International research collaboration activities in Photonics Center of Osaka University

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Abstract
Photonics Center at Osaka University has been a world-class center for research, education and industrial collaboration in the field of photonics for the past 10 years. Particularly, for the past 5 years, Photonics Center had a JSPS-funded Asian Core research program, which was aimed on collaborative research in the field of photonics through the exchange of students and young scientists between Japan and three other Asian countries. This program successfully completed in March 2016 with highly productive results and was evaluated very high by the JSPS. After the successful completion, we applied for and were able to secure a new JSPS-funded Core-to-Core program for another 5 years. With our past experiences, international networking and growing research ideas, the new program includes 11 different countries and is not only limited to Asia, but also involves USA, UK and Australia. We will discuss more details of the international research collaboration activities in the past 5 years, present status and future prospective.

Keywords: Photonics, International research collaboration, Exchange of young students/scientists.

1. Photonics: future of the 21st century
Photonics is a key technology that has already been attracting huge attention and is expected to redefine the practical usage of science and technology for the society in the 21st century. The 20th century saw a boom in electronics and electronics was established as an essential part of our lives. Photonics is going to be as important, if not more, in the 21st century. Electronics is all about controlling the mobility of electrons for the desired results, where electrons need a medium to travel, such as metallic wires and semiconductors. Thus the development of electronics has covered the Earth with wires and cables. On the other hand, photonics is all about controlling light (photons) to achieve desired results. Interestingly, light can travel through air, water, glass, vacuum space, or even through our bodies for certain wavelengths, without a need of any particular medium. Photonics will allow us to get rid of all wires and cables and revolutionaries the future science and technology. Therefore, photonics has a pronounced future and this is very timely to focus our research attention on photonics. The Photonics Center in Osaka university has taken up this challenge for the past 10 years, and there have been dedicated funding and very active international collaboration in the past 5 years.

2. Asian Core Program
The Photonics Center at Osaka University had an Asian Core research & education exchange program, named as the “Advanced Nano-Photonics Research and Education Center in Asia”, which was funded by the Japan Society for the Promotion of Science (JSPS) for 5 years starting from April 2011 to March 2016. This program was based on international exchange of students and scientists, where several Japanese universities and institutes under the leadership of the Photonics Center at Osaka University had very active and productive collaborations with various universities and institutes in China, Taiwan and Singapore. Figure 1 schematically explains the structure of this program, where different countries focused on different topics within the broad field of photonics and nano-photonics. High-level joint research in these fields were conducted through exchange of personnel. Especially, graduate students and young researchers were both dispatched and accepted for short and long terms to conduct collaborative research and to educate one another in the advanced research on photonics and nano-photonics. This established the Photonics Center of Osaka University as the nano-photonics research and education hub in Asia. Under
this program, we not only successfully completed 14 bilateral research projects between Japan and partner Asian countries, but also conducted eight international symposia in either Japan or in a partner country. The total number of dispatch of students and young researchers was 165 with a total of 1,174 man-days, and that for the accepted was 198 people with a total of 3,072 man-days, constituting a total of 4,246 man-days of exchange. This program was highly evaluated by the JSPS and we successfully completed the term of the program. The details of some scientific results that came out from the activities of this program is discussed elsewhere [1].

3. Core-to-Core International Program

The allocated term of the Asia Core program finished in March 2016, but it only left us with more experience and confidence in leading photonics research, more ideas for further high-impact research, and more international networking, leading us to apply for a bigger plan with a larger international team to go ahead with the further collaborative research in photonics. In the fiscal year 2016, we were able to secure yet another 5-year Core-to-Core research exchange program. This time the program involves 11 countries, not only from Asia, but also USA, UK, and Australia. This Core-to-Core program is named as the “Advanced Nanophotonics in the Emerging Fields of Nano-imaging, Spectroscopy, Nonlinear Optics, Plasmonics/ Metamaterials and Devices”. The structure of this new program is briefed in Fig. 2, where one can notice that various partner countries are collaborating with Japanese teams in different hot topics in the field of nano-photonics [2]. This program has just started and we are expecting huge success with impressive impact in photonics research. We have already started 15 individual bilateral projects and planned a kick-off seminar at the end of November 2016, where we are expecting a participation of about 120 scientists/graduate students from 11 partner countries.

![Fig. 2: The structure of the new Core-to-Core Research Program at Photonics Center of Osaka University.](image)

References
2. Home page of the Core-to-Core Program: http://c2cgnp.parc.osaka-u.ac.jp/

Biography
The first author, Prabhat Verma, is presently a Professor at the Department of Applied Physics and a member of Photonics Center at Osaka University. He is an Executive Director of the Japan Society of Applied Physics and the Chair of the JSPS Core-to-Core Program at Osaka University. Prof. Verma received his Master from the Indian Institute of Technology (IIT), Kanpur and Doctorate from IIT Delhi, India, after which he did his post-doctoral research in Germany and Japan. He joined Osaka University in 2002 as an Associate Professor, and subsequently became a full Professor in 2010. His current research interests are tip-enhanced Raman spectroscopy (TERS), plasmonics, nanophotonics, nanospectroscopy and nanoimaging. He has co-authored a large number of papers in high ranked journals, such as Nature Photonics, Nature Communications, Physical Review Letters, ACS Nano, Nanoscale, etc. He has organized multiple international conferences and has delivered about 50 invited talks in various international conferences.