DRIVE In

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

Deliverable D6.7 (D26)

Technical hands-on courses (TC) – TC2
Hands-on VPI Photonics

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Abstract

In addition to the scientific-based training, DRIVE-In offers to all ESR specific short-term hand-on training which can provide the ESRs with skills in highly experienced organizations, receiving cutting-edge technological knowledge and skills. These hands-on training will be provided at the same time the ESRs are seconded to Partner Organizations providing the courses, i.e. CTAG and BP, and are aimed to explore knowledge in circuit simulation and packaging.

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

Change Record

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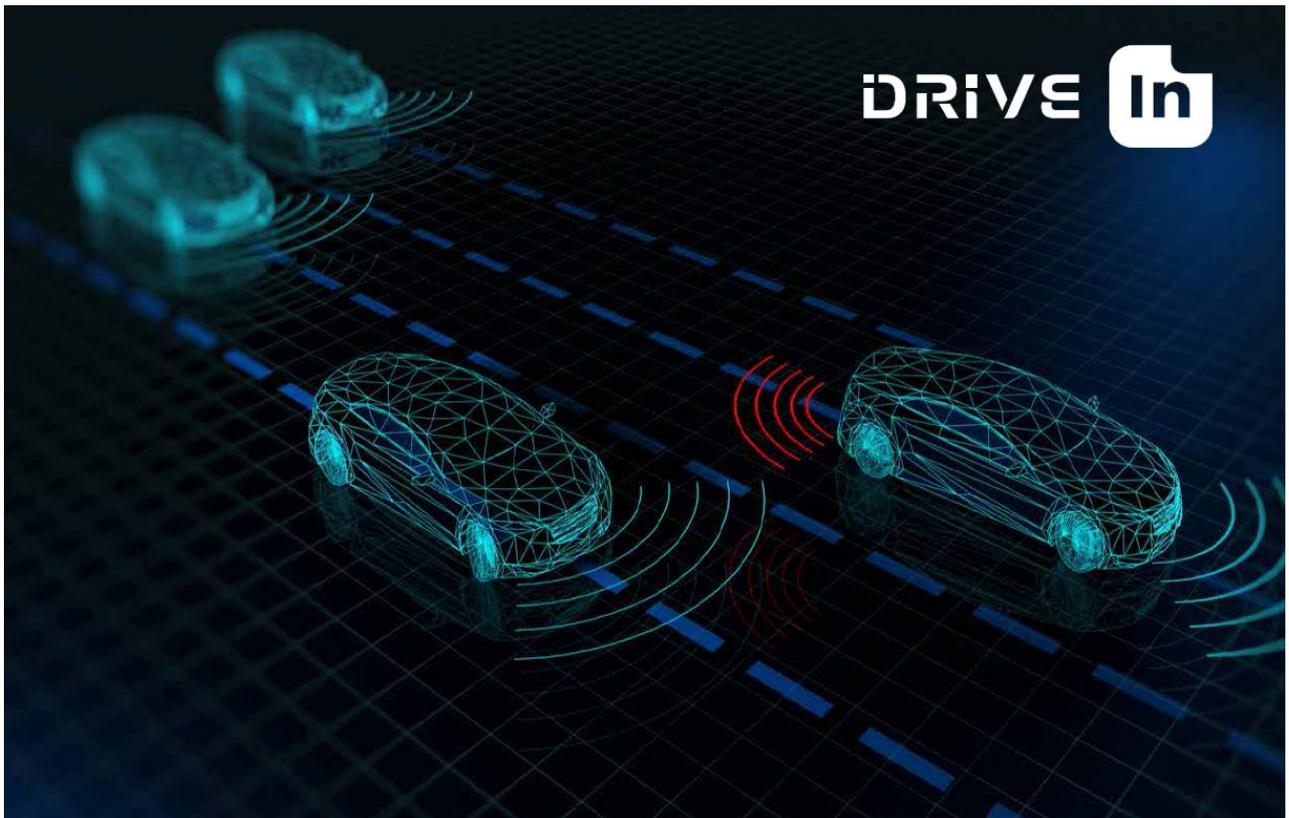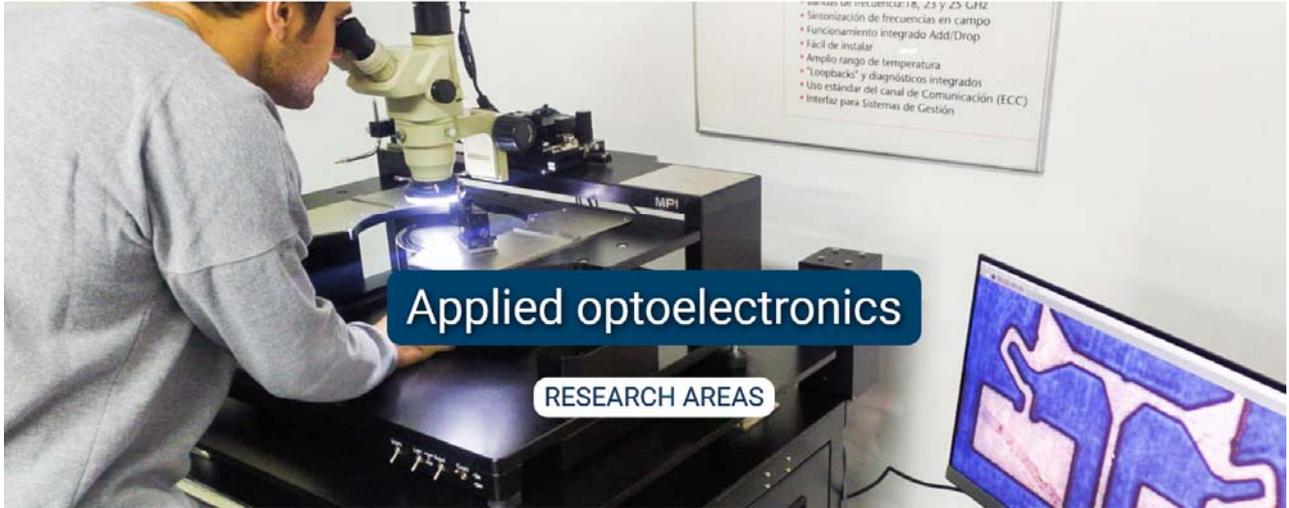
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1. INTRODUCTION

The aim of this report is to provide a brief overview of the **Technical Hands-on Course TC2-Hands on VPI Photonics** organized in the framework of the project DRIVE-In. As a general introduction, the challenge for the DRIVE-In Training Network is to develop new fundamental skills on simulation, design, measurement automation, fabrication and validation, and organization in an integrated photonics foundry. These are intended to develop PDK specifically for LiDAR and FSO applications and new hybrid photonics and electronics modelling and simulation software for the next generation of ITSs and ADASs enabling integrated InP technologies. As collateral goals, the ESRs will contribute to the development of new test structures, advanced PIC designs and new optoelectronic hybrid software tools. To achieve this, DRIVE-In training strategy aims to combine scientific advanced training (Scientific Courses 1-5), technical hands-on courses (TC1-3), Winter School and regular EID meetings and networking events. Furthermore, all ESRs will be equipped with a range of transferable skills, as defined in the proposal.

The following specific training objectives (TOs) are defined to fulfill these goals:

- TO1: To enhance the attractiveness of a career in the front-line area of research in photonics' software circuital and physical simulation, design and modelling tools and in the creation of building blocks, test structures and models for generic InP integration platforms. This will provide the opportunity for the ESRs to be involved in the creation of a new and major research area in hybrid photonics and electronics simulation and modelling, joining two major different technologies like microelectronics and integrated photonics; by applying consolidated knowledge coming from integrated circuits to develop integrated photonics-electronics software with enhanced performance.

- TO2: To provide future employers (both academic and industrial) with the next generation of researchers that: i) are skilled in a wide range of techniques and methods, stemming from software to design, fabrication and characterization of InP integrated circuits; ii) have direct experience of interaction across disciplines and sectors with different background in electronics/photonics towards the development of a completely new area of research, producing new devices suitable for, but not limited to, the next generation of ITSs and hereby ADASs.

- TO3: To produce researchers with excellent transferable skills and the ability to transform abstract and challenging ideas into influential and practical outcomes.

- TO4: To create an active, long-term network of young researchers whose personal contacts, support and expertise will help Europe shape the future of research in ITSs and ADASs for active/passive sensing and optical communication devices; and to enhance/optimize the software simulation tools by integrating electronics in the optical

design process.

- TO5: To cascade expertise and spread good practice throughout Europe by personnel exchange and delivering European researchers able to – in the near and mid-term future – become leaders in the fields of integrated hybrid photonics and electronics software simulation and design, PIC designs, ADAS applications and automation in photonics industry.

The four ESRs **have been enrolled (07/10/2020) in the PhD program from the UVigo (Doc-TIC)**. Doc-TIC is the PhD Program promoted by the School of Telecommunications Engineering and atlanTTic. Its mission is to train the best professionals and researchers to generate quality research with international impact and to provide the industry with professionals with advanced knowledge to improve its competitiveness at global level. Doc-TIC involves the merging and expansion of the previous PhD Programmes in Signal Theory and Communications (TSC) and Telematics Engineering, both with Mention of Excellence awarded by the Spanish Ministry of Education. Each ESR will be required to accumulate at least 30 ECTS (European Credit Transfer and Accumulation System) credits, among the pool of scientific- and transferable skills-based courses at UVigo and TUe **to obtain their PhD title**.

Through the Doc-TIC PhD Programme the UVigo offers a number of **course modules in areas related to photonics (active and passive devices), quantum mechanics, solid-state physics**, all of which are given in English. Between them, **this group of Technical-based courses (TC) offered to each ESR, will allow them to obtain six ECTS, two per TC (30 lecturing hours and 10 hours of homework).**

1.1 TECHNICAL HANDS-ON COURSE TC2 – HANDS-ON VPI PHOTONICS

In the following Table we describe the fundamentals of these technical training group of courses and corresponding skills to be acquired by the ESRs.

Title	Hands-on JeppiX training (TC1)		Month: 13	Duration: 2 Weeks
Lead	UVigo			
Contents: To get an overview of the latest status of the integrated photonics eco-system for the three major photonics technologies: InP, silicon photonics and TriPleX (SiN). This overview will include the available design tools and the importance of considering test and packaging in an early stage. The unique combination of lectures and hands-on training will teach how to perform circuit simulations, including fabrication tolerances, how to use and develop a PDK and how to set-up libraries in a structured way. Several Software tools will be used for this purpose (Synopsys Optodesigner, VPI, Lumerical).				
Skills for ESRs: Get introduced to Integrated Photonics Design Flow Automation. Learn the use of photonic integrated circuit simulation tools. Obtain in-depth knowledge of integrated design from mask to photonic and process flow simulations. Exchange experiences and ideas with other participants. Learn different technologies for integrated devices, other software tools, cleanroom processing and testing mechanisms.				
Title	Hands-on VPI Photonics (TC2)		Month: 13	Duration: 2 Weeks
Lead	VPIP			
Contents: To learn a suite of robust circuit solvers for integrated photonics structures, using HHIF PDKs. It supports time and frequency domain solvers, and large number of complementary algorithms which allows it to solve a large variety of photonics and electronics problems which may be made of any material and of almost any geometry. VPI Photonics allows product modelling, design and optimization of heterogeneous PICs, linear electric circuits, and multisection optoelectronic devices and can show how the current co-simulation with electronic software (Keysight ADS) works and highlight the current limitations. Designed optoelectronic devices cover applications such as widely tuneable and mode-locked lasers, gain-clamped SOAs, electro-absorption modulators, wavelength converters and 2R/3R optical regenerators, etc. Designed PICs cover applications such as coherent transmitters and receivers for advanced modulation formats, optical interconnects, recirculating optical buffers and reconfigurable delay lines, multi-ring filters and arrayed waveguide gratings, and practically any other monolithically integrated or hybrid PICs based on silicon (Si), indium phosphide (InP) or gallium arsenide (GaAs) substrates. VPIPhotonics optical design and configuration products come with an extensive library of over 700 demonstration applications.				
Skills for ESRs: to learn how to model InP related devices, subsystems and circuits; how to optimize their performance, perform the layout and mask simulation, optimize structures according to specifications sweeping parameters and gain knowledge on programming and scripting aspects. Design topics include: Graphical User Interface features, Overview of signal models and simulation technique, Parameter sweeps and optimizations, Visualization and post-processing of simulation results, Scripted simulations and automated system design				
Title	Automotive ADAS devices and specifications (TC3)		Month: 14	Duration: 1 Week
Lead	CTAG			
Contents: A full course on ADASs. It will give an overview about sensor types, topologies, and system setups today. It will show later on examples based on camera sensors, radar sensors, lidar, free space optics communication systems inside and outside the car, types of Advanced Driver Assist Systems. It will introduce driver assist systems associated with the windshield and their related concerns. This module provides an overview of some of these systems and how they assist the driver. These include: Lane departure warning and lane keep assist systems; Collision mitigation systems; Pre-collision systems; Automatic high-beam assist systems; Night vision systems; Head-up displays; Automatic Windshield Wipers.				
Skills for ESRs: An introduction and overview towards ADASs, algorithms devices and electronics technologies to develop ADASs; specifications and guidelines to produce devices with enhanced performance; interdisciplinary knowledge in photonics and electronics applied to automotive disciplines.				

1.2 SYLLABUS

The outline of this course is described below. TC2 has been held between 1-5 March 2021 as online seminar (09:30-13:30).

Topics covered in the course: design waveguides and fibers, automate the design of photonic integrated circuits, design fiber-based devices such as doped-fiber amplifiers, and ultimately simulate high-speed optical transmission systems. Each day includes software access and an 8-hour virtual session of lectures, guided labs, and independent work with 1-on-1 support.

Technical Hands-on Course TC2: Hands-on VPI Photonics (Dr. Eugene Sokolov)

Section 1.

Cross-section design (waveguide-based example)

- Predefined and custom materials
- Nonuniform meshing
- Various layout shapes
- Best solvers for desired applications
- Mode visualization
- Extraction of circuit-level parameters

BPM for 3D photonic integrated devices

- Expanding the cross-section into 3D structures
- Simulation of basic integrated components such as Waveguides, Bends, S-bends, etc.

Section 2.

- Photonic design environment & getting started
- Passive photonic components: waveguides, ring resonators, AWGs
- Active photonic elements: lasers, amplifiers, tunable optoelectronic components
- Heterogeneous PICs combining active and passive photonics
- Hybrid PICs combining different technologies
- Application cases, your own designs

Section 3.

- Simulation of Erbium- and Thulium-doped fiber amplifiers
- Design multi-pump Raman amplifiers
- Optimization of fiber amplifier design
- Characterization of fiber amplifiers

Section 4.

- High-speed access networks
- Optical interconnects for datacenter applications
- Performance assessment of PAM-4 signals
- Fundamental automation techniques
- DSP demodulation for high-order coherent M-QAM systems
- Mitigation of transmission-induced impairments using DSP
- Performance comparison of different modulation formats
- Exploring benefits of probabilistically-shaped QAM constellations and FEC coding
- Investigation of nonlinear interference noise in WDM systems

Section 5.

- GPU and Parallel Simulation
- Simulation scripts and Macros
- API (Cosimulation and Simulation Engine Driver)
- Design your own schematics

The **methodology** applied was based in:

Lectures: The professor introduces the main contents of each chapter to the students. These lectures did not cover all the contents of each subject. For that reason, the students had to review the supplementary notes provided in class. It is also expected that the students reviewed the concepts introduced in the classroom and expand on their contents using the guide of each chapter, together with the recommended bibliography, as a reference.

Laboratory: The lectures included some exercises in the lab involving different optical devices and optical communication systems.

Case studies: It consisted on activities that complement the master sessions and allow a better understanding of the theoretical concepts.