Silicon-Organic hybrid Fabrication platform for Integrated circuits

Final report on SOFI dissemination and promotion activities

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List of Partners concerned

<table>
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<th>Partner number</th>
<th>Partner name</th>
<th>Partner short name</th>
<th>Country</th>
<th>Date enter project</th>
<th>Date exit project</th>
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<tr>
<td>1 (coordinator)</td>
<td>Karlsruhe Institute of Technology (formerly University of Karlsruhe)</td>
<td>KIT</td>
<td>Germany</td>
<td>M1</td>
<td>M42</td>
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<td>Greece</td>
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<td>The University of Sydney, Centre for Ultrahigh bandwidth Devices for Optical Systems</td>
<td>CUDOS</td>
<td>Australia</td>
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¹ PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)
Deliverable Responsible

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Change Records

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<th>Author</th>
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<td>2013-6-26</td>
<td>Start</td>
<td><a href="mailto:gcangini@gigoptix.com">gcangini@gigoptix.com</a></td>
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SECTION A .....................................................................................18
1. Executive Summary

This deliverable reports the actions taken by the SOFI consortium in terms of dissemination of the project results during the 3rd year of the project covering the period from January 2012 to July 2013 included.

In the third year of the SOFI project a significant amount of knowledge was generated in the specific topics related to the project.

While the actual exploitation activities and plans are detailed in Deliverable 6.9, it is worth mentioning the good results achieved during the third year suggest great potential for the further developments of the technologies and devices developed within SOFI after the conclusion of the project.

To disseminate the project results and promote its visibility several actions were taken by the different partners:

- The project web site was updated providing summary of the activities performed over the full duration of the project, including list of publications and participation to events like conferences and trade shows.
- Significant presence at the most relevant optical conferences and symposiums in 2012 and in first half of 2013.

All partners have been very active in promoting the SOFI project in renowned scientific journals, magazines, conferences and seminars with great impact.

2. Dissemination of Knowledge

All partners of the SOFI consortium have been committed to mobilize their contacts in the international research society and industry to promote the project results.

The participation in conferences, workshops and EU events not only falls in the project scope but it is one of the main project objectives.

Scientific contributions have and will continue to be submitted, throughout the project lifetime, for publication to journals/conferences, provided that they will enhance project visibility and release useful conclusions to the telecom community.

The dissemination plan includes the creation and maintenance of a professional project website containing all public information and facilitating contacts and exchanges with other research and industrial initiatives on the relevant topics. This consortium WEB site was created and is maintained by KIT with inputs from all partners.

In Sections 3.1 to 3.6 the activities per partner are listed.
3.1 RB Dissemination activities

Conferences and Symposia

Rainbow Photonics was present at the following international exhibitions with the company booth, where we were also promoting our work within the SOFI project:

- SPIE Photonics West exhibition, Febr. 4–7 2013 in San Francisco USA
- Laser World of Photonics exhibition, May 13-16 2013 in Munich, Germany

In the reporting period Rainbow Photonics promoted the activities within SOFI in the following papers:

- ‘Organic DSTMS crystals for high-field wide bandwidth THz spectroscopy’ (Invited, Keynote Presentation); Peter Günter, Mojca Jazbinsek, Tobias Bach, Blanca Ruiz, Carolina Medrano, SPIE Photonics West (February 2-7, 2013); San Francisco, USA. This presentation promoted organic electro-optic crystals for generation and detection of THz waves, but also their potential for high-speed integrated optics.

- ‘Generation of frequency tunable and broadband THz pulses in the frequency range 1-20 THz with organic electro-optic crystals OH1 and DSTMS’ (Oral presentation); Mojca Jazbinsek, Tobias Bach, Blanca Ruiz, Carolina Medrano, Peter Günter; SPIE Photonics West (February 2-7, 2013), San Francisco, USA. Experimental results on frequency tunable THz-wave generation with bulk organic crystals, also mentioning their potential for high-speed integrated optics.

- ‘Broadband THz-Wave Generation with Organic Crystals OH1 and DSTMS’; Mojca Jazbinsek, Blanca Ruiz, Carolina Medrano, Peter Günter; CLEO Europe (May 12-16, 2013), Munich, Germany. Experimental results on ultra-broadband THz-wave generation with bulk organic crystals based on their ultra-fast electro-optic response.


- One journal paper by KIT, RB and IMEC on hybrid integration of organic crystals in silicon platform is in preparation.
3.2 AIT Dissemination activities

Conferences and Symposia

- *AIT* presented a paper at Fifth International Conference on Micro - Nanoelectronics, Nanotechnologies and MEMS "Micro&Nano2012" (October 7-10, 2012, Heraklion, Greece). This work included the results from the simulation studies performed under WP2 on the potentials of the SOFI devices in high speed telecom systems. Paper title and author list: “Silicon-Organic Hybrid Modulators for High Speed Transmission Systems”, Panagiotis Zakynthinos, Leontios Stampoulidis, Efstratios Kehayas and Ioannis Tomkos


Journals


Other Dissemination Activities

- During a short seminar event, AIT has presented the SOFI technology platform to interested AIT graduate students and researchers.
- AIT organised two conference workshops:
  a) A Special Session on “Silicon Photonics Based Components”, co-located with ICTON 2012, held in Coventry, England, on July 2 – 5, 2012.
  b) A joint Special Session in collaboration with ICT FP7-NAVOLCHI on "CMOS Fabrication-Based Photonic Technologies for Communications" co-located with ICTON 2013, held in Cartagena, Spain on June 23-27, 2013
- During the “Niki Award 2012” event, AIT’s researchers presented the SOFI project and its achievements to the director of Lawrence Berkeley National Laboratory and to a large number of scientists.
- AIT prepared an extended presentation for the Europhotonics Spring School 2013 (April 8-10, Pforzheim, Germany) organized by KIT. More details about this event is provided in D6.7
3.3 SELEX Dissemination activities

Conferences and Symposiums

In the reporting period Selex contributed to the following papers:


- SOFI partners contributed to a joint Special Session in collaboration with ICT FP7-NAVOLCHI on "CMOS Fabrication-Based Photonic Technologies for Communications" co-located with ICTON 2013, held in Cartagena, Spain on June 23-27, 2013
3.4 GO Dissemination activities

Conferences and Symposia

GigOptix was present at the following international exhibitions with the company booth, where we were also promoting our work within the SOFI project:

- ECOC 2012, September 16–20 2012 in Amsterdam, The Netherlands
- OFC 2013, March 19-21 2013 in Anaheim, USA

In the reporting period GigOptix contributed to the following papers:


- 'Silicon-organic hybrid (SOH) IQ modulator for 16QAM at 112 Gbit/s';

- 'Silicon-Organic Hybrid (SOH) Modulator Generating up to 84 Gbit/s BPSK and M-ASK Signals';

- 'Silicon-organic hybrid devices';
  OPTO SPIE Photonics West (OPTO-SPIE'13), San Francisco (CA), USA, paper 8629-24; Feb. 2-7, 2013,[invited]
  doi:10.117/12.2005866

- 'Silicon organic hybrid fabrication platform for integrated circuits'
Journals

In the reporting period GigOptix contributed to the following journals publications:


3.5 IMEC Dissemination activities

Conferences and Symposiums


Journals

IMEC’s journal publication with relation to SOFI are mainly joint publication with KIT.


Leuthold, 42.7 Gbit/s electro-optic modulator in silicon technology, Optics Express, 19(12), p.11841-11851 (2011).


**Other Dissemination Activities**

IMEC Organized a workshop on Hybrid Silicon Photonics at the European Conference on Optical Communication (ECOC) in Amsterdam, September 2012. The half-day workshop was attended by over 50 people and had several high-profile international speakers

- John Bowers, UCSB
- Juerg Leuthold, KIT
- Lionel Kimerling, MIT
- John Kouvetakis, ASU
- Nicolas Izard, UP-Sud
- Peter Verheyen, IMEC

The focus of the workshop was on the integration of novel photonic materials in the CMOS-like environment of silicon photonics, and the benefits that this integration can bring. The SOFI project was organizer of this project, and the results of the project were prominently present in the presentation by Prof. Leuthold.
3.6 KIT Dissemination activities

Conferences and Symposia

‘Silicon-Organic Hybrid (SOH) Frequency Comb Source for Data Transmission at 784 Gbit/s’
C. Weimann et al.; ECOC 2013

‘High-Speed Silicon-Organic Hybrid (SOH) Modulator with 1.6 fJ/bit and 180 pm/V In-Device Nonlinearity’
Palmer et al.; ECOC 2013

‘Silicon-organic (SOH) IQ modulator for 16QAM at 112 Gbit/s’;
Conference on Lasers and Electro-Optics Europe (CLEO-Europe/IOOC 2013), International Congress Centre Munich, Germany; Paper CK-9.2 THU; May 12–16, 2013;

‘Surface Plasmon Polariton High-Speed Modulator’
A. Melikyan et al; Postdeadline Paper CLEO 2013

‘First monolithic GaAs IQ electro-optic modulator, demonstrated at 150 Gbit/s with 64-QAM.’
Optical Fiber Communication Conference (OFC’13), Los Angeles, Anaheim (CA), USA, 17.–21.03.2013
Postdeadline Paper PDP5C.4

‘Silicon-Organic Hybrid (SOH) Modulator Generating up to 84 Gbit/s BPSK and M-ASK Signals’;
Optical Fiber Communication Conference (OFC2013) Anaheim, CA; Novel Modulators (OW4J); pp. OW4J.6; March 17, 2013

‘Silicon-organic hybrid devices’;
OPTO SPIE Photonics West (OPTO-SPIE’13), San Francisco (CA), USA, paper 8629-24; Feb. 2-7, 2013,[invited]
doi:10.117/12.2005866
'Ultracompact CMOS-compatible Modulators'
http://www.opticsinfobase.org/abstract.cfm?URI=FiO-2012-FTu4A.1

'Silicon-Organic Hybrid - a path towards active silicon photonic devices'

'Silicon-Organic Hybrid Integration and Photonic Wire Bonding: Technologies for Terabit/s Interconnects'
Joint Symposium on Opto- andMicroelectronic Devices and Circuits (SODC2012), Hangzhou, China, Sept. 24-27, 2012 [invited]

'Ultracompact CMOS-compatible Modulators'
http://www.opticsinfobase.org/abstract.cfm?URI=FiO-2012-FTu4A.1

'Silicon organic hybrid fabrication platform for integrated circuits'
Verheyen, P.; Wouters, J.; Moelants, M.; Absil, P.; Dispenza, M.; Secchi, A.; Jazbinsek, M.;
Gunter, P.; Wehrli, S.; Bossard, M.; Zakynthinos, P.; Tomkos, I.;
14th Intern. Conf. on Transparent Optical Networks (ICTON'12), University of Warwick, Coventry, UK, July 2012 [SOFI, invited]

Journals

'Silicon-Organic Hybrid Electro-Optical Devices'
Leuthold et al., JSTQE 2013

'High-Speed Plasmonic Phase Modulator'
A. Melikyan et al., submitted to Nature Photonics 2013

'Silicon-organic hybrid (SOH) IQ modulator using the linear electro-optic effect for transmitting 16QAM at 112 Gbit/s'

'Low Power Mach-Zehnder Modulator in Silicon-Organic Hybrid Technology'
doi: 10.1109/LPT.2013.2260858

'Silicon-Organic Hybrid MZI Modulator Generating OOK, BPSK and 8-ASK Signals for up to 84 Gbit/s' ;
Pantouvaki, M.; Van Campenhout, J.; Absi, P.; Dinu, R.; Freude, W.; Koos, C.; Leuthold, J.;
IEEE Photonics J.; Vol. 5; Issue 2; pp. 6600907; 2013
doi: 10.1109/JPHOT.2013.2258142

'Low-Loss Silicon Strip-to-Slot Mode Converters,'
Wahlbrink, T.; Freude, W.; Koos, C.; Leuthold, J.; February 2013
IEEE Photonics J.; Vol. 5; issue 1; pp. 2200409
doi: 10.1109/JPHOT.2013.2239283

'Using carrier-depletion silicon modulators for optical power monitoring'
Yu, H.; Korn, D.; Pantouvaki, M.; V. Campenhout, J.; Komorowska, K.; Verheyen, P.; Lepage,

'Second-order nonlinear silicon-organic hybrid waveguide'
Alloatti, L.; Korn, D.; Weimann, C; Koos, C.; Freude, W.; Leuthold, J.;
http://dx.doi.org/10.1364/OE.20.020506

'Silicon-organic hybrid phase shifter based on a slot waveguide with a liquid-crystal cladding'
Pfeifle, J.; Alloatti, L.; Freude, W.; Leuthold, J. and Koos, Ch.;
Optics Express, Vol. 20, Issue 14, pp. 15359-15376, July 2012
http://dx.doi.org/10.1364/OE.20.015359

'Performance tradeoff between lateral and interdigitated doping patterns for high speed carrier-depletion based silicon modulators'
Optics Express, Vol. 20, Issue 12, pp. 12926-12938, June 2012
dx.doi.org/10.1364/OE.20.012926
3.6 Consortium Future Actions

The following 2 publications have been accepted for the ECOC 2013:

- ‘Silicon-Organic Hybrid (SOH) Frequency Comb Source for Data Transmission at 784 Gbit/s’
  C. Weimann et al.; ECOC 2013
- ‘High-Speed Silicon-Organic Hybrid (SOH) Modulator with 1.6 fJ/bit and 180 pm/V In-Device Nonlinearity’
  Palmer et al.; ECOC 2013

Activities on SOH are planned to continue at SOFI consortium members. Further experiments on 784 Gbit/s WDM-SOH comb line are currently under discussions and will likely focus on OFDM with SOFI3 chips.
# Section A

## TEMPLATE A1: List of Scientific (Peer Reviewed) Publications, Starting with the Most Important Ones

<table>
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<th>Title</th>
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<th>Title of the periodical or the series</th>
<th>Number, date or frequency</th>
<th>Publisher</th>
<th>Place of publication</th>
<th>Year of publication</th>
<th>Relevant pages</th>
<th>Permanent identifiers([1]) (if available)</th>
<th>Is/Will open access([2]) provided to this publication?</th>
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<td>1</td>
<td>‘Silicon-organic hybrid (SOH) IQ modulator using the linear electro-optic effect for transmitting 16QAM at 112 Gbit/s’</td>
<td>KIT</td>
<td>Optics Express</td>
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<td>doi: 10.1364/OE.21.013219</td>
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<td>‘Silicon-Organic Hybrid MZI Modulator Generating OOK, BPSK and 8-ASK Signals for up to 84 Gbit/s’</td>
<td>KIT</td>
<td>IEEE Photonics J.</td>
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<td>2013</td>
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<td>4</td>
<td>‘Low-Loss Silicon Strip-to-Slot Mode Converters,’</td>
<td>KIT</td>
<td>IEEE Photonics J.</td>
<td></td>
<td></td>
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<td>doi: 10.1109/JPHOT.2013.2239283</td>
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<td>‘Second-order nonlinear silicon-organic hybrid waveguide’</td>
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(\[1\]) A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

(\[2\]) Open Access is defined as free of charge access for anyone via Internet. Please answer “yes” if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.
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<td>Optics Express</td>
<td>2011</td>
<td>doi:10.1364/OE.19.011841</td>
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<td><strong>8</strong></td>
<td><strong>Monolithic GaAs Electro-Optic IQ Modulator Demonstrated at 150 Gbit/s with 64 QAM</strong></td>
<td><strong>KIT</strong></td>
<td>Lightwave Technology</td>
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### TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES

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[^4]: A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other (‘multiple choices’ is possible).
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<td>KIT</td>
<td>Frontiers in Optics</td>
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