



Integrated Photonics for the Next Generation of Autonomous Vehicles using InP Technologies

Deliverable D6.9 (D28)

Winter School

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Abstract

Through the Doc-TIC PhD Programme a number of course modules in areas related to photonics (active and passive devices), quantum mechanics, solid-state physics and integrated photonics are given to the ESRs. A Winter School has been organized taking advantage of the JePPIX PIC Design Course. This Winter School is a deep-dive technology training that covers the theory and practice of integrated photonic component and circuit design using the powerful JePPIX building blocks.

Keywords: Photonics, Physics, Solid-state physics, Robotics, Training, Automation, JePPIX

Change Record

Revision	Date	Description	Reviewer
0.1	01-09-2020	Outline proposal	Francisco J. Diaz Otero
0.5	01-11-2020	Partial contents developed	WP1 partners
0.7	01-11-2020	Version for peer review	Anxo Moreira (UVIGO)
0.9	05-11-2020	Reviewed	Braulio Gómez Saavedra (VPI)
1.0	20-11-2020	Final deliverable for the EC	EC



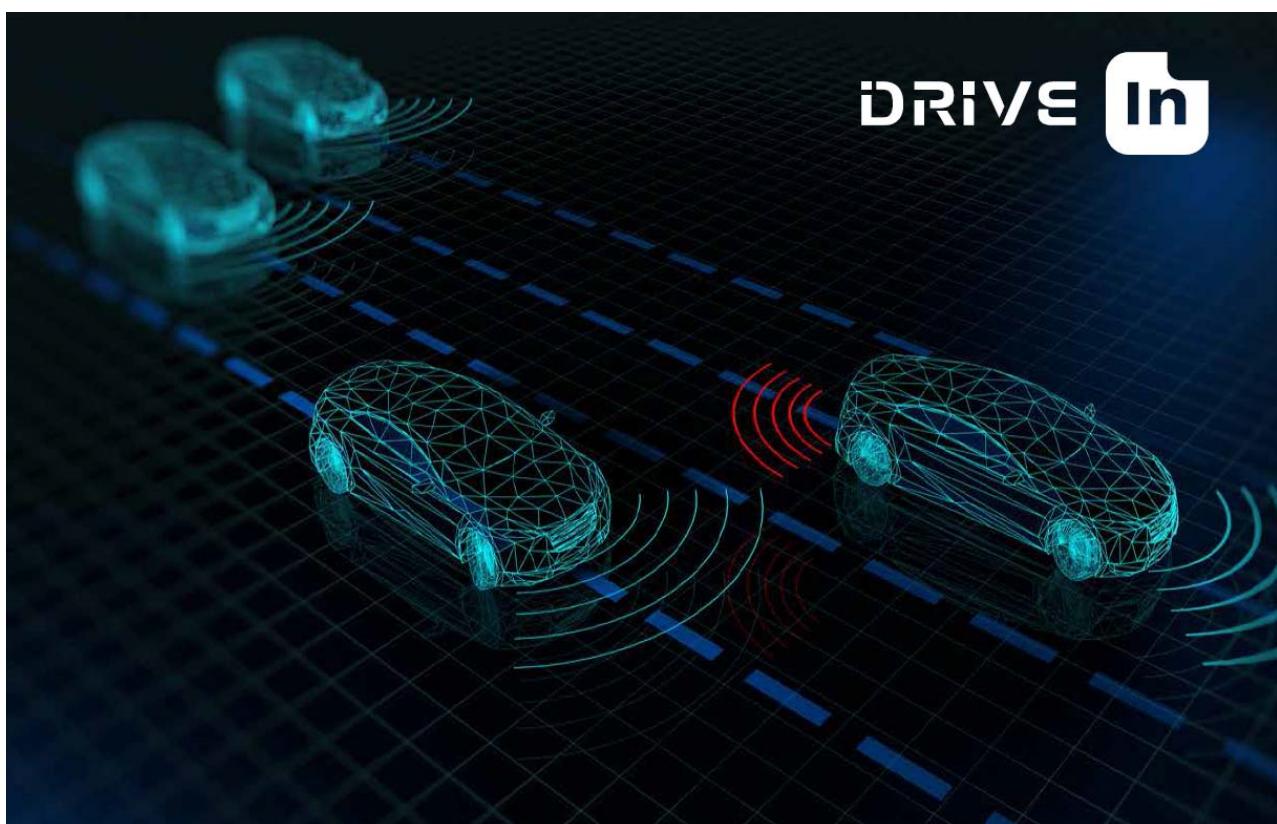


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1. INTRODUCTION

The four ESRs have been enrolled in a (virtual) Winter School (26th of October - 06th of November 2020) taking advantage of the annual JePPIX Design Course. JePPIX (<https://www.jeppix.eu/knowledge/training/deep-dive2020/>) is the joint European platform for photonic integrated components and circuits, established in 2006, and committed to driving the industrialisation and use of high performance indium phosphide, silicon nitride and hybrid photonic integration. JePPIX Partners representing all Photonics Supply chain work together to stimulate the evolution of integrated Photonics by defining standards, and optimising work flow to ensure the best insight into the technology. JePPIX also shares insights on the evolution of technology, emerging markets and applications, and future customer demands in the JePPIX Roadmap.

The objectives of this Winter School are to provide the ESRs with knowledge to learn advanced material properties, device design, technologies and applications of Photonics in different fields such as telecom, sensing, interconnections, quantum information. Photonic integration is the key issue of this school, which involves novel design techniques and fabrication processes to make integrated optic devices and systems for novel industrial products. Industrial point of view has been also considered indeed. Lectures were given by international first class scientists, research centres and industrial laboratories. Purpose of the course is also to be a forum to trigger new cultural exchanges and foster new collaborations in the field of Photonics.

With this Winter School the ESRs have acquired confidence, skills and perspective to gather a vision on the different applications of integrated photonics. It helped ESRs in their development of skills, test-taking strategies, and professional development. Moreover, it served to familiarize ESRs with conferences/workshops, talks and research plans. The ESRs have interacted with several industry and academic institutions and have started broadening their network to prepare for postdoc career. Finally, this Winter School **entitles them to obtain 2 ECTS for their PhD transcript record.**

1.1 WINTER SCHOOL

This two weeks flagship immersion Winter School has been held online between 26th of October, 2019 and 06th of November, 2020. Our ESRs have been enrolled in this training, that is designed for students/researchers/professionals who have a good background in photonics and who wish to understand how to get the best out of design tools and the PIC technology. Experts from the Institute of Photonic Integration (formerly known as the COBRA Institute) are joined by specialist trainers from the Photonic CAD community, professional designers and



experts from foundries to share insights and know-how. Participants gain virtual clean room experience and a detailed insight into the steps in designing and creating PICs.

The Winter School covers the theory and practice of integrated photonic component and circuit design using the powerful JePPIX building blocks. Layout and simulation methods are developed with JePPIX CAD tool developers and professional designers.

In the first week of the Winter School, our ESRs have developed insights into mode analysis to better understand the design space for waveguide based integrated optics, how best to construct interferometers and filters. Active building blocks including semiconductor optical amplifiers, modulators and detectors, have been introduced in terms of physical principles and practical implementation as components and circuit elements. Methods for laying out circuits, have been developed. Hybrid and monolithic integration schemes, have been described.

In the second week, the emphasis turned to practical skills, with the opportunity to trial commercial CAD tools, process design kits (PDKs) and develop insights with expert designers and leading academic instructors. Representatives from the foundries have also been available to talk through the latest platform capabilities. Virtual tours to clean room facilities and measurements laboratories were included to provide insights into the role of fabrication tolerances and testing methods on design methods. Packaging have also been reviewed to ensure package, test and manufacture aware design.

The Winter School is relevant to engineers and scientists who have an awareness of photonics and the underlying principles, and who wish to extend this knowledge to create the first photonic integrated circuits on open access foundries. It has provided both the underlying knowhow to enable an understanding of the design space, as well as the practical skills to implement designs.

Learning outcomes include the ability to identify and specify building blocks, connect building blocks and lay out for the creation of functional photonic integrated circuits. ESRs have used a range of simulation and design tools suited for active and passive components and circuits, and have been able to use foundry specific process design kits to predict circuit performance and create the file sets required for an MPW (multi-project wafer) run.

1.2 THE TRAINING

The technical program for the Winter School has been the following:



JePPIX Deep-Dive PIC Design Course 2020 – Week 1					
Time	Monday (26.10)	Tuesday (27.10)	Wednesday (28.10)	Thursday (29.10)	Friday (30.10)
09:00-10:00	Welcome & JePPIX Ecosystem <i>Sylwester Latkowski</i>	MMI couplers <i>Xaveer Leijtens</i>	Active components: SOA, lasers (Part 1) <i>Erwin Bente</i>		Active components: SOA, lasers (Part 2) <i>Erwin Bente</i>
10:15-11:15	Dielectric waveguide basics <i>Xaveer Leijtens</i>	Arrayed Waveguide Gratings <i>Xaveer Leijtens</i>	Simulation methods: mode, BPM, FDTD <i>Victor Calzadilla</i>	Processing introduction: Lithography, epitaxy, COBRA flow <i>Yuqing Jiao</i>	Standardization and packaging <i>Sylwester Latkowski</i>
11:30-12:30		Mode analysis <i>Xaveer Leijtens</i>	What is a mask? GDS, cell, PDK, DRC <i>Katarzyna Ławniczuk</i>		
Lunch break					
			Parallel sessions	Parallel sessions	Parallel sessions
13:30-14:30	2D confinement, propagation <i>Xaveer Leijtens</i>	Overview of software tools <i>Aura Higuera</i>	Software Hands-on	Software Hands-on	Software Hands-on
14:45-15:45	Curved waveguides, junctions <i>Xaveer Leijtens</i>	Participants' presentations	NAZCA or PhotonDesign or Luceda*	Nazca or PhotonDesign or Lucei	NAZCA or PhotonDesign or Luceda*
16:00-17:00	Couplers and splitters <i>Xaveer Leijtens</i>	Mode analysis <i>Xaveer Leijtens</i>			

JePPIX Deep-Dive PIC Design Course 2020 – Week 2					
Time	Monday (2.11)	Tuesday (3.11)	Wednesday (4.11)	Thursday (5.11)	Friday (6.11)
09:00-10:00	Process tolerances and device design <i>Victor Calzadilla</i>	Workshop on the PHIsim PIC simulator <i>Erwin Bente</i>	Fraunhofer HHI <i>Moritz Baier</i>	KLayout <i>Dzmitry Pustakhow</i>	Evaluation 9:00-9:30
10:15-11:15	SMART Photonics <i>Nazanin Shafiee</i>	Lasers in InP technology <i>Erwin Bente</i>	LioniX International <i>Douwe Geuzebroek</i>	Characterization of optical chips <i>Marija Trajkovic</i>	Design with Experts 9:30-12:30
11:30-12:30	Why InP? Application examples <i>Anna Nikiel</i>	Practical hands-on worked example <i>Rastko Pajkovic</i>	From system specs to PIC design <i>Iñigo Artundo</i>	JePPIX MPW workflow and DRC <i>Xaveer Leijtens</i>	
Lunch break					
		Parallel sessions	Parallel sessions	Parallel sessions	
13:30-14:30	RF Components: MZI, EAM, Detectors <i>Weiming Yao</i>	Software Hands-on Ansys/Lumerical or Synopsys or VPIphotronics	Software Hands-on Ansys/Lumerical or Synopsys or VPIphotronics	Software Hands-on Ansys/Lumerical or VPIphotronics* or Synopsys*	
14:45-15:45					
16:00-17:00	Hybrid integration <i>Kevin Williams</i>				



And the lecturers have been:



Prof. Dr. Kevin Williams
Full Professor and Chair of
the Photonic Integration
research group,
TU/e



Dr. Xaveer Leijtens
Associate Professor in the
Photonic Integration
research group,
TU/e



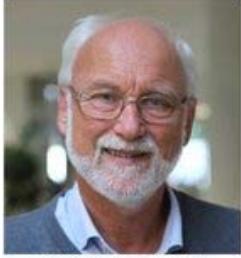
Dr. Erwin Bente
Associate Professor in the
Photonic Integration
research group,
TU/e



Dr. Yuqing Jiao
Assistant Professor in the
Photonic Integration
research group,
TU/e



Dr. Weiming Yao
Scientist in the Photonic
Integration research group,
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Prof. Dr. Meint Smit
Full Professor in the
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Engineering,
TU/e



Dr. Sylwester Latkowski
Senior Researcher in the
Photonic Integration
research group,
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Dr. Victor Calzadilla
Scientist in the Photonic
Integration research group,
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Dr. Luc Augustin
CTO,
SMART Photonics



Dr. Moritz Baier
Head of the Photonic InP
Foundry group,
Fraunhofer HHI



Dr. Douwe Geuzebroek
VP Marketing and Sales,
LioniX International



Dr. Iñigo Artundo
CEO,
VLC Photonics



Dr. Dominic Gallagher
CEO,
Photon Design



Dr. Ronald Broeke
General manager,
BRIGHT Photonics and
Nazca Design



Dr. Pieter Dumon
Co-founder, CTO,
Luceda Photonics



Dr. Luis Orbe
Customer Support
Coordinator,
Synopsys



MSc. Greg Baethge,
Senior Support Engineer,
Lumerical Inc.



MSc. Andrzej Polatynski,
Photonics Application
Engineer,
VPIphotonics



Dr. Huub Ambrosius
Managing Director,
Nanolab TU/e



Dr. Dzmitry Pustakhowd,
Scientist in the Photonic
Integration research group,
TU/e



Unfortunately we don't have pictures of the training, as it was completely online. Below some pictures of the Winter School 2019. Many aspects of the virtual training are represented in these pictures, covering from theory and design to experimental and foundry knowledge.





