Directly Modulated Lasers on Silicon

Deliverable Report D6.1

First Report on Dissemination, Exploitation and Standardization Activities

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Confirmation

Any work or result described in this report is either genuinely a result of this project or properly referenced. Any statements and results in the report reflect only the author's view and the European Commission is not responsible for any use that may be made of the contained information.

Version Management

Table 1: List of Revisions.

Version	Description	Author (partner short name)	Released
V0.1	First draft	B. Wohlfeil (ADV)	July 17, 2017
V0.9	Draft – ready for review	B. Wohlfeil (ADV)	July 21, 2017
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Executive Summary

The first report on dissemination, exploitation and standardization activities aims to give an overview over the ongoing actions on raising the awareness in the optics community for the DIMENSION project as well as over the exploitation of suitable results. In addition, activities in standardization bodies will be detailed, as those are a vital part in the exploitation of the project's results in future products. Also further plans are listed.

1 Introduction

Work package (WP) 6 is led by ADV and deals with the exploitation and dissemination of the project's results. The objectives of this WP are listed below:

- Publication of press releases (especially at beginning and end of project); providing dissemination kit
- Generation of intellectual property (patents portfolio) to set the basis for potential commercialization of products relevant to the project results.
- Promotion of the project outputs through the participation in optical conferences and symposia. Preparation and distribution of technical brochures.
- Dissemination of project results through publications in scientific journals and magazines, presentations in international conferences and workshops.
- Coordinate Activities towards possible contributions to standardization bodies (e.g. IEEE, ITU/FSAN)
- Interaction with other EU and National projects (e.g. FP7/H2020 IPs/NoEs/STREPs/SSAs projects, COST, CRE, FET Actions).
- Organisation of workshops, aiming to inform the researchers of the scientific community around the research topics, advances and implementation techniques that this project deals with.

The dissemination and exploitation plans and activities including standardisation and IP/IPR activities will be summarized and reported in this and forthcoming reports which are accompanied with the project periodic reports. The dissemination/exploitation reports encompass all activities, e.g. organisation of/attendance at work-shops, conferences etc., publications, trainings and describes relevant business cases.

This report is structured in three main sections: Section 2 gives an overview over past dissemination activities, such as initial press releases, media coverage, conference contributions, publications in industrial magazines and scientific publications in journals. In addition, an overview over the stated number of target dissemination activities is laid out. Section 3 details the current state of standardization activities that are relevant for the DIMENSION project and in which way members of the project consortium are participating in those efforts. In Section 4, the current status of exploitation plans are presented together with an up-to-date list of filed patents that are based on the results of the DIMENSION project. Section 5 gives an overview of the current status of WP6 within the overall scope of the project. It details all deliverables and relevant milestones of WP6.

2 Dissemination Activities

Dissemination of DIMENSION related material and information was conducted via multiple channels and is listed by category in the following tables. The project partners took great effort in rising the awareness about DIMENSION in the optical community. This not only resulted in a high count of dissemination activities in various channels but also in multiple mentions in the same channel as will be detailed below.

2.1 *Press Releases*

At the start of the project press releases were issued by the DIMENSION partners, which were in turn echoed by several media outlets. Tables 2 and 3 list the press releases and the following media coverage, respectively.

Table 2: Press releases.

Issued by	Language	Link
TU Dresden	DE	https://tu-dresden.de/tu-dresden/newsportal/news/news_1-1
TU Dresden	DE	https://www.et.tu-dresden.de/etit/index.php?id=889
AIT	EN	http://www.ait.gr/ait_web_site/news/201603/003.html
ADVA	DE	http://www.advaoptical.com/en/newsroom/press-releases-german/20160609
ADVA	EN	http://www.advaoptical.com/en/newsroom/press-releases-english/20160609-adva-optical-networking-joins-consortium-to-create-revolutionary-data-center-technology

Table 3: Media coverage.

Medium	Date	Language	Link
dresden.de	09/02/2016	DE	http://invest.dresden.de/csdata/download/1/de/160209_tud_siliziumphotonik_chips_941.pdf
Oiger	09/02/2016	DE	http://oiger.de/2016/02/09/dresdner-forscher-wollen-lichtschnelle-computerchips-konstruieren/157838
Silicon Saxony	10/02/2016	DE	http://www.silicon-saxony.de/news/news-detail/archive/2016/february/article/tu-dresden-forscher-wollen-lichtschnelle-computerchips-konstruieren.html?tx_ttnews%5bday%5d=10&cHash=b8ce0a7eab193230ed2bc16da430af10
Dresdner Universitätsjournal	16/02/2016	DE	https://tu-dresden.de/tu-dresden/newsportal/ressourcen/dateien/universitaetsjournal/uj_pdfs/uj_2016/UJ03-16.pdf?lang=de
Silicon Saxony	01/05/2016	DE	http://newsletter.silicon-saxony.de/Newsletter-2012.html?usetopic=NLLTOPIC_1455117268

Finanz und Wirtschaft	09/06/2016	DE	http://www.fuw.ch/newsticker-single/201606090329/gnw-adva-optical-networking-unterstutzt-konsortium-bei-der-entwicklung/
finanzen.net	09/06/2016	DE	http://www.finanzen.net/nachricht/aktien/ADVA-Optical-Networking-unterstuetzt-Konsortium-bei-der-Entwicklung-revolutionaerer-Rechenzentrumstechnologie-4926536
Globenewswire	09/06/2016	EN	https://globenewswire.com/news-release/2016/06/09/847246/10163380/en/ADVA-Optical-Networking-Joins-Consortium-to-Create-Revolutionary-Data-Center-Technology.html
Photonics Online	09/06/2016	EN	http://www.photonicsonline.com/doc/adva-optical-networking-joins-consortium-to-create-revolutionary-data-center-technology-0001
Compound Semiconductor	10/06/2016	EN	http://www.compoundsemiconductor.net/article/99535-adva-joins-eu-lasers-on-silicon-consortium.html
Datacenter Dynamics	10/06/2016	EN	http://www.datacenterdynamics.com/content-tracks/design-build/adva-joins-project-to-manufacture-lasers-into-silicon-chips/96357.fullarticle
Semiconductor Today	10/06/2016	EN	http://www.semiconductor-today.com/news_items/2016/jun/adva_100616.shtml
CompoundSemi	13/06/2016	EN	http://www.compoundsemi.com/adva-optical-networking-collaborate-project-embed-iii-v-lasers-silicon/
Gazettabytes	28/11/2016	EN	http://www.gazettabyte.com/home/2016/11/28/dimension-tackles-silicon-photonics-laser-shortfall.html
Optical Connections News	07/12/2016	EN	http://opticalconnectionsnews.com/2016/12/european-project-developing-integrated-silicon-photonics-process/

2.2 *Conference Contributions*

In addition to the initial press and media coverage, dissemination activities at conferences were carried out to raise awareness of the DIMENSION project in the optics community. Table 4 lists the activities of DIMENSION partners at conferences where the project was generally introduced. Table 5 lists conference contributions where DIMENSION material has been published and presented.

Table 4: Conference contributions with general DIMENSION introduction.

Conference	Presentation	Date	Presenter	Affil.
Photonics21 Annual Meeting	DIMENSION Project Introduction	01/03/2016	Jörg-Peter Elbers	ADV

CS International	Hybrid IIIV/SiGe technology for CMOS and beyond, opportunities for 3D monolithic integration	02/03/2016	Lukaz Czornomaz	IBM
DATE16	Electro-optical integration of III-V–on–silicon for efficient on-chip laser sources	18/03/2016	Marc Seifried	IBM
Data Center Summit 2016 at OFC 2016	Silicon Photonics Electro-optical Integration in Support of Scalable DC Architectures	22/03/2016	Bert Offrein	IBM
18th Annual Next Generation optical networking	Optical Networking Opportunities in the Access, Metro and Long-Haul Networks to Support DC Connectivity	30/06/2016	Jim Theodoras	ADV
PhoxTrot Summer School 2016	Silicon photonics technologies for optical interconnects in future data centers	01/08/2016	Marc Seifried	IBM
ECOC 2016	Super-Channel Optical Interconnects for Datacenters	18/09/2016	Jörg-Peter Elbers	ADV
	System and Device-level Integration Trends of Optical Interconnects in Data Centres	18/09/2016	Bert Offrein	IBM
11th Annual Meeting Photonic Devices	III-V on silicon for monolithic electro-optical integration of on-chip laser sources	09/02/2017	Marc Seifried	IBM
PIC International Conference 2017	Driving down the cost of datacenter photonics applying novel scalable integration concepts	07/03/2017	Bert Offrein	IBM
	Silicon Photonics for Inter-Data Center Interconnects	07/03/2017	Jörg-Peter Elbers	ADV
OFC 2017	III-V + Silicon: To Integrate or to Co-package?	19/03/2017	Bert Offrein	IBM
	Silicon Photonics and High-Performance BiCMOS – Challenges for Monolithic Integration	19/03/2017	Lars Zimmermann	IHP
	Enabling 64Gbaud Coherent Optical Transceivers	19/03/2017	Danish Rafique	ADV
DATE17	Electro-Optical Integration Technology for High-Bandwidth Optical Interconnects	27/03/2017	Bert Offrein	IBM
ECIO 2017	Photonic Integrated Circuits for Data Center Interconnects	03/04/2017	Benjamin Wohlfeil	ADV
International Meeting on Integrated Photonics	CMOS-embedded III-V on Silicon laser sources	08/05/2017	Gustavo Villares	IBM

Silicon Saxony Day 2017	Electro-optical platform for data centers enabling the internet of things	20/06/2017	Niels Neumann	TUD
ODCI 2017	Performance Potential & Limitations of the Next Generation Intra- and Inter-DC Interconnects	20/06/2017	Ioannis Tomkos	AIT
Device Research Conference	Towards the integration of electro-optical hybrid III-V on Si lasers into the BEOL of a CMOS process flow	28/06/2017	Herwig Hahn	IBM

Table 5: Conference contributions with DIMENSION publication and presentation.

Conference	Presentation	Date	Presenter / Co-authors	Affil.
ICTON - 3rd workshop on Technology for Data Center Interconnects	Digital pre-emphasis based system design trade-offs for 64 Gbaud coherent data center interconnects (Invited)	03/07/2017	Danish Rafique / N. Eiselt, H. Griesser, B. Wohlfeil, M. Eiselt, J.-P. Elbers	ADV
	CMOS-Embedded Lasers for Advanced Silicon Photonic Devices (Invited)	04/07/2017	Bert Offrein / M. Seifried, H. Hahn, G. Villares, F. Horst, D. Caimi, C. Caër, Y. Baumgartner, M. Sousa, R. Dangel, L. Czornomaz	IBM
	Monolithic photonic BiCMOS technology for high-speed receiver applications (Invited)	04/07/2017	Stefan Lischke / D. Knoll, C. Mai, A. Awny, G. Winzer, M. Kroh, K. Voigt, L. Zimmermann1	IHP
	Designing the next generation of intra- and interdatacentres interconnects (Invited)	04/07/2017	Ioannis Tomkos / V. Vgenopoulou, N. Raptis, E. Grivas	AIT

2.3 *Industrial Magazines*

The following table lists industrial magazines, which published articles about the project.

Table 6: Industrial magazines.

Medium	Date	Language	Author(s)	Link
Gazettabyte (Interview)	28/11/2016	EN	B. Offrein, L. Zimmermann	http://www.gazettabyte.com/home/2016/11/28/dimension-tackles-silicon-photonics-

				laser-shortfall.html
Photonics In Germany	01/04/2017	EN	J.-P. Elbers, D. Rafique, B. Wohlfeil	http://www.optical-technologies-in-germany.de

2.4 *Scientific Journals*

Owing to the early stage of the project, a large number of scientific publications are not to be expected until availability of first samples. Nonetheless, early stage results have been published and are shown in Table 7.

Table 7: Scientific journals.

Journal	Volume	Number	Title	Author(s)
Journal of Physics D: Applied Physics	50 (2017)	235102	Low-resistive, CMOS-compatible ohmic contact schemes to moderately doped n-InP	H. Hahn, M. Sousa, L. Czornomaz

2.5 *Other Activities*

In addition to the dissemination activities mentioned above, various other actions to raise the awareness of the DIMENSION project were taken. These include:

- Launch and maintenance of DIMENSION webpage: http://www.dimension-h2020.eu/
- Preparation of "Dissemination Kit" consisting of fact sheet and presentation slides
- Setup of a calendar highlighting important events
- Co-organization (together with FP7 ADDAPT project and others) of 3rd workshop on Technology for Datacenter Interconnects (DACINT) at 19th International Conference on Transparent Optical Networks (ICTON) 2017, July 2-6, Girona, Spain

2.6 *Outlook*

As of now, the consortium sees no reason to deviate from the dissemination plan as outlined in the DIMENSION grant agreement and summarized in Table 8.

Table 8: Summary of major planned dissemination activities and targeted minimum numbers.

	Target # of papers or exhibitions	Name of suitable journal/conference/ magazine/trade fair; Examples	Probable partners
Key journals (scientific)	10	Nature Photonics	IBM
		IEEE Photonics Technology Letters	TUD
		IEEE Journal of Lightwave Technology	IHP
		Optics Express	ADV

		Optics Letters	AIT OPC
		Electronics Letters	
		IEEE Journal of Solid-State Circuits	
		Transactions on Microwave Theory and Techniques	
Key conferences (scientific community, industry contact)	20	Optical Fiber Conference (OFC)	IBM IHP ADV AIT OPC
		European Conference on Optical Communication (ECOC)	
		IEEE Group IV Photonics	
		IEEE Optical Interconnects Conference	
		Conference on Lasers and Electro-Optics	
		European Conference on Integrated Optics (ECIO)	
		SPIE Photonics West / LASE	
		International Solid-State Circuits Conference (ISSCC)	TUD IHP IBM
		European Solid-State Circuits Conference (ESSCIRC)	
		International Semiconductor Conference Dresden and Grenoble (ISCDG)	
Key magazines (user oriented, industry, SMEs)	10	Laser Focus World	IBM ADV AIT OPC
		Photonics.com	
		SPIE Electro Optics Magazine	
		LightWave	
		RF Design Magazine	TUD
		MicroWaves & RF	
		Microwave Journal	
Trade fairs (demonstrators)	2	ECOC Exhibition	ADV OPC
		OFC/NFOEC Exhibition	

3 Standardization/Patent Management

Relevant standardization organizations have been identified and consortium members are actively supporting their efforts. Specifications for the DIMENSION demonstrators were derived from multiple sources including IEEE 802.3bs (400G Ethernet) for demonstrator 1 and the Consortium for On-Board Optics (COBO) and the OIF 'IC-TROSA' (Integrated Coherent Transmitter Receiver Optical Subassembly) project for demonstrator 2. Both IBM and ADVA have now joined COBO. In addition, further industry projects such as the OIF 400G ZR, OSFP and QSFP-DD are monitored to ensure compatibility of the DIMENSION demonstrators with future form factors and transmission links. Table 9 shows contributions made to COBO.

Table 9: Contributions to COBO.

Project	Date	Title of contribution	Contributor	Partner Affiliation
DCN	22/06/2016	Baseline Review & Comments	Jörg-Peter Elbers	ADV
CohOBO	29/09/2016	Coherent COBO Use Case	Jörg-Peter Elbers	ADV
CohOBO	08/02/2017	Form Factor Considerations	Benjamin Wohlfeil	ADV
CohOBO	18/04/2017	IBM introductory presentation	Isabel De Sousa	IBM
CohOBO	25/04/2017	IC-TROSA Form Factor Considerations	Jörg-Peter Elbers	ADV
DCN	25/04/2017	IBM SiPh Packaging COBO	Isabel De Sousa	IBM
DCN	25/04/2017	COBO format design from IBM	Isabel De Sousa	IBM
CohOBO	22/06/2017	IBM Clip design details	Isabel De Sousa	IBM

The OIF 'IC-TROSA' project aims to standardize a photonic package for coherent application that is as easy to use as common electronic packages. A common footprint, high- and low-speed electrical in- and outputs as well as a common optical interface are part of this project. Apart from these aspects, the implementation agreement specifies a black box, leaving the exact implementation to the vendor. Therefore, two different variants are planned with the first being a non-hermetic package with BGA mount suitable for silicon photonic transceivers and the second being a hermetic gold-box package featuring flex cables as electrical contacts for use with Indium phosphide based transceiver chips. Both variant are depicted in Figure 1.

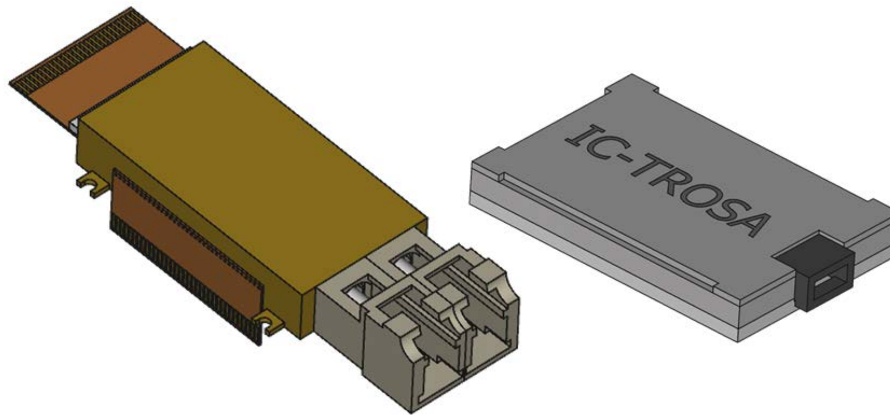

Figure 1: Gold-box (left) and BGA variant of the IC-TROSA with detachable fiber connector.

Contributions made by project partners to the OIF IC-TROSA project are listed in Table 10:

Table 10: Contributions to OIF IC-TROSA.

Date	Title of contribution	Contributor	Partner Affiliation
11/08/2016	Project Start Proposal Preview: IC-TROSA	S. Grindstaff	ADV
24/10/2016	Editor's Report IC-TROSA Q4-2016 PLL Technical Meeting Auckland	S. Grindstaff	ADV
25/10/2016	Draft of electro-optic specification for IC-TROSA	J.P. Elbers	ADV
30/10/2016	Draft Proposal: IC-TROSA I/O Requirements	S. Grindstaff	ADV
30/10/2016	IC-TROSA Mechanical Considerations	S. Grindstaff	ADV
10/01/2017	IC-TROSA Package Proposal for Option-B Applications	J.P. Elbers	ADV
17/01/2017	Editor's Report Part B: San Jose: IC-TROSA Survey #1 Results on Voltage supplies, Comms, I/O	S. Grindstaff	ADV
19/01/2017	Editor's Report Part-A San Jose: IC-TROSA	S. Grindstaff	ADV
19/01/2017	IC-TROSA Option B mechanical outline proposals	J.P. Elbers	ADV
16/02/2017	400ZR Reference Link Considerations	J.P. Elbers	ADV
13/03/2017	IC-TROSA Mechanical Baseline Proposals and I/O Considerations	S. Grindstaff	ADV
08/05/2017	IC-TROSA Survey #2 results	S. Grindstaff	ADV
08/05/2017	Draft IA OIF-IC-TROSA ver0.01	S. Grindstaff	ADV
09/05/2017	Editor's Report IC-TROSA Q2-2017	S. Grindstaff	ADV
09/05/2017	IC-TROSA Mechanical Design and I/O updates	J.P. Elbers	ADV
10/05/2017	IC-TROSA IA Work List	S. Grindstaff	ADV
12/06/2017	Liaison Contribution to COBO re:IC-TROSA	S. Grindstaff	ADV
19/06/2017	IC-TROSA Editor's Update Interim Q2-Q3 conf call	S. Grindstaff	ADV
22/06/2017	Liaison letter to COBO re:IC-TROSA mech. contribution	S. Grindstaff	ADV
05/07/2017	Q2-2017 Liason Letter to COBO regarding IC-TROSA maximum	S. Grindstaff	ADV

	height dimensions		

The DIMENSION approach offers a unique advantage over state of the art packages as it allows to use InP based light sources in a package suitable for silicon photonics. The resulting benefits to the overall assembly are therefore manifold:

- Non-hermetic packages are much cheaper compared to traditional gold-boxes as a lower complexity and reduced effort in assembly are required.
- The footprint of the non-hermetic IC-TROSA is lower, as BGA mount and low complex package require less space compared to gold-boxes with flex cables.
- The local oscillator laser would usually be external to the BGA IC-TROSA. With the laser integrated on the silicon photonics transceiver chip, no external laser will be required, saving space on the module PCB.
- Fiber routing from local oscillator to transceiver using a PM fiber is no longer necessary, reducing complexity of the module assembly and offering additional degrees of freedom as positioning of components on the module PCB is no longer constrained by minimum fiber bend radius.
- Cost of the overall assembly is reduced, as the local oscillator laser is the single most expensive component of the overall assembly. Integrating it with minimal additional effort into the silicon photonic BiCMOS process is expected to greatly improve cost efficiency.
- With closer integration of passive optics, electronics and laser, even smaller footprint modules compared to state of the art, emerging pluggables and on board optics are feasible, while further increasing the bandwidth density of switches and transceiver line cards.

4 Exploitation of Project Results

No change in the exploitation plans as outlined in the grant agreement is intended. However, to secure the rights to DIMENSION's key findings five patents have been filed and are anticipated to be granted in the next years. The following table lists all the patents filed.

Table 11: Filed patents.

Application Number	Date filed	Title	Inventor(s)	Affiliation
ID 92343448 (USPTO)	21/07/2016	Low-resistive CMOS-compatible Au-free ohmic contact to n-InP	H. Hahn	IBM
EP16198701	14/11/2016	Optical interference filter device, especially for an optical wavelength locking device	B. Wohlfeil	ADV
ID 92343640 (USPTO)	22/02/2017	Thin laterally homogenous electric field vertical current injection laser	H. Hahn, J. Fompeyrine, L. Czornomaz, M. Seifried, F. Horst and S. Abel	IBM
ID 92343600 (USPTO)	22/02/2017	Adiabatic coupling between III-V stacks and Si-waveguides cladded with higher refractive index materials	M. Seifried, H. Hahn	IBM
ID 92343631 (USPTO)	22/03/2017	Transverse mode filter for hybrid III-V on silicon lasers	M. Seifried, H. Hahn and F. Horst	IBM

In specific, the industrial partners aim to employ the technology developed in DIMENSION in their respective product lines.
In the case of IBM, who are already using co-packaged assemblies of CMOS chips and III-V parallel optics, the close integration of III-V optics in a CMOS compatible process constitutes the next step towards future electro-optic components that will be employed in IBM's high performance computing products. Moreover, the addition of III-V materials in next generation integrated transistors is of great interest to the company as future electronics will not solely rely on silicon based CMOS technology. Therefore, evaluating the integrability of III-V into existing CMOS is another goal of the DIMENSION project for IBM.
ADV, as a vendor of systems for data center interconnects, is planning to integrate DIMENSION-based silicon photonic transceivers in their FSP 3000 product series for WDM coherent and IM/DD links. As integration of laser sources on silicon photonic chips will yield an enormous decrease in footprint and cost of transceiver modules, DIMENSION-based systems are expected to exhibit a superior bandwidth density and lower cost compared to current approaches based on silicon photonics with fiber coupled lasers or InP optics with external electronics.

OPC will enhance its packaging capabilities for the datacenter market, specifically for high-end silicon photonic devices. The optical capabilities developed in DIMENSION will also be applied to other areas such as III-V laser assemblies for telecom or medical applications and may be licensed to enable very high volume production. The business added based on this project is expected to result in the creation of new jobs within Optocap.

IHP aims to extend its existing technology portfolio to users of its MPW services and regular customers. Due to the unique capability of integration passive silicon photonic devices with high-speed BiCMOS electronics and active III-V sources, IHP is expected to expand its customer base to manufacturers of optical transceiver modules, who are so far reliant on InP foundries. In addition, the DIMENSION technology may also be transferred to advanced CMOS foundries allowing for manufacturing of very high volume components.

The academic partners expect to increase their knowledge in the broad field of silicon photonic transceivers. In specific, AIT aims to use the competency gained in DIMENSION to increase industrial collaborations, attract research funding, offer courses for academic and industrial audiences and improve its general expertise to attract capital investment. In addition, AIT is heavily involved in education of skilled engineers. Therefore, participation in technological leading project such as DIEMSNION will improve the quality of its educational program. Furthermore, the creation of a start-up company is considered, depending on the outcome of the project.

Similarly, TUD will improve its competencies in RF circuit design to strengthen its position in the academic world and expand its connections to the industry. As teaching of young engineers is an existential part of TUD, several students will be involved in DIMENSION as PhD and master students. TUD also investigates the creation of a spin-off company.

5 Overview WP6 Milestones & Deliverables

The current report constitutes the first of three deliverables in WP6 which will summarize the achieved activities and further plans. The remaining two reports on "Dissemination, Exploitation and Standardization" are due in project months 36 (January 2019) and 48 (January 2020), respectively (see Table 12).

Table 12: WP6 deliverables.

Number	Title	Lead beneficiary	Type	Dissemina-tion level	Due (month)
D6.1	First report on dissemination, exploitation and standardisation activities	ADV	Report	Public	18
D6.2	Second report on dissemination, exploitation and standardisation activities	ADV	Report	Public	36
D6.3	Final report on dissemination, exploitation and standardisation activities	ADV	Report	Public	48

The milestones in WP6 are related to major achievements in other work packages and thus build the basis, on which dissemination, standardization and exploitation activities are pursued. Table 13 shows the milestones connected to this work package.

Table 13: Relevant milestones.

Milestone	Title	Lead beneficiary	Due (month)	Means of verification
MS4	Hardware ready from Run1	IHP	30	First fully integrated EPIC-run completed, hardware finalized until last metal and handed over to WP5 for packaging, component level and system level experiments and validation → Exchange of hardware on time?
MS5	Component-level validation completed for Run2	TUD	36	Electronic and optical design for Run2 completed, fabrication of silicon photonics short loops in BRNC finalized, process development at IHP finalized, optical and electrical components from Run1 fully characterized and validated, packaging concept established, input to standardization bodies given → D1.3, D2.4, D3.2, D5.2, D5.3, D6.2 on time?
MS6	Hardware ready from Run2	IBM	42	Hardware fabrication of fully integrated Run2 with multiple channels completed, Direct growth method established → D3.3, D4.3 submitted on time?

MS7	System-level characterization completed	ADV	48	Verification of the fully integrated and packaged 400 GbE and tunable transmitter, experiments performed as bench-top experiments at ADV → D1.4, D5.4 submitted on time?
MS8	Dissemination, exploitation and training completed	ADV	48	Dissemination and exploitation events executed according to schedule, participation in standardization entities, summer school organized, workshop at conference organized, feedback from customers acquired, marketing and technology take-up strategy finalized → D6.3 submitted on time?

6 Conclusion

Given the early stage of the project, a very large amount of dissemination opportunities were already taken advantage of. Combined with the very relevant subject matter of DIMENSION in the optics community, a very high awareness of the project was achieved in a fairly short amount of time. Consortium partners were presenting the project on every major conference with instances of multiple of such presentations by different partners on the same conference. It is thus expected that, once the experimental stage of the project is reached, a large quantity of scientific publications will follow. Given the interest of industrial and academic institutions in the topic of hybrid integration, an equally high quantity of conference contributions is likely to occur.

Consortium members actively took part in standardization activities. Latest standards were incorporated in the specifications of the DIMENSION demonstrators and, in turn, findings of the DIMENSION project were brought to the attention of standardization bodies. As the project partners are very active in this area, a large amount of exchange between the project and standards has taken place and will continue to do so in the future.

Plans for exploitation of DIMENSION's findings are unchanged compared to the initial project proposal. To secure the rights to those findings, several patents have been filed and are anticipated to be granted in the next years.

Acronyms

Acronym	Definition
BGA	Ball Grid Array
BiCMOS	Bipolar Complementary Metal-Oxide-Semiconductor
COBO	Consortium on On-Board Optics
IC-TROSA	Integrated Coherent Transmitter Receiver Optical Sub-Assembly
OIF	Optical Internetworking Forum
OSFP	Octal Small Form Factor Pluggable
PCB	Printed Circuit Board
QSFP-DD	Quad Small Form Factor Pluggable – Double Density