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Photonics CENTER

PARC
Photonics Advanced Research Center
NEWS LETTER

Vol. 6

Photonics Innovation from Handai, Osaka

Roundtable Discussion

SHARP × TRI × PARC × OSAKA UNIV. × SOSHO

Photonics revolutionizes both industry and people by linking personnel and companies that span many different disciplines.

Photonics-Related Industrialization toward the Convenience and Enrichment of Society


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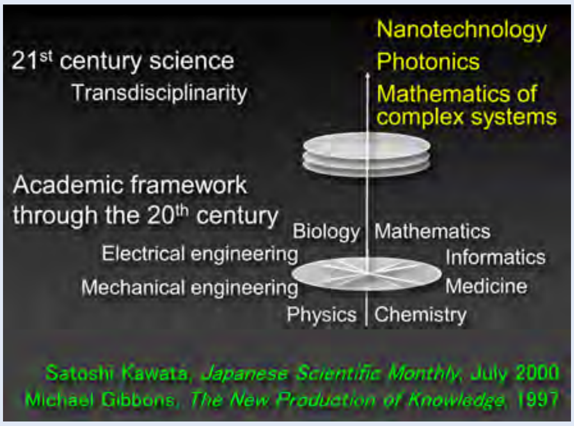
Photonics is attracting increasing attention as the successor to electronics—the technology of the 20th century—for supporting science, industry, and society in the 21st century. Unlike electrons, which are charged particles, photons are gentle messengers or probes that can travel freely through air, water, and even the human body. In 2007, Osaka University established the Photonics Advanced Research Center (PARC) through a grant from MEXT as one of the programs for the "Creation of Innovation Centers for Advanced Interdisciplinary Research Areas." PARC was created to investigate cutting-edge science related to photons, pioneer next-generation science and industry involving photons, and develop human resources for shaping the future of photonics.

Optics is one of the foundations of physics. Without optics research, the historical developments in astronomy, mathematics, chemistry, and biology would be unimaginable. Optics is expected to contribute even more extensively and profoundly in the key fields that emerged at the dawn of the 21st century, including nanotechnology, biotechnology, life science, information technology, environmental science, and energy science. We believe optics will serve as a facilitator of innovation in this new age in the form of photonics, which is the science of studying interactions between photons and nanomaterials. Photonics can be considered a basic technology that is at the forefront of 21st century science, industry, and society and that is a merging of disciplines capable of driving innovation. Photonics is gradually tearing down the walls of our traditional academic framework and giving rise to a new mode of research that Michael Gibbons has called "transdisciplinarity."



Historically known as the center of optics, Osaka University boasts the largest number of optics researchers and has worked to pioneer such fields as optics, spectroscopy, photochemistry, and photobiology. Currently we are steadily working on encouraging industrial innovation through industry-academia collaboration, facilitating startups and commercialization among our faculties and researchers, promoting international collaboration, and developing human resources all under the key concept of photonics, and have constructed a framework for accelerating innovation. Based on this framework, we aim to develop new photonics-based industries at the Photonics Center with the hope of establishing the hills of Senri as a hub of photonics industries, which we have dubbed the Photonics Hills.

We have already witnessed the development of various industrial fields that transcend 20th century boundaries for systems and disciplines, as exemplified by Apple, Google, Amazon, and iRobot. Photonics has played a foundational role in many new industries that intersect conventional industrial fields. In order to create new photonics-driven products, it will be essential to open new frontiers independent from the perspectives of researchers, entrepreneurs, and small, medium, and large companies. To accomplish this objective, we must build a photonics innovation network that includes not just businesses and start-ups, but also universities, national and public research institutes, financial institutions, patent offices, and municipalities. Based on our record of innovation, the Photonics Center is expected to continue to achieve more expansive, large-scale commercialization and industrialization as the core of this network.

This article was derived in part from the following lectures.

Satoshi Kawata, "Linking industry and academia in Japan", Workshop: Linking Industry and Academia, New Technological Advances, the International Year of Light and Light-based Technologies (IYL 2015) Closing Ceremony, Mérida, Mexico, 4-6 February 2016.

Satoshi Kawata, "University professors launch businesses and make a profit," the Science Café at Knowledge Capital, 25 November 2015

(Left to)

Toshihiro TANAKA
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Tomoyuki MIZUKOSHI
Management & Planning Division
Corporate Strategy Section Manager
Technology Research Institute of Osaka Prefecture (TRI)

Yasushi INOUYE
Director of PARC
Graduate School of Frontier Biosciences
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Hiroaki ADACHI
President and Representative Director, SOSHO, Inc.

Tomoyuki MIYAKE
Senior Manager
Research Division 1
Life and Environment Solution Laboratories
Corporate R & D BU
SHARP Corporation

Roundtable Discussion

Innovation and Photonics Network

The Photonics Center is based at Osaka University, the heart of optical science research. Its goal is to spur innovation through collaboration on the part of industry, government and academia in order to create a new photonics industry. In the ten years since the Center was established, it has produced one innovation after another. The Photonics Center will become the core of Photonics Hills, a new gathering place for photonics companies in the Senri Hills. We brought together representatives from Osaka Prefecture, Osaka University and private sector companies to talk about their hopes for Photonics Hills from their individual perspectives, as well as their thoughts on the role of the Photonics Center and the challenges that need to be resolved.

Photonics revolutionizes both industry and people by linking personnel and companies that span many different disciplines.

In the era of "light," photonics is an area in which Japan can produce new fields for advancement.

INOUYE —— If the 20th century can be called the electronics era, the 21st century is said to be the photonics era. Until recently, the field was generally referred to as optical science. But when it became possible to utilize the interaction between light and molecules on a nanoscale level, the possibilities expanded dramatically, extending far beyond the category of simple electromagnetic waves. At that point, optical science became the driving force behind innovations in many different industries, and it came to be called "photonics." Now there is furious competition around the world to discover diverse scientific technologies using photons, to see what types of industries can be created, and to become the dominant player in the next generation of scientific achievement. Already in the EU a platform for industrialization named Photonics21 has been formed, attracting the participation of 2,500 companies, research institutions and universities. In the United States, the National Photonics Initiative has been established, led by the national government and academic associations in the optical field.

Japan has been a major player in the field of optics for many years and has led the world in technologies such as cameras, microscopes, semiconductor manufacturing systems, semiconductor lasers and optical communications. In basic research as well, Osaka University has been called the heart of optical science, and more than 100 research laboratories throughout the university system are engaged in optical science-related research. The Photonics Center has continued to build on these strengths while at the same time conducting pioneering research aimed at producing innovations in industry. As the Center celebrates its 10th anniversary, we wanted to ask people who approach photonics from different perspectives what they think of the future of the Photonics Center and the photonics field.

ADACHI —— My company, SOSHO, Inc., is a venture firm that originated at Osaka University. We provide high-grade crystallization services on a contract basis. We conducted research involving the use of a unique technology in which we successfully irradiated a solution with a laser in order to crystallize difficult-to-crystallize proteins. As a result of this research, we were admitted as a member of the Photonics Center. Currently the three leaders in the area of crystal growth are Japan, China and India. We think that if "Photonics × Crystals" can be established as a new field, Japan would have a monopoly. Our dream is to collaborate with the Photonics Center to become the first company in the world to establish this uniquely Japanese field.

MIYAKE —— As you know, my company, Sharp Corporation, produces a wide range of products and devices in the optical science field. Our major products include liquid crystal displays as well as optical disks and optical sensors. However, not all of these are proprietary technologies. To take liquid crystal displays as one example, we get help from various companies that have specialist technologies, and the products are achieved through this integrated intelligence. In this sense, collaboration in manufacturing is now common practice, and such bonds are particularly strong in the Kansai region. We have high hopes for the Photonics Center, which gathers together cutting-edge knowledge and skills relating to optical science and follows through all the way to industrial development.

MIZUKOSHI —— Like the Photonics Center, the Technology Research Institute of Osaka Prefecture (TRI) is a public research institution. We have a strong desire to become the bridge that provides the seeds of technology to the industrial world. In the 1980s, TRI was one of the institutions that led the world in the development of laser beam lithography using ultraviolet lasers, and this became the prototype for modern 3D printers. Research into

The multidisciplinary field of photonics will lead the way to the universities of the future.

this laser beam lithography technology was continued by industry as a laser processing technology, and it is now one of the major strengths of TRI. In addition, although this may not be considered a state-of-the-art technology, photonics-related research with the aim of technology transfer to industry is one of the areas in which TRI is actively engaged. The Institute conducts research into LED evaluation and research aimed at the development of material modification technologies using lasers. Another unique endeavor is research being conducted by a chemical group, a control systems group and an electronics group with the aim of developing color microlens arrays. We think the efforts of the Photonics Center will produce a dizzying array of research achievements and provide a major stimulus to industry in Osaka, and we feel that TRI will have a certain role to play in this endeavor.

A venue for multidisciplinary research is needed – an arena for scholarly combat.

INOUYE —— How do you view photonics from the standpoint of the Osaka University Graduate School of Engineering?

TANAKA —— This is also true for the university as a whole, but photonics is an extremely important part of the Graduate School of Engineering. The main drivers of engineering are some of the foundational fields of academic study, including machinery, electricity, materials, biology, construction and civil engineering. As to the question of where photonics fits in, it's actually quite multidisciplinary, as Mr. Adachi indicated when he mentioned "Photonics × Crystals." What becomes important at that point is that everyone is able to participate, not whether an organization is established.

The other day when I was having a discussion on another topic, the term "arena" came up. A venue for scholarly combat. (Laugh) It's a forum for cross-disciplinary research — sort of like "a virtual reality that is actually real." The arena increases and decreases in size along with trends and developments in society, and when its purpose comes to an end it sometimes ceases to exist. So it's not a conventional organization. It's not a department, it's not a division, it's an arena. I think this is what the next universities should be like. And it is photonics that will take the lead in demonstrating this to us.

INOUYE —— When the Photonics Center was established and we finally had a venue for photonics research, the people who gathered there were not only applied physics professors but also professors in the fields of electricity and materials and bioscience. Out of a desire to advance photonics in the true sense and create new innovations, we had support from industry as well, and we were able to get the participation of various types of companies. To be sure, it was a trial-and-error process, but our activities have definitely been close to the "arena" that Professor Tanaka describes.

ADACHI —— Although this may be an extreme way of putting it, I think that everything that we do now involves photonics. But conversely, because the sector is so broad, there's nothing specific that you can point to. My company is a member of the Photonics Center, so we're exposed to photonics on a daily basis, and we're able to collaborate with various professors and companies within that context. But I think it would be difficult to understand just by looking at it from the outside. The idea of an "arena" is attractive, but what is connected to what and in what manner, what kinds of collaboration are possible, is an issue that needs to be resolved from this point on. And I think we need to take care in how we present it as well.

TANAKA —— There is no organization, but it looks as if one exists. And if you do a search, you get hits. We need to build that kind of mechanism. Fields that appear from the outside to be "Photonics × Something" don't exist in the type of organizational charts that exist today. But if we somehow managed to make those kind of cross-disciplinary venues visible, I think they would serve as a model for the approach to industry-academic collaboration in the future.

One of the current problems with industry-academic collaboration is that there is not much research funding for collaborations between a company and a single researcher, and there isn't much of a ripple effect from the achievements of that kind of research. So collaborations should be between organizations. Another aspect is that, as Mr. Miyake said, technologies are the result of an accumulation of knowledge held by multiple companies. So if we could make it so collaborations on the part of multiple industries and academia or on the part of multiple industries, government and academia were the norm, these collaborations would have much broader potential. I think photonics is a promising candidate as a field that could play a leading role in that transformation.

INOUYE —— At the Photonics Center, we're starting to see industry-industry collaborations or industry-industry-academic collaborations in which companies work with one another and use the advantages of a multidisciplinary approach to try to solve problems. There are many issues that can't be resolved by a one-to-one relationship and can only be solved by a multiple-to-multiple relationship. I think these kinds of relationships have arisen spontaneously on the part of the members who are currently participating.

MIZUKOSHI —— Although this is not an example that involves photonics, TRI is promoting collaborations between medicine and engineering. Through these medical-engineering collaborations, we learned that there are many problems that can only be resolved by collaborations between many institutions, and as a result we were made aware of the importance of industry-industry collaborations and industry-industry-academic collaborations. I think such collaborations will prove to be important in photonics research as well.

When everything is based on science, everyone gets to stand in the same arena.

INOUYE —— From a company perspective, do you have any concerns about the Photonics Center promoting industry-industry-academic collaboration, expanding membership and forming broad-based networks?

MIYAKE —— As the network grows larger, naturally multiple companies in the same field or the same line of work will come in. Companies these days have a conservative streak, and even if they're told that it's OK to come here and freely talk about things, their feeling is that this is dangerous. Specific dangers would include things like the leakage of information. If there are rival companies at a forum in which my company is participating, if we were asked if we could participate in a free discussion, probably we would all just stare at one another.

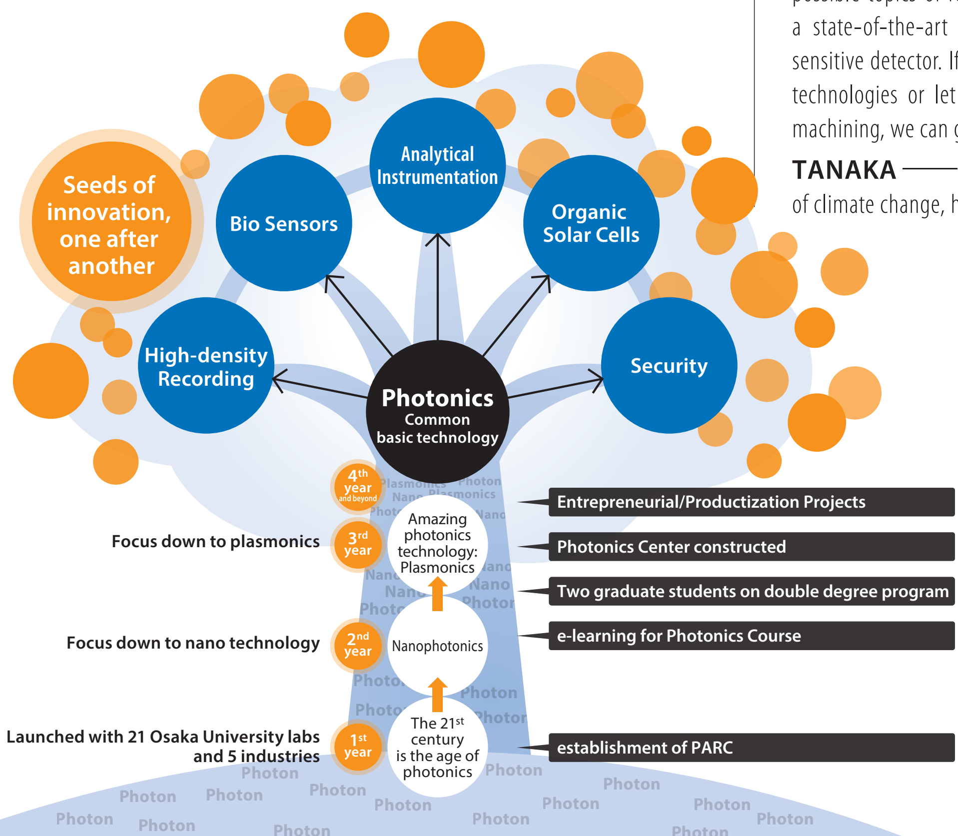
From pure science to business — flexibility is the key to industry-academic collaboration.

So whether it's at the Photonics Center, or an "arena," it would be best if people weren't tied down by their companies. I know it would be difficult to put in practice, but if there were no company ties, we could have a spirited discussion. But as long as we're bound, we can't really have in-depth discussions. Personally, I love to just jabber away and would like to participate, but given my position I would be worried about doing that. In discussions between companies, we're comparatively restrained with one another.

ADACHI —— What's hard for venture firms like ours is that, even if you locate a new technology, there's the question of whether it's backed up by science. Even if it looks correct and seems realistic, if it hasn't been proven, we can't get people to partner with us. I've become keenly aware of the fact that, the newer something is, the more it needs a scientific backbone. It was the same when my company was started up. If the mechanism was known to a certain extent as a result of university research, we made progress on the business front as well. So it turns out that if we base the platform on something that may not be academic but is interesting from a scientific standpoint, we're able to form collaborations and cooperative efforts with surprisingly few constraints, out of pure curiosity.

TANAKA —— The good thing about academic learning is that initially you can say whatever you like. As long as there's no way it can be turned into a business, anyone can participate in the discussion. I think it's fine to bring in new members at that stage. So initially the university can take the lead. However, in recent science and technology, it's difficult to produce research achievements without technical support from companies. There's corporate support even for research at the Nobel Prize level. So in the process of engaging in research that is based on pure science and applying the solutions produced by that research to business, I think the relationships between companies should also change so they have more flexibility.

MIYAKE —— But if you go to all the trouble to form a collaboration on the part of industry, industry, government and academia, you wouldn't want it to end with science, would we? You'd want to take it all the way to the product stage. To that end, we on the company side need to think of how to create an environment in which people can participate with looser ties. I'd love to tap someone on the shoulder and send people off by telling them to "go off and do science that will lead to future results." I think that would be a lot of fun.



Gathering the wisdom and technologies of the Kansai — from major corporations to midsize companies to venture firms.

Clear-cut objectives that make companies want to participate to achieve a shared dream are essential.

INOUYE —— There are many companies in the Kansai region, ranging from major corporations to midsize companies to small and medium-sized enterprises to venture firms, each with its own unique technologies and seeds of technologies. If they can get in sync with one another, the resulting synergy will surely produce interesting technologies. The Photonics Center and Osaka University can be the glue that makes that possible. What do you think we need to do to create greater unity on the photonics stage?

MIZUKOSHI —— We have everything under the sun in Osaka and the Kansai, so in a sense it's not clear what we should focus on. Currently the people at small and medium-size companies are in a bind because they can't figure out how to make use of their technologies. It's true that a platform is an effective means of doing that, but just creating a venue for interchange won't get companies to come there. We need one more thing: a clear-cut mechanism that will make them want to participate. That will make it easy for us to recommend it to companies.

TANAKA —— Without a goal we won't be able to attract members. So we need to establish some kind of major goal. I think it could be something like using photonics to see things we haven't been able to see before, or achieving a double-digit increase in measurement accuracy. We would announce in how many years the goal will be achieved. To that end, we would need companies with a certain kind of elemental technology, companies with a certain kind of ultra-fine processing technology, and companies with the technology to manufacture a certain kind of component. We could broaden our base in that manner.

INOUYE —— For example, we think photonics will make it possible to use spectrographic technology to view the proteins that hold the key to the mechanism of intractable disease onset. In terms of the role of the university, possible topics of research might include developing a new light source as a state-of-the-art technology, or using plasmonics to develop a highly sensitive detector. If we then release the specifications needed for elemental technologies or let it be known that we have a need for ultra-precision machining, we can get companies to become interested in specific projects.

TANAKA —— Safety will be another important objective. In the face of climate change, how can we contribute to safety against natural disasters?

And sensing technologies that make self-driving vehicles possible will also involve light-related technologies, so there must be any number of things that photonics can contribute.

ADACHI —— There is a tree diagram that shows the orientation of the Photonics Center. It might be interesting to extend this tree diagram by adding those types of clear-cut objectives and elemental technologies. Small and medium-size companies are led by the top in the best sense of that phrase, so if the head of the company see something and finds it interesting, it might be possible to achieve something sooner than we think.

However, if I were told to achieve a double-digit increase in sensitivity and precision as a numerical objective, if I tried to make it happen as an extension of existing technology, I think that effort would turn to anguish. (Laugh) I get more excited about a five-digit increase or some other enormous objective that forces me to think about things from a completely different angle.

MIYAKE —— It's the nature of companies to create a succession of small innovations. To researchers like us, it's more interesting to want to launch straight into flight. But for the manufacturing side, single-digit progress is fine. That way you can expand the applications while at the same time improving reliability. From a company stance, naturally risk must also be considered. So the truth is that in a sense it would be difficult for companies to participate if there isn't even the objective of a double-digit increase.

TANAKA —— That's true. It can be a five-digit change or a double-digit change. I think having the freedom to operate on a variety of different levels will produce more stimulation. I'd like to have the capacity and latitude to be able to accept everything.

On the 120th anniversary of the founding of the Osaka University School of Engineering, we can say that, up to now and in the future as well, everything is the result of the people who are involved.

INOUYE —— The original mission of a university is to educate people. I conduct basic research, but even as I do so I'm constantly worrying about how to train young researchers. At the Photonics Center as well, it's essential to fulfill that role with an eye to the future. If there are young people who have a flexible approach and the ability to make conceptual leaps, including them in the circle of open discussions has the potential to spur innovation. As participating companies, how do you view this?

MIYAKE —— I think the Photonics Center will be very useful as a training facility. Getting the participation of young people who have experienced the process of creating a product that takes three to five years, and who have gained sufficient communication skills to be able to translate what companies want, will enable us to conduct in-depth discussions, and I think we'll gain a lot. However, as I said a moment ago, our job on the company side is to put them in a position where they can engage in discussions freely. That will enable them to do various things and enjoy the experience. I think this is a very good field for human resource development as well.

INOUYE —— If they're considering a career as a researcher, it will be even more important to have a college degree, so we on the university side definitely want to provide assistance. At the same time, this will also lead to stimulation for the university. It will give the students and young instructors the opportunity to see things from a corporate perspective and think about

Photonics is also an ideal field for human resource development using university resources.

what kind of research should be conducted with a view to future industrial development. They'll be able to stimulate one another.

TANAKA —— Last year the Osaka University School of Engineering celebrated its 120th anniversary. The university opened its doors in 1896 under its former name as the Osaka Technology School. So it has celebrated the traditional sexagenary cycle (60 years) not once but twice. The university began its history with the objective of training engineers in Osaka. Subsequently, it was incorporated into Osaka Imperial University, laying the foundation for the current engineering department. It is the only engineering school at a national university that was established partly through contributions from the private sector. This is an indication of the desire to train the personnel who would be in charge of manufacturing in the Kansai, and it is an indication that the foundations for industry-academic collaboration were present even at that time. The effort finally bore fruit and the graduates went on to support Japan's period of high-level economic growth in the postwar period. That began around 1956, at the time of the completion of the first sexagenary cycle. From that point on, the university contributed to the progress of the establishment of an industrial nation through research and training to meet the changing needs of society, until the completion of the second sexagenary cycle. So what will be important to enable the School of Engineering to survive through the next sexagenary cycle? The answer is people. There will be nothing left in 60 years unless people are educated. And photonics is expected to play a major role in this regard. It is my firm belief that the people trained within the innovations of the photonics field will include those who will lead the way to the future.

INOUYE —— The Photonics Center will soon celebrate its 10th anniversary as a facility established through the Photonics Advanced Research Center project of the Ministry of Education, Culture, Sports, Science and Technology. Together with five cooperating institutions, the Center has promoted industrial development in the photonics field and has produced both products and industry-industry-academic collaboration. The Center also itself founds enterprises based on the research achievements of university teaching staff, and initiates emergent projects to assist product development. These ongoing innovation efforts have resulted in the establishment of three startup companies and more than 20 products. In terms of international projects, the Center brought the five-year Asian CORE Program of the Japan Society for the Promotion of Science to a successful conclusion, and starting this fiscal year the JSPS Core-to-Core Program (Advanced Research Networks) will begin. The Center will also promote personnel exchanges and personnel training on a global scale.

The Asian CORE Program dispatched and welcomed four thousand several hundred students and researchers. I feel confident that this achievement will prove very useful in creating a venue to serve as the source of the kind of successive photonics innovations that have been talked about here, by companies, venture firms, local governments, national and public research institutions and universities. For example, we have sponsored more than 50 colloquiums that were attended by company researchers, teaching faculty and students, and we plan to continue to hold them in the future as well in order to build a network for active research exchanges in the photonics field. We hope that this will eventually grow into a network that will create Photonics Hills, which will have as its core the Photonics Center located at the Suita campus.

The Photonics Center's Initiatives in Entrepreneurship, Practical Application and Commercialization

At Osaka University, the university with the largest number in Japan of researchers in the field of photonics (the science and technologies related to light), the following projects have been promoted centering mainly on the Photonics Center, and the creation of an "Handai Model" for industry-academia alliances regarding photonics has been pursued.

- **IIndustrialization of photonics**
- **Fostering of young human resources who can take over responsibility for the next generation of photonics**
- **Creation of an international photonics network**
- **Creation of hubs for regional innovation and science parks**

With regard to the industrialization of photonics, we have pursued interpenetration-type cooperation with companies involved in different areas of the light business and photonics partner collaborations with a wide range of small-to-medium companies, also we have encouraged entrepreneur education projects, and the setting up of businesses/productization by faculty and students themselves.

The Entrepreneurial and Productization Projects targeted are those that will lead to business start-ups or productization within two years, and as can be seen from the following table the solicitation of such projects has been conducted four times since FY2012. Following screening by a panel of external judges, 11 of the 59 candidate projects have been selected. Three of them have led to business startups in practice (including one scheduled) and other projects as well have brought a number of successful results in product development. In the following columns (page 6 to 14) shown are a part of our achievements including some of the project themes with the aim of industrial product development which were raised from the Center researchers, photonics appliances, and our industrial product line jointly planned with partner companies. All this shows how we are continuing to build-up and provide a spring that pours out one innovative idea after another, and serves as a forum for the creation of innovation.

Entrepreneurial/Productization Projects	Selected proposals / Applications
1st project application (FY2012)	4 / 18
2nd project application (FY2013)	3 / 18
3rd project application (FY2014)	2 / 17
4th project application (FY2015)	2 / 6
Total	**11 / 59**

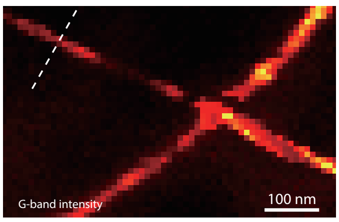
Entrepreneurial/Productization

Tip-Enhanced Raman Scattering Microscope

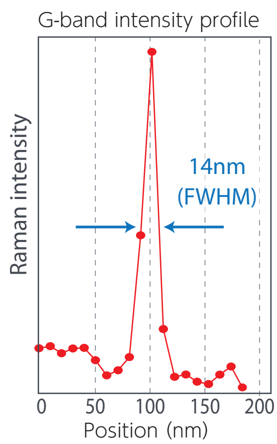
Professor **Satoshi KAWATA**
Department of Applied Physics, Graduate School of Engineering, Osaka University

A Raman microscope that is capable to image molecules with nanometer resolution was invented and patented by Professors Satoshi Kawata and Yasushi Inouye (patent no. 3196945; filing date: October 23, 1992). Its fundamental technologies were developed with support of two JST-CREST projects. This optical microscope consists of a collection of cutting-edge technologies such as atomic force microscope, wavelength-stabilized laser, highly sensitive CCD camera, high performance spectrometer, and plasmonic probe. The operation of the instrument therefore demands professional skills. As a consequence, only certain researchers had been able to use the microscope.

In order to make the instrument usable for general, non-practiced users in the fields of semiconductors, polymers, biotechnology and drug development, and nanomaterials, the inventors themselves started to commercialize the microscope through Start-up and Commercialization Project at the Photonics Center. In particular, they developed reproducible probes by optimizing the shape and materials and established a fabrication technology of these probes. As a result, they could achieve reproducibility exceeding 50%, with 10 nm spatial resolution and Raman enhancement by a factor of several thousands. The technology was transferred to Nanophoton company, where the engineers further polished it up and completed as a compact and easy-to-use apparatus. The nano Raman scattering microscope is now on the market with a brand name of "TERSsense", and is used for strain distribution analysis in carbon nanomaterials and semiconductor devices, imaging biomolecular and polymer materials, and evaluation of lithium-ion batteries.



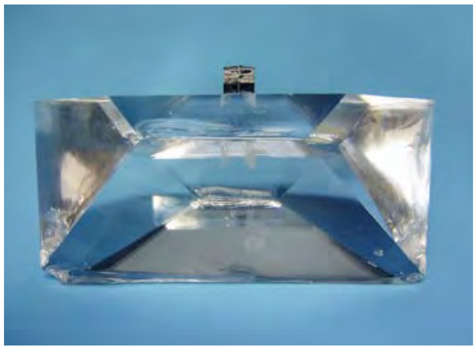
TERS image of Carbon Nanotubes



URL http://www.nanophoton.jp/products/terssense/

CLBO-Supported Manufacturing for a New Era

Professor **Yusike MORI**
Division of Electrical, Electronic and Information Engineering, Grad. School of Engineering, Osaka Univ.



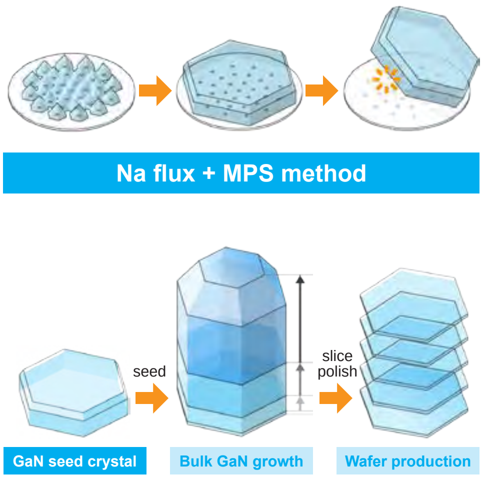
Osaka CLBO™
(115×71×54 mm, 468g)

CLBO, a nonlinear optical borate crystal invented at Osaka University, enjoys widespread use as a wavelength-conversion element for deep-UV lasers in mask inspection systems used in semiconductor device fabrication. In the future, deep-UV laser light sources with higher output than current devices by more than an order of magnitude will be needed for such applications as the inspection of wafers for advanced semiconductor devices that are approaching a few nanometers in size, and the machining of microholes in glass composite circuit boards for microservers. Deep-UV laser ablation will also be needed due to the excellent light absorption of deep-UV in materials that are ordinarily difficult to machine, such as carbon fiber-reinforced plastic (CFRP) and nitride semiconductors.

CLBO crystal has become the only candidate for generating high-power deep-UV light, but crystals currently available on the market have far too many internal flaws and simply do not have sufficient laser damage resistance to the generated UV light. Recently Osaka University in collaboration with Sosho Inc., a university-originated startup, achieved a high-quality CLBO crystal with improved damage resistance and subsequently succeeded in producing crystals at a product-level size of 300g or more. Sosho officially began shipping CLBO samples under the brand name Osaka CLBO™. We will continue working to further strengthen collaboration among industry, government, and academia around this core technology, and hope to develop the world's first high-power deep-UV laser machining system.

Strategy for Creating a GaN Seed Crystal Business to Support Energy-Efficient GaN Wafers

Professor **Yusike MORI**
Division of Electrical, Electronic and Information Engineering, Grad. School of Engineering, Osaka Univ.



GaN wafer production by utilizing GaN seed

While GaN-based nitride semiconductors possess the best optical and electronic properties among all semiconductor materials, the use of heterogeneous substrates such as sapphire and silicon worsen the crystal quality in the device layer. Thus, while GaN-based nitride semiconductors have been used to produce LEDs, the intrinsic characteristics of the material are not exhibited in the device. If we can fabricate large-diameter, high-quality GaN wafers to produce GaN-based devices that exhibit the intrinsic properties of GaN semiconductors, we could achieve optical devices, such as LEDs for high-intensity lighting, and laser diodes with high output power in the red-to-ultraviolet range, including green lasers that are indispensable for laser displays; energy-efficient power devices having less than one-tenth the power loss of silicon devices; and innovative optoelectronic devices, such as ultrahigh-speed transistors capable of dramatically improving the transmission speed and capacity of cell phones.

Achieving high-performance GaN devices requires GaN wafers that are as low in cost and high in quality as Si wafers. However, GaN crystals are grown on heterogeneous substrates such as sapphire using HVPE technology, the only growth technique that has been practical for fabricating GaN wafers. Consequently, large-diameter, high-quality wafers have been impossible to achieve since, in principle, it is not possible to resolve the dislocations and other defects introduced by lattice mismatch between sapphire and GaN and the bends in wafers produced by the difference in their thermal expansion coefficients. For this reason, Osaka University employed the Na flux method as a liquid phase epitaxy process with a multi-point seed technique to achieve GaN crystal growth of a quality that has not been achieved with HVPE technology.

Reducing costs will be an important factor in popularizing GaN wafers. We have plans to launch a university-originated business venture for selling GaN seed crystals. The idea is that supplying our high-quality, large-diameter GaN crystals grown at Osaka University for use as seed crystals to material manufacturers that grow GaN crystals through various methods can be a shortcut to the mass production of low-cost GaN wafers. Our business model is not to acquire revenue through the sales of seed crystals but rather in the form of royalties from the sales of GaN wafers produced from our seed crystals, similar to the business model of ARM Holdings that was recently acquired by Softbank. This business could improve the competitive strength of all related companies from our intended customers, the materials manufacturers, to device manufacturers and system manufacturers, and could help create an ultra-energy-efficient society.

Productization of a Plasma Detector for Gas Chromatography

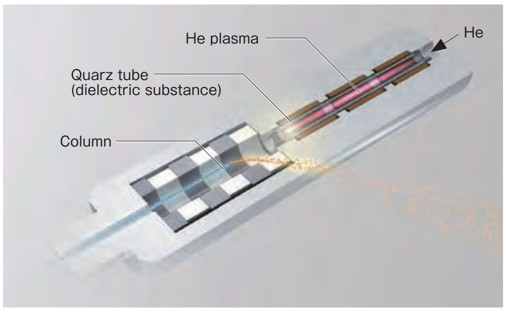
Assosiate Professor **Katsuhisa KITANO**
Center for Atomic and Molecular Technologies, Graduate School of Engineering, Osaka University

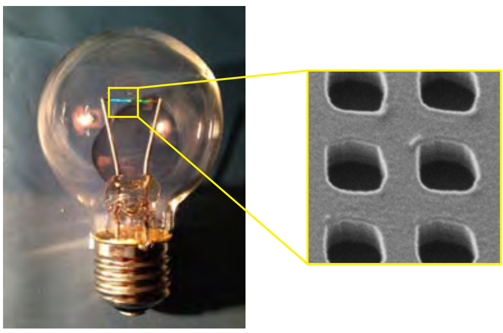
Working with Shimadzu Corporation, we developed a barrier discharge ionization detector (BID), which is a plasma detector for gas chromatography (GC) that uses vacuum ultraviolet (VUV) light emitted from atmospheric-pressure plasma. A gas chromatograph system incorporating this BID went on sale in February 2013 under the brand name Tracera. Known to be emitted from atmospheric-pressure helium plasma, VUV is in the region 13.5–17.7 eV (60–100 nm) called the Hopfield emission and is capable of ionizing any gas species since it possesses photon energy higher than the ionization potential of all gases except neon. Our GC detector was developed based on this principle of photoionization. The detector uses VUV to ionize the sample gas that comes out of the capillary column and electrically counts the resulting charged particles.

Compared to general-purpose detectors such as the conventional flame ionization detector (FID) and thermal conductivity detector (TCD), our groundbreaking BID features superior sensitivity, low variation in response for all gases, and long-term stability that have garnered much acclaim in the marketplace.

URL http://www.an.shimadzu.co.jp/gc/tracera/

– Plasma Technology is the Future of GC Detection –





Eco Light Bulbs Developed through Spectral Control of Thermal Radiation

Professor **Junichi TAKAHARA**
Department of Applied Physics, Graduate School of Engineering, Osaka University

Incandescent light bulbs are gradually being phased out with the increasing popularity of LED lights, since incandescent bulbs are seen as an inefficient twentieth-century technology. Still, I can't help feeling sorry to see these incandescent bulbs disappear, along with their beautiful glowing filaments.

The spectral radiation of thermal emitters like incandescent bulbs includes invisible, and therefore unnecessary, infrared light, which is blackbody radiation described by Planck's law. However, when viewed as energy converters for converting electricity to radiation, thermal emitters have the potential to be 90% efficient or better. If we could suppress the infrared part of the spectrum and put that energy into producing visible light, we could achieve a high-efficiency eco light bulb.

By forming a nanostructure with microcavities in the surface of the incandescent filament, we demonstrated that the visible light spectrum in thermal radiation could be controlled based on the size of the holes. We succeeded in producing an Eco Light Bulb prototype based on this technology. These bulbs are suitable for mass production since their nanostructures are fabricated with the latest nanotechnology called nanoimprint lithography.

We have established a company called Metalumina LLC for planning and designing the bulb. The company name is a portmanteau of metal and lumina (Latin for "light") with an emphasis on the "meta" (meaning "higher order") in metamaterial. For a world that has come to rely more and more on LEDs, we hope to offer more choices in lighting by producing high-efficiency Eco Light Bulbs at Metalumina.

Portable Electrochemiluminescence Analyzer

Professor Eiichi TAMIYA
Division of Precision Science & Technology and Applied Physics, Graduate School of Engineering, Osaka University

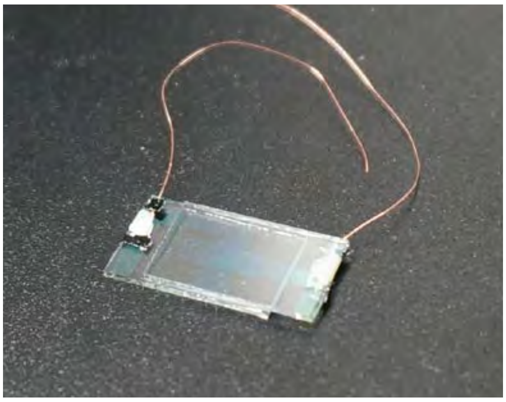
Electrochemiluminescence as a basis of detection in biosensors has attracted attention for achieving high-performance biosensors that can induce precise luminous phenomena through electrochemical control and have high sensitivity in detecting photons released during electrochemical reactions.

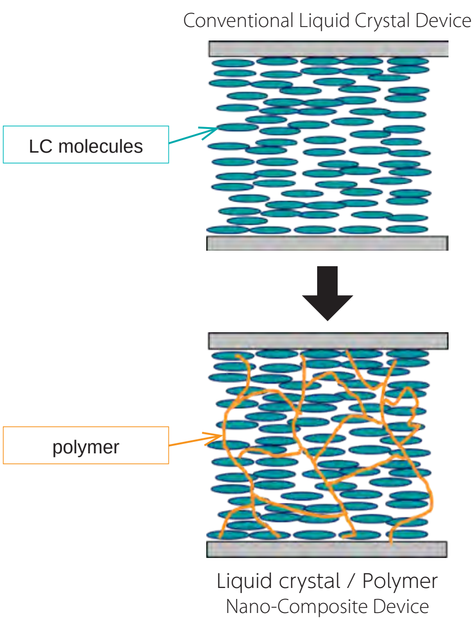
This analyzer incorporates printable electrodes that require no complex electrochemical operations and houses a small, lightweight electrochemical device and an ultra-sensitive photodetector (photomultiplier) that we developed previously. The device has portable specifications, allowing it to be carried to any site where measurements are required. Our analyzer has been employed as many types of biosensors using electrochemiluminescent molecules as indicators (enzyme sensors, gene sensors, immunosensors, and antioxidant sensors), and the research achievements have been published in academic papers and described in patent applications.

We are currently working on making the analyzer more compact and expanding its measurements applications. The prototype is already available on the market through an affiliated company.

URL http://biodevicetech.com/BDTeCLO.html

BDT-eCLP100


Fast and polarization-independent Phase modulator

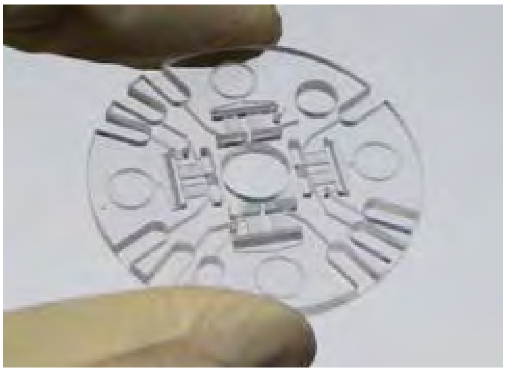


Fast and Polarization-Independent LC Spatial Light Modulator: Academic Achievements and Commercialization Efforts

Professor Masanori OZAKI
Assistant Professor Hiroyuki YOSHIDA
Division of Electrical, Electronic and Information Engineering, Grad. School of Engineering, Osaka Univ.

In recent years, there has been increased demand for devices that can change the direction of light propagation, including variable-focus lenses, light sources with variable irradiating direction, and photonic switches for optical communications. Liquid crystals are being viewed as a promising material system for implementing such devices, since their index of refraction can be tuned by application of voltage. Nematic liquid crystals, which are employed in liquid crystal displays, have rod-like molecules with orientational order and can be switched using just a few volts. However, they are not perfectly suited for phase modulation purposes, since their response speeds are not so fast (on the order of tens of milliseconds) and are inherently polarization dependent.

We are developing a new composite material based on liquid crystals to achieve fast and polarization-independent phase modulation. We are focusing on systems in which liquid crystals are combined with a polymer network having pores approximately 100 nanometers in size. Confinement of the liquid crystal molecules into nano-sized pores has been found to cause a drastic improvement in the response time, enabling sub-millisecond switching. Further, we have shown that the cholesteric liquid crystal, which spontaneously forms a helical structure, can effectively suppress the optical anisotropy and enable polarization-independent phase modulation. We are now developing numerous devices that incorporate this material to achieve a balance of low drive voltage, fast response speed, and polarization independence.



Microchip (top) and device (bottom) prototype. This chip can take in the needed volume of sample and can do rapid PCR on the device.

Easy-to-Use POCT System for Rapid Detection of Pathogens and Infectious Diseases


Assistant Professor **Masato SAITO**
Department of Applied Physics, Graduate School of Engineering, Osaka University

Gene amplification by polymerase chain reaction (PCR) is not only used in basic research, but has applications ranging from genetic diagnosis in clinical laboratories to diagnosis of infectious diseases and food safety and inspection. Quick and sensitive detection and diagnosis of such pathogens as influenza, norovirus, and enterohemorrhagic E. coli is needed, particularly in medical settings and workplace environments like food-processing factories and restaurants, in order to administer suitable medication before a condition becomes severe and to prevent food poisoning by periodically monitoring sanitation.

However, the use of such technologies requires precise and complex preparation of very small amounts of solution, proficient skills, and specialized instruments and equipment, as well as time to perform the reactions and analyses (approximately two hours), which are enormous hurdles to achieving promptness and ease-of-use. To resolve these issues, we developed a rapid and highly sensitive PCR detection system designed for point-of-care testing (POCT) that improves the rate of heat exchange through centrifugation-assisted thermal convection. We also designed and created a prototype of a microchip that introduces only the required volume of sample into the thermal cycler, making it easy for users with no special skills to conduct PCR testing. When verifying the performance of the chip in conjunction with Osaka University Hospital, we succeeded in the rapid (within 15 minutes) detection of drug-resistant bacteria.

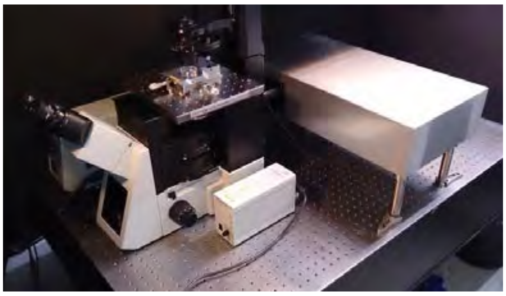
Development of a Commercial Super-Resolution Fluorescence Microscope


Associate Professor **Katsumasa FUJITA**
Department of Applied Physics, Graduate School of Engineering, Osaka University

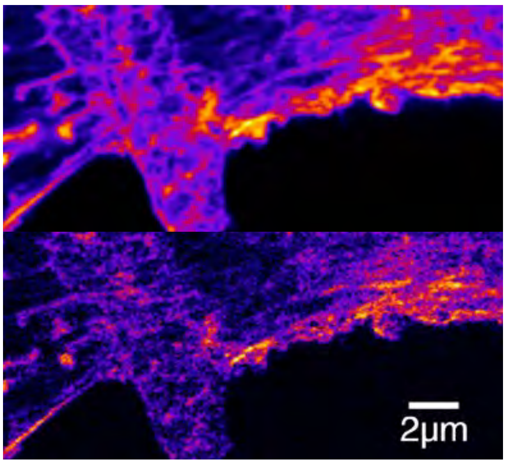
Through support from the Entrepreneurial/Productization Project at Osaka University's Photonics Center, we worked on developing a commercial version of a saturated excitation (SAX) microscope based on our accumulated research and development on super-resolution microscopy.

Super-resolution microscopy was the subject of research awarded the 2014 Nobel Prize in Chemistry. However, around 2005 we were considering a different technique from the technology recognized by the Nobel Committee. We manufactured a prototype from the proof-of-concept, and have been using the technique to carry out basic and applied research on bioimaging. In the Start-up and Commercialization Project we designed a more compact optical system and improved its signal-to-noise ratio with an eye to commercialization. Moreover, we were able to increase the number of applications for super-resolution imaging from cultured cells to biological tissue, develop a prototype capable of standing up to commercialization, and demonstrate achievements in a performance evaluation. By re-examining the optical system and signal processing technology over the course of development, we achieved other technical advances, such as improved resolution over that during the basic research stage, and filed several patent applications.

We are currently in talks with related companies on the commercialization of this super-resolution microscope, and plan to continue creating products from new technologies developed at the Photonics Center.



A prototype of a super resolution microscope (SAX microscope).



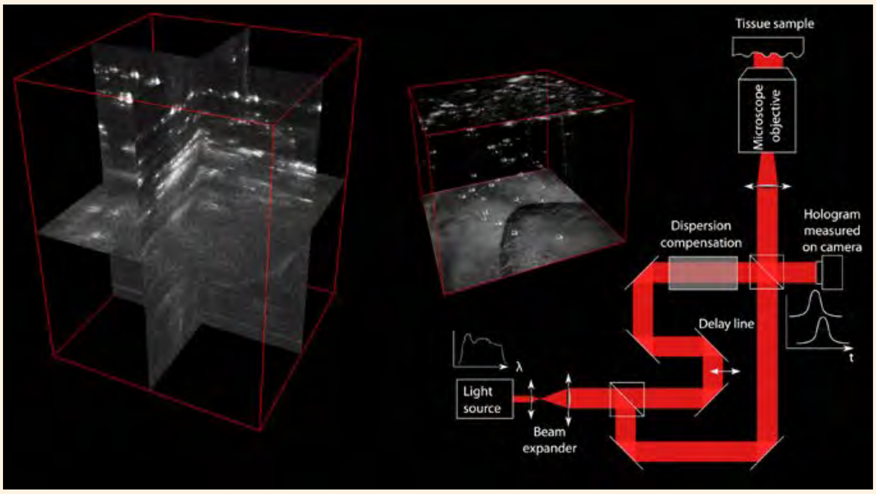
Fluorescence images of cytoskeleton in a cancer cell by (top) conventional confocal microscopy and (bottom) SAX microscopy.

Fast Live Tissue Imaging through Holographic Imaging-Based Coherence Gating

Associate Professor
Dr. Nicholas Smith
Biophotonics Laboratory,
Immunology Frontier Research Center,
Osaka University

Although I started out in physics, I had the chance to open a laboratory in the Immunology Frontier Research Center, where the focus is on finding novel ways to investigate changes in cells or tissue during the immune response. A collaboration with the Photonics Advanced Research Center (PARC) has allowed us to look at new ways of using label-free optical techniques for diagnostic analysis or in-vivo imaging. One of the members of my lab, Dr Nicolas Pavillon, had been working with digital holographic microscopy (DHM), which can recover the phase of a wavefront, that can be linked with the local optical density of the sample.

This DHM mode is non-invasive, and also quantitative, which have generated wide attention and new applications recently, even though it is based on interferometric principles that go back through the history of optics. The key points, as often, lie in the details of implementation. In our lab we had been mostly interested in single cell-level analysis but talking to collaborators in immunology we realized there is significant interest in label-free tissue imaging. Although our DHM mode works in transmission, we then considered similar approaches that can be used in a back-scattering configuration, which is much more applicable to tissue samples. Using a near-infrared broadband light source, which is generated by a pulsed laser and photonic crystal fiber, the coherence of the light then determines the imaging properties of the system. Our system is now constructed and thanks to the support from PARC for equipment and Dr Pavillon's efforts on implementation of this project, the microscope is now able to image at depths of up to 1mm, depending on the scattering properties of the tissue. Initially, for testing and characterizing the system and for saving unnecessary animal experiments, we have focused on either tissue phantoms with beads, or on onion samples, which are layered objects that resemble tissue, with groups of cells that can be resolved by our setup. The images in the figures show a volume of dimensions 1x1x0.8mm for the beads and 1x1x0.9mm for the onion cells. We look forward to now testing on tissue samples, where we hope this setup will provide a new view for biological research or medical diagnostic imaging system.



3d stacks of onion layers (left), and beads in a tissue phantom (middle), as imaged by the broadband coherence gated microscope (right) developed with the support of PARC.

Continuous International Partnerships and Development of Young Human Resources

To create an innovation center, it is important to involve the world from a global view point. At the Photonics Center we therefore have conducted a wide variety of international research exchanges, and also strived for the development of young personnel who will lead the photonics innovation of the next generation.

Funded by JSPS (Japan Society for the Promotion of Science) for the duration of 2011 to 2015, we dispatched/received over four thousand young researchers, teaming up with overseas research institutes in China, Taiwan and Singapore, with the aim of forming an advanced nanophotonics research and education center in Asia. From 2016 the Center has developed and expanded to the CORE-to-CORE Global Center of Nanophotonics Research and Education. We now work with institutes from 11 countries/regions, and the funding will continue till 2020.

We have so far hosted Asia/Global Student Photonics Conferences five times. All planned and organized by university students, the Conferences have attracted a cumulative total of over 300 participants.

More than 50 colloquiums (lecture meetings) have been held since the inauguration of the Photonics Center, focusing on a wide range of subjects including entrepreneurship. We also provide "Tuesday Morning Tea" for our Center members at the Photonics Center building, where professors, students and partner company researchers gather each week to exchange their views and ideas in a free atmosphere.

We have hosted photonics science schools for children ("Super Hikarijuku") seven times. Run by university students, this series of outreach seminars has attracted the participation of 40 to 50 elementary school students every time it has been held.

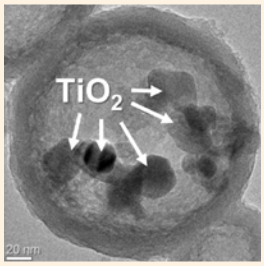
Hollow Nanocapsules for Developing Paper Products with Photocatalytic Functions

Professor
Hiromi YAMASHITA
Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University

Assistant Professor
Yasutaka KUWAHARA

Owing to its excellent photochemical properties, titanium dioxide (TiO_2) is widely used in photocatalysts for environmental purification, UV absorbers, and exterior building materials. However, when exposed under ultraviolet light, TiO_2 has a strong oxidizing power that can degrade and damage organic supports, such as fibrous or resinous materials. Therefore, the surface of the TiO_2 must be deactivated for certain applications. Our research group developed a new technique for encapsulating TiO_2 in hollow silica nanocapsules (patent application no. 2015-029778). The silica acts as a protective wall that prevents the TiO_2 from contacting the supports, thereby suppressing photodegradation. In addition, by providing space between the TiO_2 and silica, the TiO_2 demonstrates an intrinsic photocatalytic decomposition function that can effectively decompose and remove VOC gases (aldehydes, etc.) present in the atmosphere at low concentrations. Our photocatalyst can be used to manufacture paper products having deodorizing and anti-fouling properties, such as wallpaper, fusuma and shoji sliding doors, and is expected to have applications in amenity spaces.

We are currently working with the Paper Technology Center (Ehime Institute of Industrial Technology) in Ehime prefecture to develop paper products having these photocatalytic functions, as well as their practical applications.



TEM image of a silica nanocapsule photocatalyst encapsulating TiO_2

paper fabricated from a composite of this photocatalyst

Tunable-Focus Eyeglasses: Academic Achievements and Commercialization Efforts

Professor
Masanori OZAKI
Division of Electrical, Electronic and Information Engineering, Graduate School of Engineering, Osaka University

Assistant Professor
Hiroyuki YOSHIDA

Specially Appointed Researcher
Giichi SHIBUYA

Liquid crystal lenses can control the wavefront of incident light owing to the retardation of the liquid crystals, causing light to converge or diverge just like normal convex and concave lenses. However, liquid crystal lenses are distinctive in that their focal length is readily modified according to the magnitude of applied voltage. By exploiting this feature, a liquid crystal lens 2mm in diameter has been incorporated into a micro camera as an autofocus system having no moving parts. However, one shortcoming with conventional liquid crystal lenses is the tradeoff between lens power and lens diameter. It is difficult to increase the aperture of the lens without a decline in response times and transmittance.

In our research on how to resolve this issue, we attempted to apply the principles of a Fresnel lens to liquid crystal lenses. By devising special transparent electrodes and thin film structures, we succeeded in inducing in the liquid crystal layer a sawtooth distribution of electric potential similar to that in a Fresnel lens.

Applying this Fresnel structure to a liquid crystal lens having a 30μm thick liquid crystal layer, comparable to previous lenses, we succeeded in expanding the lens aperture to 30mm while achieving a variable lens power of ±4D (diopters: the reciprocal of focal length). We are now conducting research daily in an effort to apply this technology to tunable-focus eyeglasses.

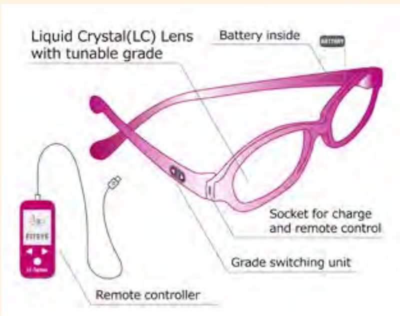
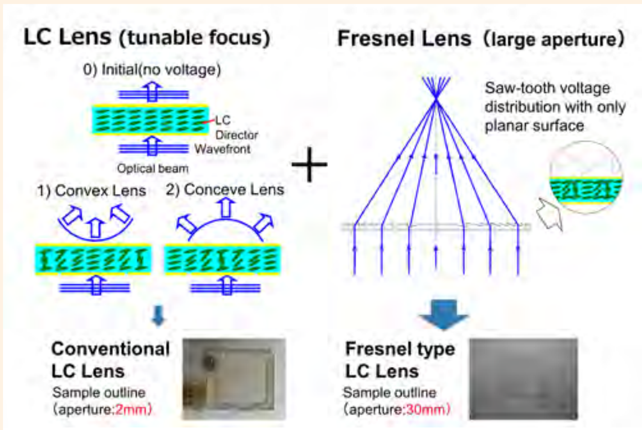


Image of product



Principle of Fresnel LC Lens

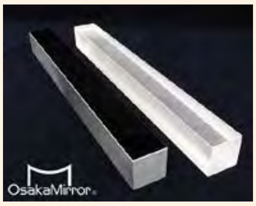
A Wide Range of Photonics Applications

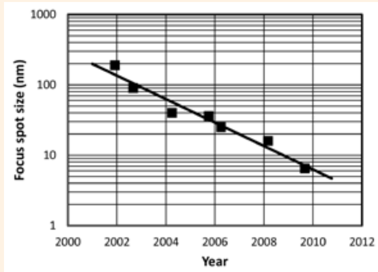
State-of-the-Art X-Ray Mirror Opticsoptics

Professor Kazuto YAMAUCHI
Department of Applied Physics
Gradduate School of Engineering
Osaka University

In order to fabricate a surface with nanometer-level accuracy, we developed an ultraprecision machining method for measuring the distribution of figure error in an area several hundred nm^2 at sub-nm height resolution and sub-10-μm lateral resolution and for deterministically removing the error profile in units of atoms. An exceptionally smooth surface of 0.1 nm RMS or less could be obtained automatically in areas no greater than 10 μm^2. Practical applications for X-ray mirrors were also being developed around 2005 at the same time we were perfecting this method, and we became the first in the world to successfully realize diffraction-limited X-ray focusing. Of all the various focusing techniques, focusing with an X-ray mirror was anticipated to produce great advances in synchrotron radiation science, provided that the technique could achieve better than 90% efficiency at a long working distance with no chromatic aberration.

We began developing a commercial product at once aimed at meeting the demand at synchrotron radiation facilities around the world. My involvement with this venture company (JTEC Corporation), which was launched by fellow classmates at the university, came about because I was mentoring a student in the doctoral program who was just entering the company at that time. Though it was all by chance, the circumstances came about as if by design. This is a field in which high precision is more important than productivity, and we were able to achieve commercialization smoothly rather than becoming another research casualty. Our core group of three engineers has now grown to more than twenty members and, having received funding this year from Osaka University Venture Capital, we are now supplying the world with mirrors capable of forming a nanometer-size beam. Branded the Osaka-Mirror, our product has become indispensable for advanced synchrotron beam lines.





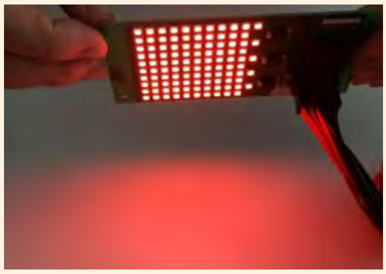
This graph shows improvements over the years in the hard X-ray spot size produced with the Osaka-Mirror. We began making a commercial product after achieving sub-50-nm resolution in 2004, and broke through the 10-nm barrier in 2010. Having now reached the limit in spot diameter, we are currently working on developing new X-ray optical systems, including an optical system with adjustable beam size and a chromatic aberration-free optical imaging system. These systems provide experimental conditions essential for X-ray free-electron laser facilities.

Development of Narrow-Band Red LEDs and Their Application to Phototherapy

Professor Yasufumi FUJIWARA
Division of Materials and Manufacturing Science
Graduate School of Engineering
Osaka University

Advances in light-emitting devices built around lasers and LEDs has led to increasing development of their applications in medicine, and particularly dermatology. It has been reported that low-level laser radiation can promote hair growth. In fact, a hair growth stimulator using red lasers has been approved in the United States. In the meantime, LED phototherapy has drawn interest as a means of irradiating the surface of the body more safely and with wider coverage. Hair growth was also reportedly stimulated by combining conventional AlGaInP/GaAs red LEDs and a band-pass filter to irradiate light in a narrow-band spectrum with 10 nm full width at half maximum (FWHM). Moreover, experiments conducted at the cellular level confirmed that this radiation encouraged dermal papilla cells to secrete a cell growth factor. We were the first in the world to successfully develop red LEDs using nitride semiconductors by doping GaN with europium (Eu), a rare earth element (PARC Newsletter Vol. 4).

Unlike conventional red LEDs, this red LED has a sharper emission spectrum owing to the use of intra-4f shell transitions in the trivalent Eu ions, and less than 1nm FWHM at room temperature. We have begun verification tests for phototherapy applications using our narrow-band red LEDs, and hope to expand the applications of these LEDs to other fields.



A narrow-band red LED panel
with promising applications in phototherapy

Jointly Planned Products

Hulscope

ジュラロン工業株式会社
JURARON INDUSTRIES INC.

When discussing research once with the Photonics Center at Osaka University, they suggested we could try to construct a small, high-performance macro lens for use with a smartphone. Greatly interested in this idea, we promptly created a prototype of a case configured to hold a lens, and inserted a mass-product objective lens for optical pickup. The researchers at the Photonics Center were quite pleased when we showed them this prototype, and encouraged us to keep working on a more user-friendly version with better optical characteristics. We concentrated all our company's technological resources into manufacturing a special lens, which is a single aspheric lens reducing distortion in the periphery of the image. Then, employing our precision plastic molding technology, we manufactured a plastic lens having a tiered structure around it designed to let in ample light and a cap that easily snaps on and off the body.

The primary challenge was how to mount the Hulscope on a smartphone given the size limitations of the product. The solution was to incorporate an adhesive sheet capable of repeated use (whose adhesive power can be restored by washing). After setting up a production system, the product went on sale in September last year. The Hulscope was officially selected as a 2015 OSAKA-SEI Brand.

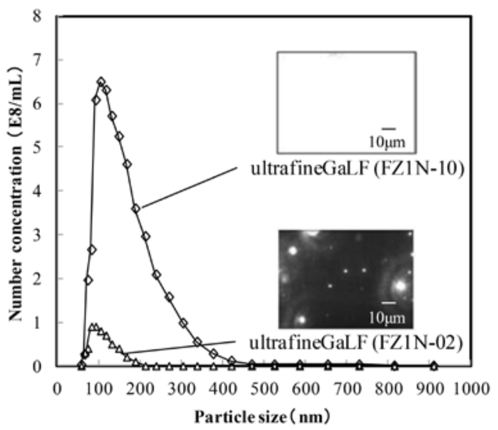
The body and cap
of the Hulscope

The Hulscope attached
to a smartphone

IDEC **IDEC CORPORATION** http://www.idec.com/

Superior Ultrafine Bubbles Generation Technology ultrafineGaLF

Superior ultrafine bubbles generation technology of IDEC has been developed by optimizing the ultrafineGaLF construction, resulting in far higher ultrafine bubble concentration. Laser diffraction method will be an extremely effective with fine bubble measurement method once the technology is mature, as it can be used over a wide range of particle diameter and number concentration without significant pre-processing. The ultrafine bubble water generated with this technology was measured for number concentration using laser diffraction method of SHIMADZU, and was found to have an ultrafine bubble concentration of over 1E9 bubbles/mL. A comparison of experimental results showed that laser diffraction method is more accurate than particle tracking analysis in terms of measuring bubble diameter distribution and number concentration.



Particle size distribution of UFB analyzed
by laser diffraction/scattering and scatted-light images (insets)

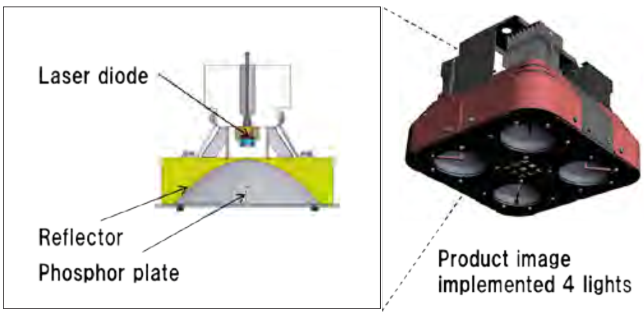
ultrafineGaLF(FZ1N-10)

High-Efficiency White Spotlight with a Laser Diode Light Source

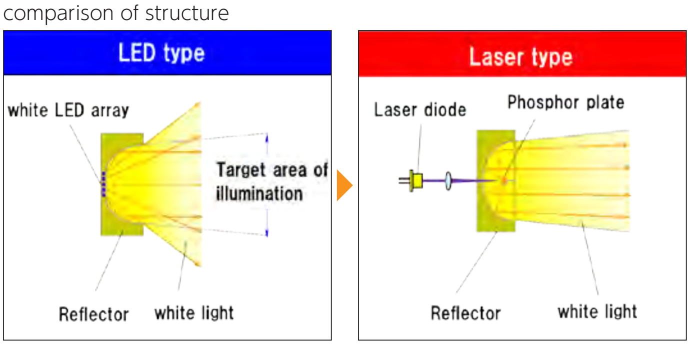
IDEC Corporation succeeded in developing a high-efficiency spotlight that combines a high-power laser diode with a phosphor plate having excellent conversion efficiency and a reflector with good focusing capability. This white spotlight saves 30% more energy (power required for focusing light with luminous flux of 890 lm within ±3° angular distribution) than a spotlight using a white LED array. Next, we hope to develop an efficient spotlight for visual work illumination that is practical for use in factories and warehouses having a ceiling height of 10m or more.

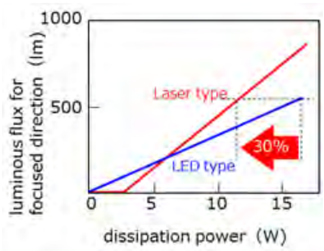
LED light sources are difficult to focus and are inefficient at high outputs. However, the spotlight developed by IDEC achieves good focusing capability by exciting a phosphor plate with a laser diode to produce a point source. They also designed a thermal insulation construction for dissipating heat from the light source and phosphor plate in order to realize better energy-saving performance than LEDs at high outputs.

Some of the elemental technology was made possible through collaboration with Panasonic (laser devices having both high power (5W) and high efficiency (37%)) and Nitto Denko Corporation (temperature control technology for ceramic phosphor plates). Also, this work is supported by the New Energy and Industrial Technology Development Organization (NEDO), Japan, under the Strategic Innovation Program for Energy Conservation Technologies.



comparison of structure





comparison of dissipation power with LED

A Photonics Network in Germany's Jena Region

Seminar report: Photonics Cluster Opportunities in Eastern Germany;
held in Tokyo and Hamamatsu in 2016; sponsored by Germany Trade & Investment

Jena is considered the birthplace of modern optics, where scientists like Ernst Abbe, Otto Schott, and Carl Zeiss were active in the latter half of the 19th century. Today, Jena is home of the Jena optics valley, center of the photonics network OptoNet in the state of Thuringia. Through state and federal support, numerous start-ups have been launched in this region, some of which have grown into small and medium-sized businesses. OptoNet has been nurturing close and longstanding industry-academia collaboration between these small and medium businesses and university and non-university research institutes such as the Fraunhofer institutes. The region is fertile ground in Germany for such industry-academia collaboration as establishing new strategies for advanced technology, strengthening collaboration among university and non-university research institutes and users companies, and refining ideas into innovation (see PARC Newsletter Vol. 5). As a result of these efforts, the photonics industry has been elevated to one of Germany's principle technologies. The asset turnover in the Jena optics industry is three times Germany's average. The industry exceeds 10% in R&D investment and anticipates the creation of three thousand new jobs by 2020. The optics industry in Thuringia boasts 175 companies, a workforce of 1,500 employees, about 4,000 students majoring in optics-related fields, about 1,300 employees in research institutes (university and non-university), about 630 trainees, €2.8 billion in sales, and a 66% export share of sales.

OptoNet –Competence network for Optical Technologies–

optonet Photoniknetzwerk Thüringen

» Founded in 1999 within the framework of the German program "Optical Technologies for the 21st century".

» Currentry 92 members

75	6	4	6	1
Companies	Research establishments	Universities & Other educational institutions	Banks & Venture capital	Technology transfer agency

The Jena optics valley: Visit POPsud 2008
(source: Optonet, Dr. Klaus Schindler, CEO of OptoNet)

Dr. Klaus Schindler, the CEO of OptoNet, notes that the association was formed in 1990 with just ten companies. At that time, OptoNet relied on government assistance, but by 2011 had become self-funded, operating only on membership fees. OptoNet represents the interests of its more than 100 members, serves as an information and communication platform, strengthens the domestic and international visibility of the cluster, sponsors career programs (engineers are the most valuable asset), markets the photonics region, facilitates collaboration between small and medium businesses and research institutes (the small and medium businesses are what support Thuringia), and stresses the importance of collaboration and networking over commercialization and profits.

According to Andreas Tünnermann, director of the Fraunhofer Institute of Applied Optics and Precision Engineering, the Fourth Industrial Revolution (Industry 4.0) is expected to meet the needs of society by helping an aging workforce maintain and expand Germany's manufacturing industry. To this end, machines must be designed to assist humans, which will require novel sensors, which in turn will require optics and photonics. Thus, the problem of an aging population is actually an opportunity to find solutions with photonics. He also emphasized the importance of making this region a hotspot for specialized research institutes and industries.

The experience in Jena and OptoNet e.V. are great references for the photonics network being constructed in Osaka.

AIST and Osaka University's Cooperative Open Innovation Laboratory is Commencing

In April 2017, the AIST-Osaka University Advanced Photonics and Biosensing Open Innovation Laboratory, or "PhotoBIO-OIL," will open at the Photonics Center, Osaka University.

In March 2011 the National Institute of Advanced Industrial Science and Technology (AIST) and Osaka University agreed to cooperate to promote rapid progress in research, education and social contributions, as well as advancement in international partnerships, industry-government-academia cooperation and personnel development. The agreement includes joint studies concerning the man-machinery fusion domain, informatics application in industries and cooperative research in engineering with medical science.

The PhotoBIO-OIL will be the first lab to implement laboratory cooperation between AIST and Osaka University, and it will focus on R&D concerning the new generation biosensing system at bio molecular level by utilizing AIST's bio device technology in genetic engineering and micro fluid control, in addition to the Photonics Center's highly advanced fundamental technology in low-invasive/high-sensitivity biomolecule measurement and data processing.

The Laboratory will adopt the cross-appointment system in which researchers will serve as personnel of both Osaka University and AIST, thereby helping to promote the development of human resources who have a wide perspective and can contribute to the industrial world.

Opening ceremony
on January 6th, 2017

President Ryoji Chubachi of AIST and President Shojiro Nishio of Osaka University

Photonics CENTER

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