



## Silicon-Organic hybrid Fabrication platform for Integrated circuits

### Report on the impact and outcome of the organized promotion events.

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2	SELEX - Sistemi Integrati	SELEX	Italy	M1	M42
3	Interuniversity Microelectronics Centre - IMEC	IMEC	Belgium	M1	M42
4	Rainbow Photonics AG	RB	Switzerland	M1	M42
5	GigOptix-Helix AG	GO	Switzerland	M1	M42
6	Research and Education Laboratory in Information Technologies	AIT	Greece	M1	M42
7	The University of Sydney, Centre for Ultrahigh bandwidth Devices for Optical Systems	CUDOS	Australia	M1	M42

<sup>1</sup>

PU = Public

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## **1. Executive Summary**

This deliverable reports the outcomes of the promotion event that have been organized by SOFI project with the purpose to promote the research results to the scientific community.

The SOFI project has organized 3 major events that include: one workshop at ECOC 2012 and two special sessions collocated with ICTON 2012 and 2013 conference. Moreover SOFI has participated in a spring school in 2013.

The major outcomes that are identified are:

- The awareness of the targeted audience about the SOFI research studies, the results and the project objectives that are generated based on specific targets and approaches agreed by a group of collaborative institutes rather than individual research activities
- The valuable discussions with other researchers that are active in similar topics resulting in the identification of common solution and approaches and the generation of new ideas and fruitful collaborations for the fulfillment of the SOFI project objectives

## 2. SOFI project promotion events

SOFI project has organized the following promotion events:

- A Special Session on “Silicon Photonics Based Components”, co-located with ICTON 2012, held in Coventry, England, on July 2 – 5, 2012.
- An ECOC 2012 Workshop on “Silicon Hybrid Photonics” held in Amsterdam, Netherlands, on September 16, 2012
- A joint SOFI/NAVOLCHI Special Session on "CMOS Fabrication-Based Photonic Technologies for Communications" co-located with ICTON 2013, held in Cartagena, Spain on June 23-27, 2013.

The purpose of these events was to present the outcomes of the undertaken research activities on Silicon photonics components and systems and to stimulate useful discussions among experts in this topic on the new technology trends, achievements and solutions.

Also SOFI participated in the Erasmus Mundus Spring School 2013, held in Hohenwart Forum, Germany on April 08-10, 2013 and organized by the SOFI partner KIT.

The following paragraphs provide details on the structure of the organized events and evaluate their outcome and impact to the SOFI project.

### 2.1 Special Session on Silicon Photonics Based Components at ICTON 2012

This promotion event has been organized by the SOFI partners AIT and KIT as a full half day session on the 5<sup>th</sup> of July 2012. The main goal of this event was to solicit invited and contributed presentations on the hot topic of silicon photonics based components for telecommunications and high performance computing applications.

The final structure of the session program is shown below:

SESSION Th.A5 (9:30 – 11:40)	
SOFI	
9:30	<b>Th.A5.1</b> Chip-to-chip plasmonic interconnects and the activities of EU project NAVOLCHI ( <i>Invited</i> ) <i>A. Melikyan, M. Sommer, A. Muslija, M. Kohl, S. Muehlbrandt, A. Mishra, V. Calzadilla, Y. Justo, J.P. Martínez-Pastor, I. Tomkos, A. Scandurra, D. Van Thourhout, Z. Hens, M. Smit, W. Freude, C. Koos, J. Leuthold</i>
9:50	<b>Th.A5.2</b> Surface plasmon-polariton amplifiers ( <i>Invited</i> ) <i>I. Suárez, P. Rodriguez-Cantó, R. Abargues, J. Martinez-Pastor, E.P. Fitrakis, I. Tomkos</i>
10:10	<b>Th.A5.3</b> Low energy routing platforms for optical interconnects using active plasmonics integrated with silicon photonics ( <i>Invited</i> ) <i>K. Vyrsokinos, S. Papaioannou, N. Pleros, D. Kalavrouziotis, G. Giannoulis, D. Apostolopoulos, H. Avramopoulos, J-C. Weeber, K. Hassan, L. Markey, A. Dereux, A. Kumar, S.I. Bozhevolnyi, M. Baus</i>
10:30	<b>Th.A5.4</b> Broadband and picosecond intraband absorption in lead based colloidal quantum dots ( <i>Invited</i> ) <i>B. De Geyter, P. Geiregat, D. Van Thourhout, Yunan Gao, S.T. Cate, A.J. Houtepen, J.M. Schins, L.D.A. Siebbeles, Z. Hens</i>
10:50	<b>Th.A5.5</b> Silicon-organic hybrid fabrication platform for integrated circuits ( <i>Invited</i> ) <i>D. Korn, L. Alloatti, M. Laueremann, J. Pfeifle, R. Palmer, P.C. Schindler, W. Freude, C. Koos, J. Leuthold, Hui Yu, W. Bogaerts, K. Komorowska, R. Baets, J. Van Campenhout, P. Verheyen, J. Wouters, M. Moelants, P. Absil, A. Secchi, M. Dispenza, S. Wehrli, M. Bossard, P. Zakyntinos, I. Tomkos</i>
11:10	<b>Th.A5.6</b> Exploiting photosensitive As <sub>2</sub> S <sub>3</sub> chalcogenide glass in photonic integrated circuits <i>S. Grillanda, A. Canciamilla, F. Morichetti, Juejun Hu, V. Singh, A. Agarwal, L.C. Kimerling, A. Melloni</i>
11:25	<b>Th.A5.7</b> Towards plasmonic lasers for optical interconnects <i>V. Dolores-Calzadilla, A. Fiore, M.K. Smit</i>

The speakers identified the great potentials of the silicon photonics technology as it is based on the mature low-cost CMOS fabrication process technology, thus allowing for the convergence of electronics with optics on the same platform. This was highlighted in many presentations, showing the requirements and fabrication processes of platforms for integrated circuit systems. Moreover, the session presented the new technology advancements, like the silicon-organic hybrid technology developed within the framework of SOFI, that enable the creation of new components with functionalities that so far are not available in silicon and achievable bit-rates beyond 100 Gbit/s.

The participation in this session was exceeded 40 people; (no official participation data per session are available by the organizers). The session closed with a 15min open discussion among the invited presenters in which all highlighted the future potential of silicon photonics mainly towards: a) the creation of low energy consumption and high bandwidth components and b) integrated system solutions primarily for applications in data interconnects.

## 2.2. Workshop on “Silicon Hybrid Photonics” at ECOC 2012

The most significant promotion event for SOFI project was organized at ECOC 2012 held on Amsterdam, Netherlands on September 16-20, 2012. ECOC is the largest conference on photonic technologies, system and network applications in Europe and the second largest in the world attracting over 1000 researchers to present their work and be updated on the latest research achievements. The first day of the conference is devoted to limited number of specialized and targeted half day workshops.

The SOFI workshop on Silicon Hybrid Photonics was organized by the SOFI partner IMEC in collaboration with Rainbow Photonics partner and Ghent University. A list of the presentations in this workshop is provided in the table below:

Sunday, 16 September • 09:00–12:30 Room B WS2: Silicon Hybrid Photonics
<b>III-V on Silicon Integration for Active-passive Photonic Integrated Circuits</b> <i>John Bowers,</i> <i>University of California, Santa Barbara, USA</i>
<b>Silicon-organic Hybrids for Modulators and Nonlinear Applications</b> <i>Juerg Leuthold,</i> <i>Karlsruhe Institute of Technology, Germany</i>
<b>Monolithic Optical Isolators for Silicon Microphotonics</b> <i>Lionel Kimerling,</i> <i>Massachusetts Institute of Technology, USA</i>
<b>SiGeSn Photodiodes with Tunable Band Gaps Integrated Directly on Si and Ge Platforms</b> <i>John Kouvetakis,</i> <i>Arizona State University, USA</i>
<b>New Trends in Carbon Nanotubes Based Photonics on Silicon</b> <i>Nicolas Izard,</i> <i>Université Paris Sud, France</i>
<b>Bringing New Materials in a Silicon Fab: A Good Idea?</b> <i>Peter Verheyen,</i> <i>IMEC, Belgium</i>

The event hosted a total of six 30 minute presentations and allocated another 30 minutes at the end for discussions and questions between the audience and panel of presenters. It is noted that

half of the presentations were provided by researchers in European institutes and the half by researcher from renowned institutes in the USA. All presenters are among the worlds' experts in the field of silicon photonics, and as a result the latest research trends in the field were summarized in this workshop.

The presenters identified silicon photonics as one of the most promising technologies for large-scale photonic integration. They have highlighted the new capabilities that are offered for the development of high index contrast, compact and complex passive circuits based on CMOS manufacturing technology today. However, it was commonly agreed that since silicon on its own is impossible to be a material for active optical elements (e.g. modulators, switches, detectors, and especially light sources), the hybridization of the silicon platform with novel materials is strongly required. The key though to successful hybrid platform is the identification of solutions that does not compromise the advantages of silicon technology. Many presentations in the workshop have focused on the properties, the advantages and the disadvantages of different materials that have examined by various research groups but also on the integration approaches and the related technical challenges for a variety of on-chip optical functions. The final discussions between the audience and the panel were concentrated mainly on the optimum choice of materials for improved optical performance, the most promising solutions for the integrated silicon platforms and functionality of the integrated systems that can be achieved according to the selection of the material and the platform.

It is noted that the workshop have attracted more than 120 attendees, including a large number of renowned researchers in the field from around the world that have actively contributed to the commenting of the presented work and the final panel discussions.

### **2.3 Special Session on CMOS Fabrication-Based Photonic Technologies for Communications at ICTON 2013**

The last promotion event was a joint activity between the projects SOFI and ICT FP7-NAVOLCHI and organised by the partners AIT and KIT. The main goal of this event was to show the latest research outcomes of both projects before their completion and highlight the future potentials and capabilities of the developed technologies. The primary foci of this session talks was on the plasmonic-silicon and organic-silicon based components for communication applications.

The final structure of the session program is shown below:

SESSION We.D6 NAVOLCHI/SOFI Chair: Ioannis Tomkos	
9:30	<b>We.D6.1</b> Waveguide-coupled nanolasers in III-V membranes on silicon (Invited) <i>V. Dolores-Calzadilla, D. Heiss, A. Fiore, M. Smi</i>
9:50	<b>We.D6.2</b> Optical properties of SOI waveguides functionalized with close-packed quantum dot films (Invited) <i>Z. Hens, A. Omarí, P. Geiregat, D. Van Thourhout</i>
10:10	<b>We.D6.3</b> Light coupling from active polymer layers to hybrid dielectric-plasmonic waveguides (Invited) <i>I. Suárez, E.P. Fitrakis, H. Gordillo, P. Rodriguez-Cantó, R. Abargues, I. Tomkos, J. Martinez-Pastor</i>
10:30	<b>We.D6.4</b> Low energy routing platforms for optical interconnects using active plasmonics integrated with silicon photonics (Invited) <i>K. Vyrsokinos, S. Papaioannou, D. Kalavrouziotis, F. Zacharatos, L. Markey, J-C. Weeber, A. Dereux, A. Kumar, S.I. Bozhevolnyi, M. Waldow, G. Giannoulis, D. Apostolopoulos, T. Tekin, H. Avramopoulos, N. Pleros</i>

The speakers presented the latest research outcomes on SOI waveguide based systems as well as plasmonic waveguide platforms highlighting the light coupling properties achieved at low energy consumption levels. The event also hosted a presentation from the project PLATON presenting an integrated platform with active plasmonics on silicon photonics.

The participation in this session was exceeded 50 people; (no official participation data per session are available by the organizers). The session closed with a 15min summary of the research achievements in projects SOFI and NAVOLCHI while each speaker identified the future trend of these technologies and their requirements for the creation of functional low-energy systems.

#### **2.4 SOFI in Erasmus Mundus Spring School 2013**

The Europhonics Erasmus Mundus Spring School is an annual workshop designed to gather together Master students, PhD students and professors and is a privileged moment for exchanging experiences and preparing future careers.

The program consists of talks and courses in selected areas of photonics given by invited researchers. All Europhonics second year Master students and all PhD students attend the Spring School. The School is also open to other students from across Europe/

SOFI project has offered a general educative presentation to all students attending the Erasmus Mundus Spring School. This spring school was a two and a half day event organized by SOFI partner KIT and included a mixture of presentations on new material and technologies as well as their application in our lives. The spring school program can be found at:

[http://ksop.idschools.kit.edu/downloads/EM\\_Spring\\_School\\_2013\\_Program\\_final\(1\).pdf](http://ksop.idschools.kit.edu/downloads/EM_Spring_School_2013_Program_final(1).pdf)

The SOFI presentation was created in a form of an 1 hour lecture presentation and presented in the spring school event by AIT. This presentation included an introduction to silicon photonics research activities and photonic integration technologies as well the scope and focus of the SOFI project and its major achievements. The SOFI presentation attracted more than 30 students which showed a great interest in silicon photonics technologies with various questions to the AIT speaker.



Figure 1 a) Prof. Uli Lemmer welcomes the spring school attendees, b) snapshot from the oral sessions c) snapshot from the poster session