education of photonics, which underlies science and technology in the 21st century, through advanced scientific research of nanophotonics and plasmonics and their application and industrialization, development of photonics-based eco-life technology and support for its industrialization, and international exchange / human resources development projects.

# (Nano+Photonics) + "Plasmonics"



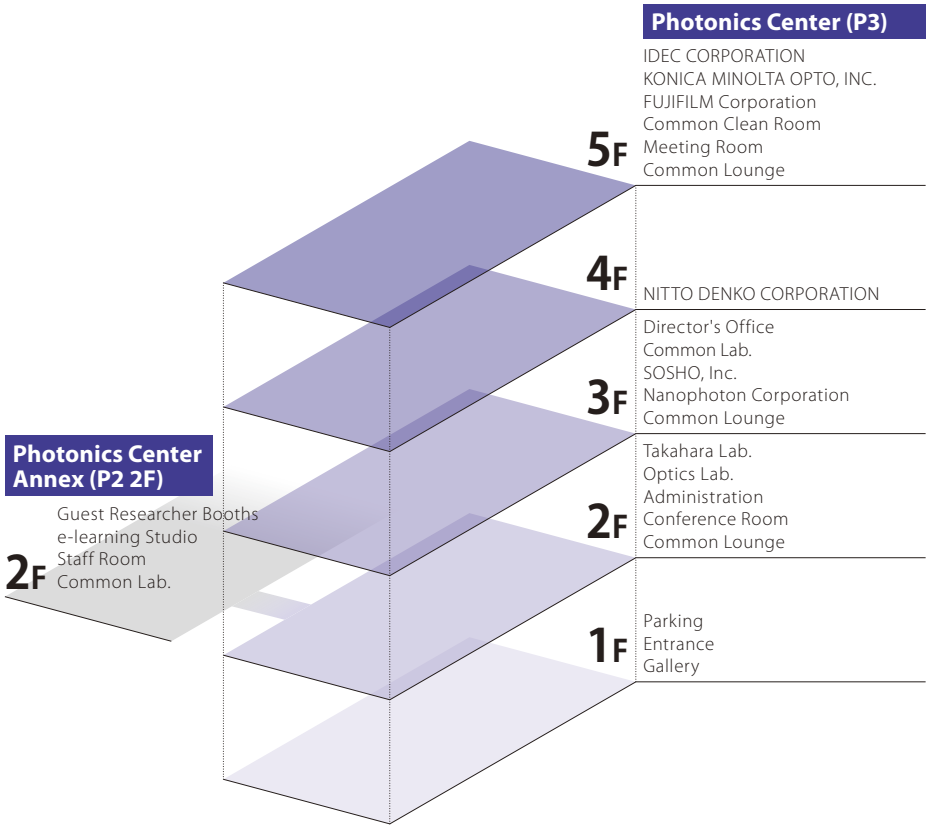



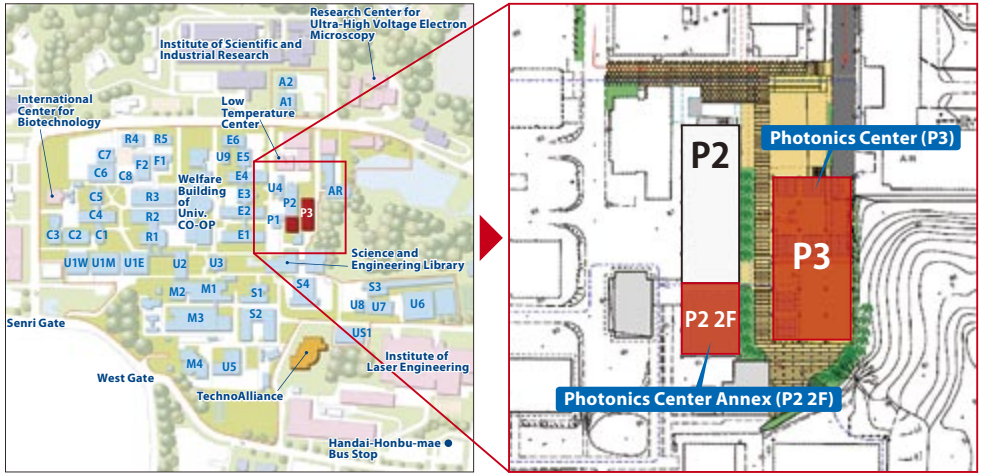
# Facilities

## Photonics Center

Five-floor building with 4,900 m² of floor space, constructed in 2011

- **Provide high security services for industries**
- **Open common laboratories with spectroscopic, chemical, bio, and micro-processing equipments**
- **Open lounges for meeting and discussions**

# Photonics Advanced Research Center (PARC)



## Interpenetration between university and industry partners is the key to industrial innovation.

Multifaceted project frameworks through winning combinations,
between the university and various partners from different sectors.

- **Applications of core technologies in nanophotonics and plasmonics**

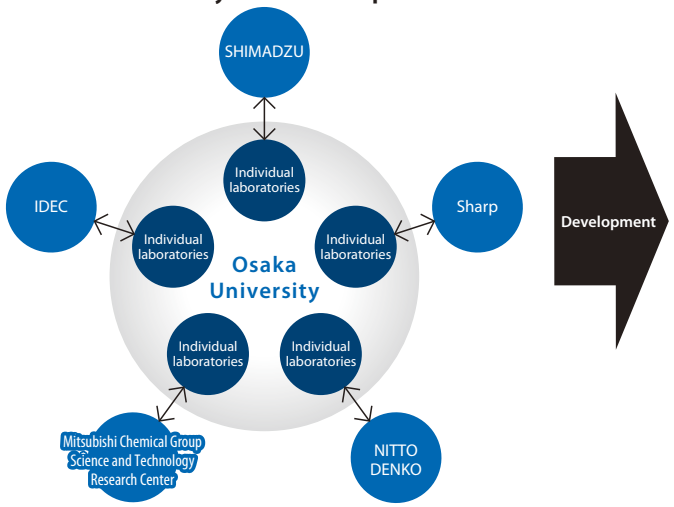
  Through the application of core technologies in nanophotonics and plasmonics,
  we aim for the creation of industries in the areas of
  information technology (IT), energy, security/safety, and analytical instrumentation.

- **Horizontal cooperation in materials, thin films, production lines, analysis, and devices**

  Infrared imaging, reagents, security, biosensors and high-density optical recording, etc.

- **A breakthrough in one field triggers a chain of breakthroughs in others.**

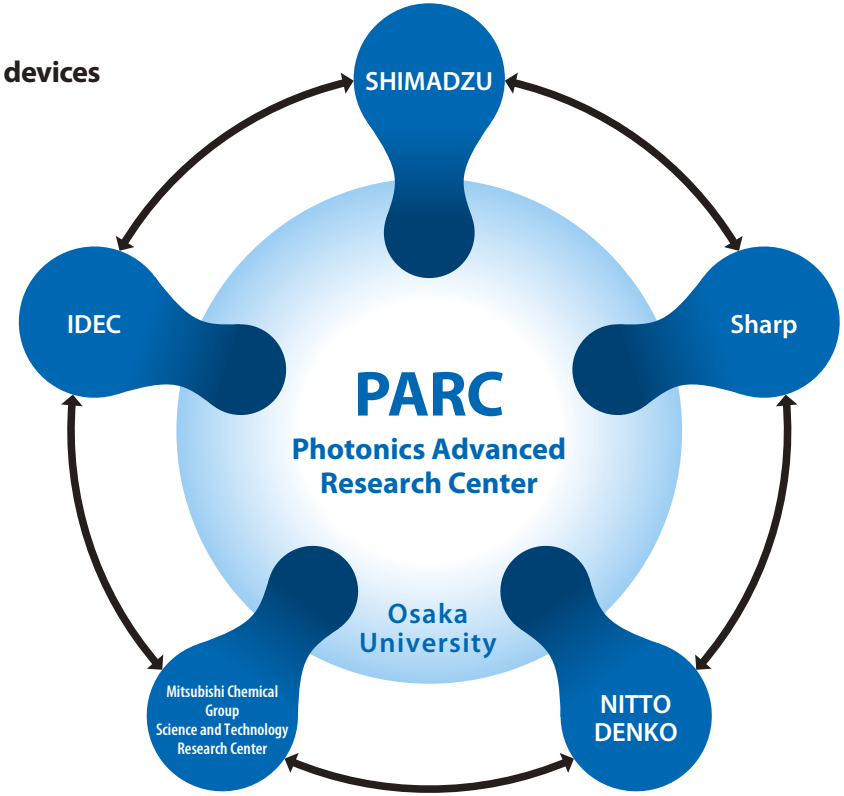
**Conventional industry-academia cooperation model**




**Interpenetrating partnership system**

**【Industry on campus model】**

Core technologies of labs ＋ partners from different sectors



# Activities on Interpenetrating between Industry and Academia

## Photonics Colloquia

| | | |
|---|---|---|
| April 4, 2011 | 20th | [Photonics Center] |
| December 6, 2010 | 19th | [SHIMADZU CORPORATION, Kyoto] |
| October 4, 2010 | 18th | [Icho-Kaikan, Osaka University] |
| June 7, 2010 | 17th | [Icho-Kaikan, Osaka University] |
| May 10, 2010 | 16th | [Icho-Kaikan, Osaka University] |
| October 28, 2009 | 15th | [Science and Engineering Library, Osaka University] |
| October 5, 2009 | 14th | [Sharp Corporation, Nara] |
| June 15, 2009 | 13th | [NITTO DENKO CORPORATION, Osaka] |
| April 7, 2009 | 12th | [IDEC CORPORATION, Osaka] |
| February 2, 2009 | 11th | [Icho-Kaikan, Osaka University] |
| January 13, 2009 | 10th | [Icho-Kaikan, Osaka University] |
| November 5, 2008 | 9th | [Icho-Kaikan, Osaka University] |
| October 6, 2008 | 8th | [Icho-Kaikan, Osaka University] |
| September 9, 2008 | 7th | [Multi-purpose Room, Applied Physics Bldg., Osaka University] |
| July 2, 2008 | 6th | [Icho-Kaikan, Osaka University] |
| June 2, 2008 | 5th | [Multi-purpose Room, Applied Physics Bldg., Osaka University] |
| May 7, 2008 | 4th | [Icho-Kaikan, Osaka University] |
| April 7, 2008 | 3rd | [Multi-purpose Room, Applied Physics Bldg., Osaka University] |
| January 15, 2008 | 2nd | [Icho-Kaikan, Osaka University] |
| November 20, 2007 | 1st | [Icho-Kaikan, Osaka University] |

## PARC Symposiums

| | | |
|---|---|---|
| September 7, 2010 | 5th | "5th PARC Symposium : Photonics in Asia"<br>[Shima Kanko Hotel the Classic, Mie] |
| November 18, 2009 | 4th | "Photonics, Nano-Photonics, and Beyond..."<br>[Otemachi Sankei Plaza, Tokyo] |
| December 12, 2008 | 3rd | "Science and Industry as Created by Optical and Nano Technologies"<br>[Otemachi Sankei Plaza, Tokyo] |
| February 29, 2008 | 2nd | "The Dawn of Photonics"<br>[Toranomon Pastoral Hotel, Tokyo] |
| December 18, 2007 | 1st | [Hotel Hankyu Expo Park, Osaka] |

## Handai Photonics Days

| | | |
|---|---|---|
| November 11, 2010 | 3rd | [Science and Engineering Library, Osaka University] |
| November 26, 2009 | 2nd | [Icho-Kaikan, Osaka University] |
| November 5, 2008 | 1st | [Icho-Kaikan, Osaka University] |
| November 6, 2008 | | Lecture "The Art of Invention : Optics and the Recording of Knowledge" |

# The Photonics-based Eco-Life Technology Development Center

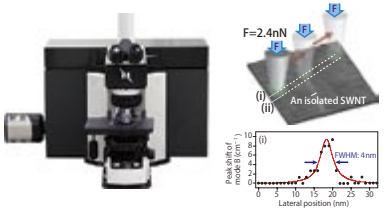


Under the framework of this subsidized project, the Photonics Center Building has been constructed in order to conduct joint R&D for practical application / industrialization of photonics-based eco-life technology. Tapping into its advanced technology in the fields of photonics, Osaka University teams up with private businesses to conduct work on fusion projects in such areas as health/environmental analysis, healthcare, environment, and energy. The Center will perform its photonics-based eco-life demonstrative research using the intelligent LED illumination system installed throughout the building.

## Photonics-based eco-life target technologies

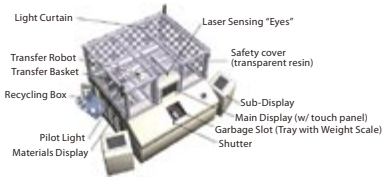
- Photon measurement/imaging technology (key to bio-information and environmental analysis) / The world's first nano optical microscope, 3D molecular imaging technology
- Development of plastic recycling robots that make use of laser sensing technology (collaborated with IDEC)

**Nano Molecular Imaging Technology**




Succeeded in developing the world's first nano molecular imaging

**Laser Sensing Technology for Plastic Separation**




Six different kinds of plastics, including polyethylene and polypropylene, are sorted by laser for ease of recycling.

## Human resources development

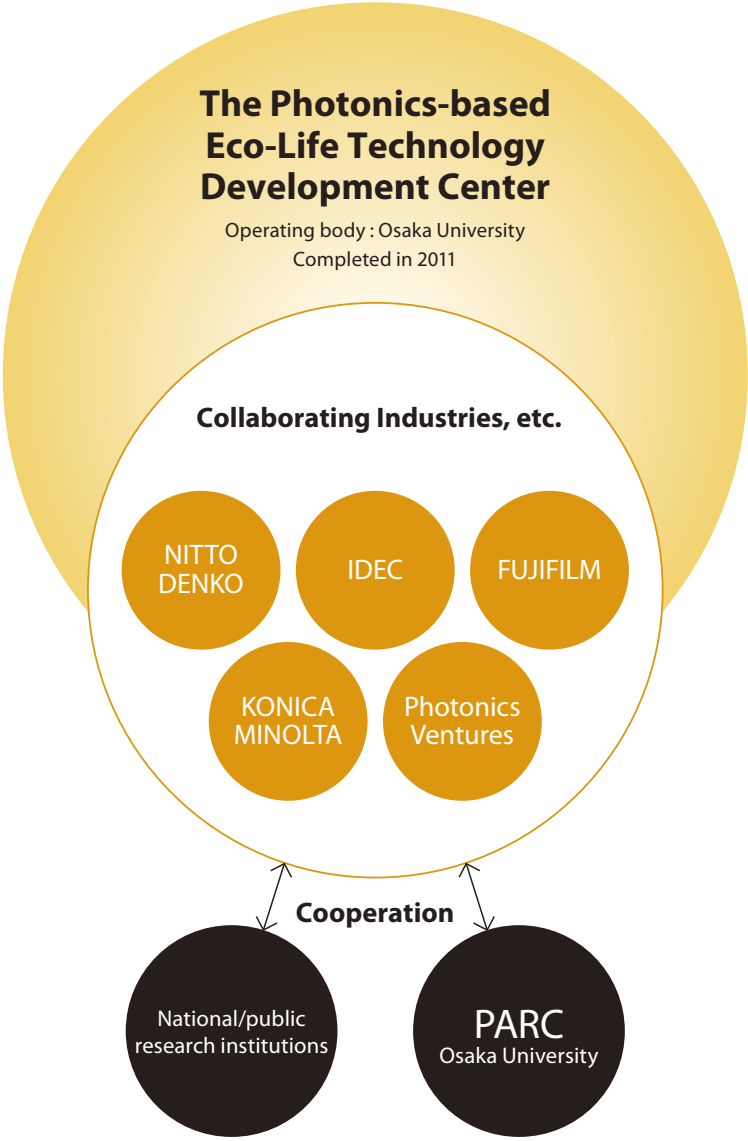
- Osaka University and private businesses join together to develop doctors for the future. ( Industry on campus model )

## Future plans

- Through cooperation with national/public research institutions and local governments, joint research with private businesses will be accelerated by leveraging connections formed during previous projects and a special district will be established within the university by gathering together businesses and research laboratories.
- A core function in "Photonics Hills"

## Expected outcomes/impact

- Create a photonics-based eco-life industry estimated to be ¥1,400 billion market (as of 2015)

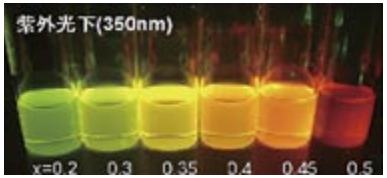


# Large scale installation on LED lighting

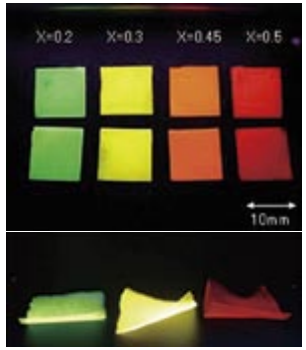
Installing 7,000 of LED lightings to measure energy consumption over a year.
To realize a "photonics-based eco-life," efforts are underway to develop LED lighting technology for energy conservation, low-cost performance, and comfortable lifestyles.

## Comfortable Color Rendering

## LED Wavelength Conversion Technology / Non toxic Semiconductor Quantum Dots




$(AgIn)_x Zn_{(1-2x)}S$ nano particles
Non toxic and quantum efficiency of 40% or higher



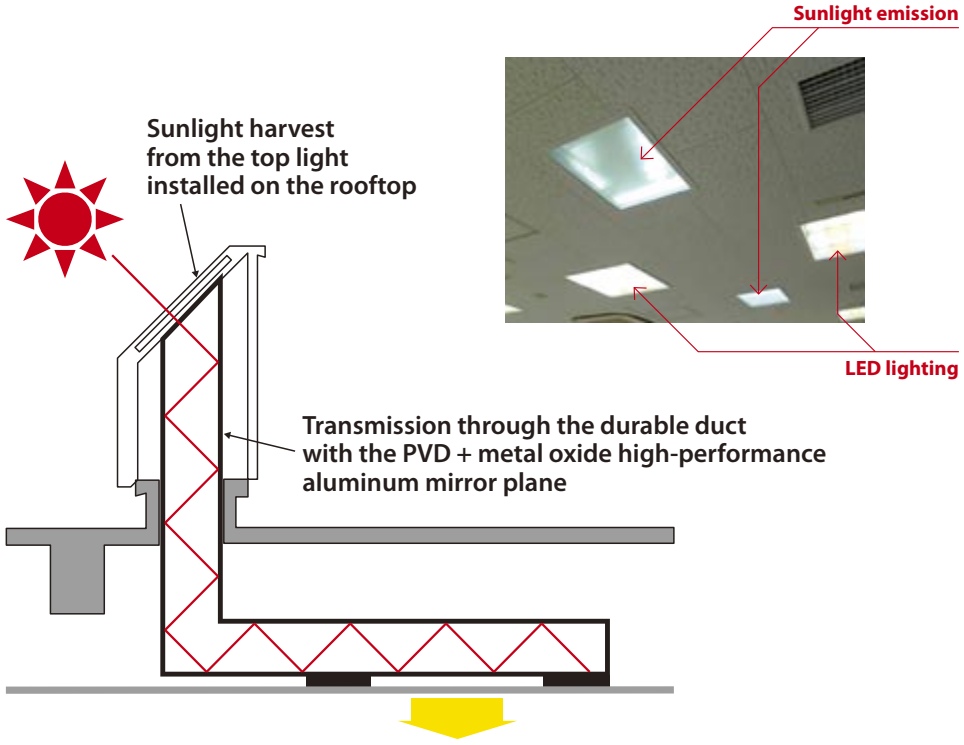

Application to security codes

## Ergonomics + Ecology + Psychology

= Lighting that changes according to the season, time of the day, emotion, preference, type of work, level fatigue, health condition, age


# Natural lighting technology for realizing a "photonics-based eco-life"

The fact that the sun constantly moves makes it difficult to utilize sunlight.
By taking into accounts of its movement, LED lighting is adjusted to save energy and valuable spaces with comfortable lighting is generated (eco-friendly, natural lighting).




# Advanced Nano Photonics Research and Education Center in Asia



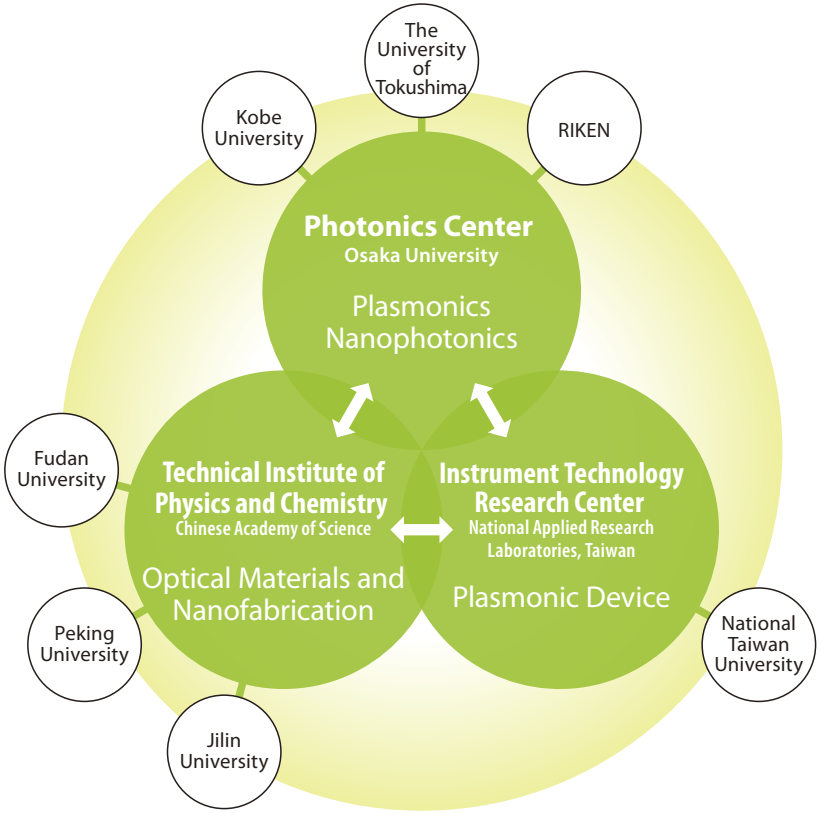
When we utilize the interactions between light and substances on a nano scale, it should be possible to shape the new discipline of advanced nanophotonics, which combines physics, chemistry, biology, medical science, and materials and electric engineering together. The fusion with nano technology will open up a new era of photonics research. Meanwhile, recent years remarkable progresses have been seen in materials engineering, photonics, and other scientific research fields in East Asian countries.

The goal of this center of research and education is to launch advanced nanophotonics research ahead of the rest and develop researchers in this pioneering subject. Toward this goal, Osaka University's Photonics Center has teamed up and conducted photonics research exchange with the Technical Institute of Physics and Chemistry, Chinese Academy of Science and the Instrument Technology Research Center of Taiwan's National Applied Research Laboratories, both of which are leading research institutes in their respective countries. A diverse group of researchers engaged in advanced photonics research involving physics, chemistry, medical science and electric engineering will be assembled to promote international joint research among Japan, China and Taiwan. A center of advanced nanophotonics research and education in Asia will be formed to create a research network that will then lead to the photonics research that forms basis of the science and technology of the 21st century. At the same time, researchers and students are expected to :

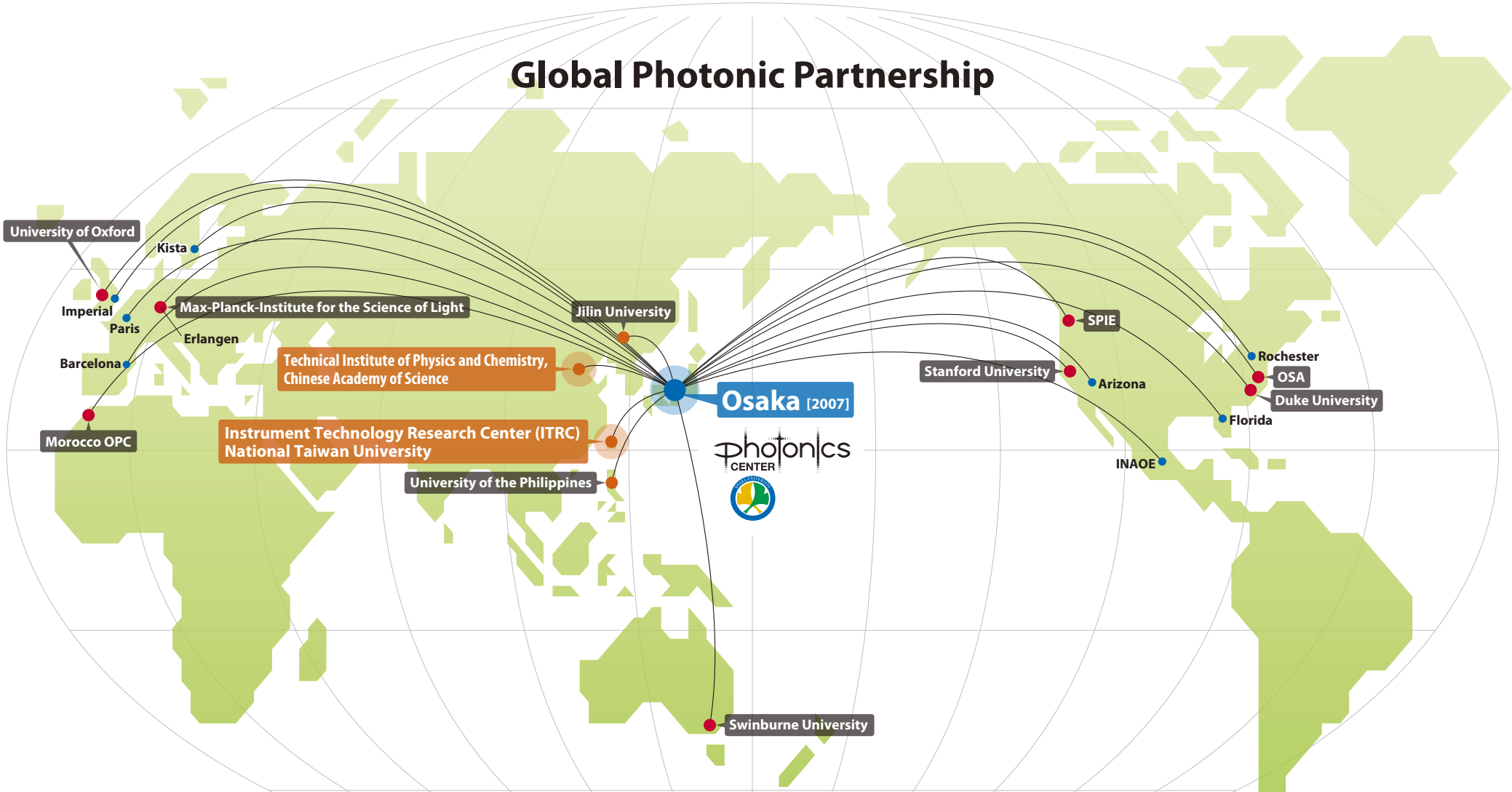
- **Develop individual expertise in fields, broaden their multidisciplinary views of photonics, and acquire the capability to share their research findings with the world; and**
- **Develop the competency required for research exchange and joint research with a diverse range of international researchers from various cultural/social backgrounds, along with abilities for networking.**

In so doing, this center aims to develop young researchers who are capable of conducting internationally viable, pioneering photonics research for future generations.

## Operation and Global Network




# Global Photonic Partnership




## MoU Partners in Asia (Including MoUs in progress)

- Technical Institute of Physics and Chemistry, Chinese Academy of Science
- Instrument Technology Research Center (ITRC)
- National Taiwan University
- Jilin University
- University of the Philippines

## MoU Partners in the World (Including MoUs in progress)

- Stanford Photonics Research Center
- OSA [The Optical Society of America]
- SPIE
- Duke University
- Max-Planck-Institute for the Science of Light
- University of Oxford
- Swinburne University
- Morocco Optics and Photonics Center

## Photonics Centers in the World

- Osaka [2007]
- Erlangen [2003]
- Kista [2002]
- Barcelona [2002]
- Imperial College London [2001]
- Florida [1986]
- INAOE, Mexico [1971]
- Arizona [1964]
- Rochester [1929]
- Paris [1917]

## International Partnerships (Including MoUs in progress)

- Max Planck Institute for the Science of Light, Erlangen, Germany
- Chinese Academy of Sciences, Beijing, China
- The Stanford Photonics Research Center, U.S.A.
- National Taiwan University, Taipei, Taiwan
- Instrument Technology Research Center, Taiwan
- The Optical Society of America
- SPIE

## Human Resources Development

PhD program for industries
Double degree program
OSA/SPIE student chapters
CVs of PhD students and postdocs
e-learning Photonics Course
Photonics Colloquia
Handai photonics days
PARC symposiums
Company partnership and exchange program

# e-learning Photonics Course

**One of the missions upheld by the Photonics Center is to develop young researchers who seek the fusion of advanced technologies with photonics serving as a core. Accordingly, the Photonics Center has organized an e-learning Photonics Course with the goal of developing future researchers.**

## Merits of the e-learning Photonics Course

### Advanced Content

Attractive scenarios for learners, experienced faculty teaching staff, and exhaustive information that merit repeated study—all of these factors serve to stimulate learners' desire to "look again and delve further."

### Video Library

Being on the "cutting edge" of advanced fusion fields, there are only a limited number of chances to learn about such pioneering subjects. As a learning tool, the video library will provide such opportunities and enhance the learning experience.

### Interdisciplenary

Learners encounter researchers from many other academic disciplines. This course encourages learners to discover for themselves research themes that cannot be solved with knowledge from a single field or areas that need to be fused together, thereby cultivating their competency as independent researchers.

### Any time, as many times as you need

Learners may access the course online at any time of the day. Since the videos are segmented into less than 20 minute sections, learners will not grow tired of repeated studying.

## Course menu

### Introduction to Plasmonics

Graduate School of Engineering,
Osaka University
Professor **Junichi TAKAHARA**

Overviewing the history and current status of metal photonics researches, the lecturer explains what is "plasmonics". This lecture gives an introduction into the basics of plasmonics and nanoplasmonics. The forefront of research on plasmonic device is also introduced.

### Introduction to Raman Scattering Microscopy

Graduate School of Engineering Science,
Osaka University
Associate Professor **Mamoru HASHIMOTO**

This lecture starts to explain one of the greatest advantages of Raman spectroscopy: it is capable of identifying the molecular species and distribution in living tissues in vivo without any preparation. Then, its principle, instrumentation, and application research are explained. The lecturer also introduces his recent research on CARS microscopy that enables real-time imaging.

### Influenza Virus Sensor

Graduate School of Engineering,
Osaka University
Associate Professor **Yoshinori YAMAGUCHI**
Assistant Professor **Masato SAITO**

This lecture takes a deeper look into molecular biological understanding of influenza, and provides an overview regarding the principle and practice of microchips which enable the rapid and sensitive diagnosis of influenza, as well as the latest research on extremely highly sensitive measurement methods exploiting plasmonics.

### Liquid Crystal Photonics

Graduate School of Engineering,
Osaka university
Assistant Professor **Hiroyuki YOSHIDA**

The fascinating property of liquid crystals is their ability to form various higher-order structures with outstanding photonic functions, by applying varying external electric field and temperature. This lecture focuses on the world of attractive liquid crystals with great potential.

### Bioimaging with Molecular Probes

Graduate School of Engineering,
Osaka University
Professor **Kazuya KIKUCHI**

Almost 30 years passed since discovery of the GFP in 1962 until actual application of the GFP started in 1994. What kinds of studies were made in this "blank" period? Let's look back to the recent history of research activities in the field of chemical biology for imaging, and you also learn the organic molecular probes as well as on the fluorescent protein probes through this lecture.

### Near Field Optical Microscopy

Graduate School of Frontier Biosciences,
Osaka University
Professor **Yasushi INOUYE**

This lecture provides principle and practice on "near-field optical microscopy" that has capability to observe samples at a nanometric-scale spatial resolution. It is worth to watch the animated illustration explaining the principle of the phenomenon called "diffraction limit".

### Semiconductor Nanoparticle (Quantum Dot)

Graduate School of Engineering,
Osaka University
Professor **Susumu KUWABATA**
Assistant professor **Taro UEMATSU**

Semiconductor nanoparticles (quantum dots) have many intriguing properties, like size tunable optical properties and fluorescence at room temperature. This lecture looks into the physics of quantum dots, as well as recent advances in the synthesis and potential application to optoelectronic devices.

### Basics of Magnetic Materials and Their Application to Information Industry

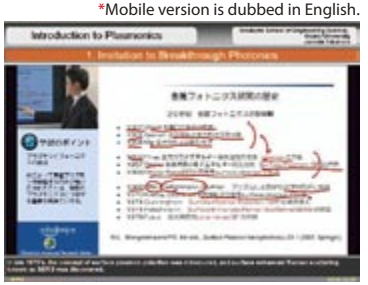
Graduate School of Engineering,
Osaka University
Professor **Ryoichi NAKATANI**

This course starts with the topics such as familiar magnetic materials found in our daily lives and the properties and history of magnets which are interesting for everybody. This informative course also covers origin of magnetic moment and the properties of various magnetic materials.

**English Version**

All content also comes with English subtitles*, which are offered as a tool that we hope will lead to the creation of a photonics training center for Asia.

*Mobile version is dubbed in English.



**Mobile Learning**

### Cutting-edge learning on your mobile device!

The e-learning Photonics Course now supports iPad, iPhone, and Android terminals.

# Photonics Center, Osaka University

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E-mail : parchq@parc.eng.osaka-u.ac.jp

## Access

- **From Shin-Osaka Station (Shinkansen)**
  Take the Subway Midosuji Line and get off at Senri-Chuo Station.
  Change to taxi or the Hankyu Bus bound for "Handai-honbu-mae" or "Ibaraki Mihogaoka".
- **From Kansai International Airport**
  Get off at JR Osaka Station, and change to the Subway Midosuji Line bound for Senri-Chuo Station.
  Get off at Senri-Chuo Station and take to taxi or the Hankyu Bus bound for "Handai-honbu-mae" or "Ibaraki Mihogaoka".
- **From Osaka International Airport (Itami Airport)**
  Take the Osaka Monorail, and get off at Handai-byoin-mae Station.

## From the nearest station or bus stop

- 15min taxi from "Senri-Chuo Station"
- 15min walk from "Kita-Senri Station", Hankyu-Senri Line
- 10min walk from "Handai-byoin-mae", Osaka monorail
- 5min walk from the bus stop "Handai-Honbu-mae"