Deliverable 6.2

Intensive technical and lab courses 2, 3 & 4

'Large scale photonic integration (part 1: design, fabrication)' (2)
'Large scale photonic integration (part 2: characterisation)' (3)
'Full-field photonic components and integrated circuits' (4)

Date: 23 September 2020

Grant agreement no.:	812818
Project acronym:	MICROCOMB
Project website:	https://www.microcomb-eu.org/
Project full title:	Fundamentals and Applications of Microresonator Frequency Combs
Project start date:	01 January 2019
Actual submission date:	23 September 2020
Work Package:	WP6 – Courses 2-4 report
Version:	1.0
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Type:	Report
Dissemination Level	Public

Abstract

Two intensive technical courses *Large scale photonic integration (part 1: design, fabrication)* and *Full-field photonic components and integrated circuits* were combined in a week-long, online training event intended for MICROCOMB ESRs and guest participants. Intensive technical course 3 had to be postponed due to Covid-19, as it is not possible to deliver it online.

In the first part of the week at the course, organised and delivered by Ghent University and a project's industrial partner Luceda Photonics, students learned theory behind the design and fabrication of photonic chips along with applying this knowledge in to practice by designing their own devices with the use of IPKISS design software, developed by Luceda Photonics.

The last two days of the week students attended *Full-field photonic components and integrated circuits*, where Universitat Politècnica de València's lecturers described the theoretical background of the OFDI structures, which followed by a hands-on training, employing MatlabTM or Octave software.

Intensive technical and lab course (2): "Large scale photonic integration (part 1: design, fabrication)"[1]

The "Large scale photonic integration (part 1: design, fabrication)" intensive technical course organised by Ghent University and Luceda Photonics took place on 14 – 16 September 2020 online via Zoom. All ESRs recruited on the MICROCOMB ITN project attended, as well as other graduate students working in the groups of the consortium beneficiaries.

Theoretical lectures covering the subjects of introduction to silicon photonic foundries, CMOS fabrication flow, design manufacturability and filter design were presented over the first two days of the workshop by Dr Abdul Rahim from Expixfab, Prof Bart Kuyken and Ewoud Vissers an Early Stage Researcher from Ghent University, which were followed by a practical training over the use of IPKISS design software developed by project partners Luceda Photonics and delivered by Dr Pierre Wahl – founder of Luceda Photonics.

Participants were emailed a software developed by Luceda prior to the training and used their own laptops to follow the simulation steps.

A major emphasis was placed on hands-on experience with exercise sessions scheduled at the third day of the workshop under the supervision of partners from Luceda Photonics. Exercise sessions were particularly designed to combine skills and knowledge acquired by the participants during all the preceding lectures.

All sessions were recorded for training purposes.

Topics:

- introduction to silicon photonic foundries
- CMOS fabrication flow
- design manufacturability
- the theory and design of filters
- practical training over the use of IPKISS design software including:
- design layout and simulation of a filter

Participants:

- 16 MICROCOMB ESRs
- 4 non-ESR researchers from 2 beneficiary groups
- 4 speakers

[1] https://www.microcomb-eu.org/ghent-luceda-course

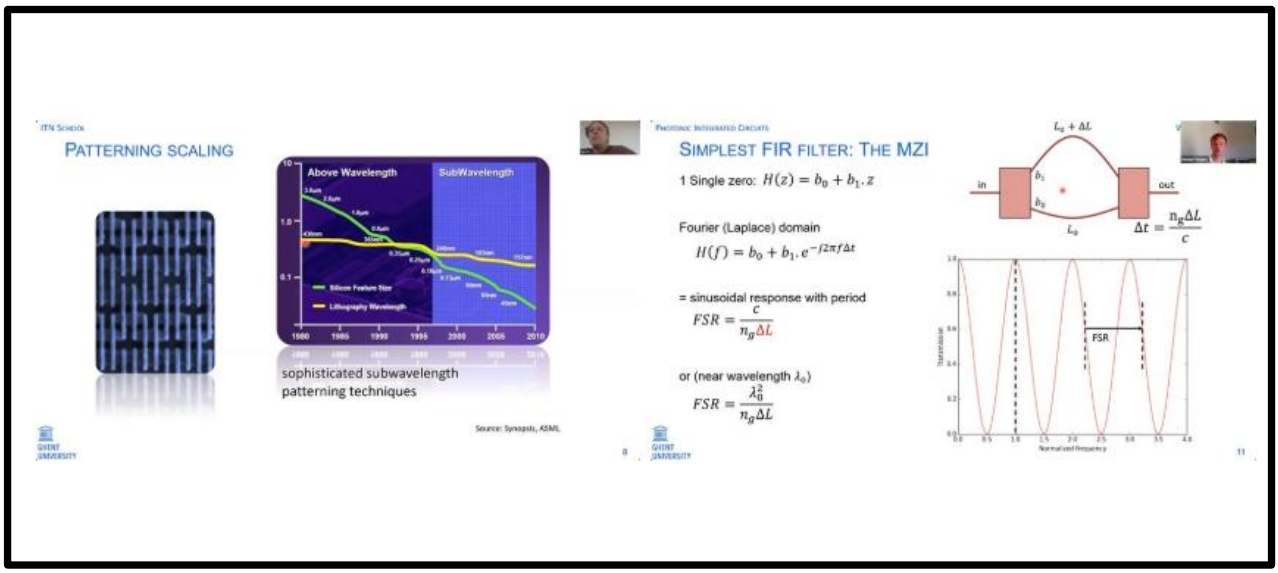

Figure 1: A snapshot of the training session given by Prof. Kuyken on CMOS scaling and fabrication and a snapshot of the filter design course given by ESR Ewoud Vissers

Intensive technical and lab course (3): "Large scale photonic integration (part 2: characterisation)"

This practical and hands-on intensive technical course was going to take place in June 2020 at Ghent University, Ghent, Belgium as a group face-to-face session. Due to the ongoing Covid-19 pandemic this training had to be postponed until it will be safe for ESRs to travel and meet in larger groups.

Intensive technical and lab course (4): "Full-field photonic components and integrated circuits"[2]

The "Full-field photonic components and integrated circuits" intensive technical course organised by Universitat Politècnica de València took place on 17-18 September 2020 online via Microsoft Teams. All ESRs recruited on the MICROCOMB ITN project attended, as well as other graduate students working in the groups of the consortium beneficiaries.

This 6 hours theoretical (3h) and practical (3h) workshop focused on Optical Frequency Domain Interferometry (OFDI) techniques. These have been demonstrated as powerful tools to the full field assessment in optical fiber devices, but in recent years they have been exploited and properly adapted to integrated optical components.

OFDI provides Time and Frequency domain precise characterization in amplitude and optical phase, leading to resolution of very short time events, and from waveguide losses up to waveguide chromatic dispersion assessment in typical structures, such as micro-ring resonators.

Lectures were delivered by Prof Daniel Pastor, Prof Pascual Muñoz and Luis A. Bru an experienced PhD student from the Photonics Research Labs PRL-ITEAM at Universitat Politècnica de València.

[2] https://www.microcomb-eu.org/upv-course

In the first session, we lecturers described the theoretical background and the required practical hardware set up to carry out measurements, and the strategies for the on-chip integration of the OFDI structures along with your own integrated structures.

The second session consisted of a hands-on employing MatlabTM or Octave, during which you will experience on the processing steps using test data from actual already structures, including ring resonators, Mach-Zehnder interferometers, and spiral waveguides.

Pre-course work and information was e-mailed to all registered participants prior to the course.

All sessions were recorded and videos from the theory part of the training are published on the Microcomb website.[3]

Topics:

1. OFDI main structures
2. OFDI simulator
    - Waveguide definition. Group delay and Dispersion
    - Finite Impulsive Response (FIR): WGs, MZIs, AWGs, etc
    - Infinite Impulsive Response (IIR): Ring Resonators (RR)
    - DUT integration onto MZI-DUT interferometer
    - Reference Interferometer and relation with MZI-DUT -> Corrected Interferogram
    - DUT Interferogram transformation to Time Domain
    - Time Domain response. Resolution
    - Time Domain response. Secondary lobes -> Windowing
    - Time Domain response. Temporal discretization -> Zero Padding
    - Back to DUT frequency response-> Examples
3. Chromatic dispersion on OFDI
    - Time broadening
    - Dependence width wavelength span
    - Crosstalk between temporal events
    - Effects of Chromatic Dispersion from ref. Waveguides- Dispersion de-embedding
4. Photonic Integrated Circuits characterized by OFDR

Participants:

- 16 MICROCOMB ESRs
- 6 non-ESR researchers from 2 beneficiary groups
- 3 speakers

[3] https://www.microcomb-eu.org/upv-course-video

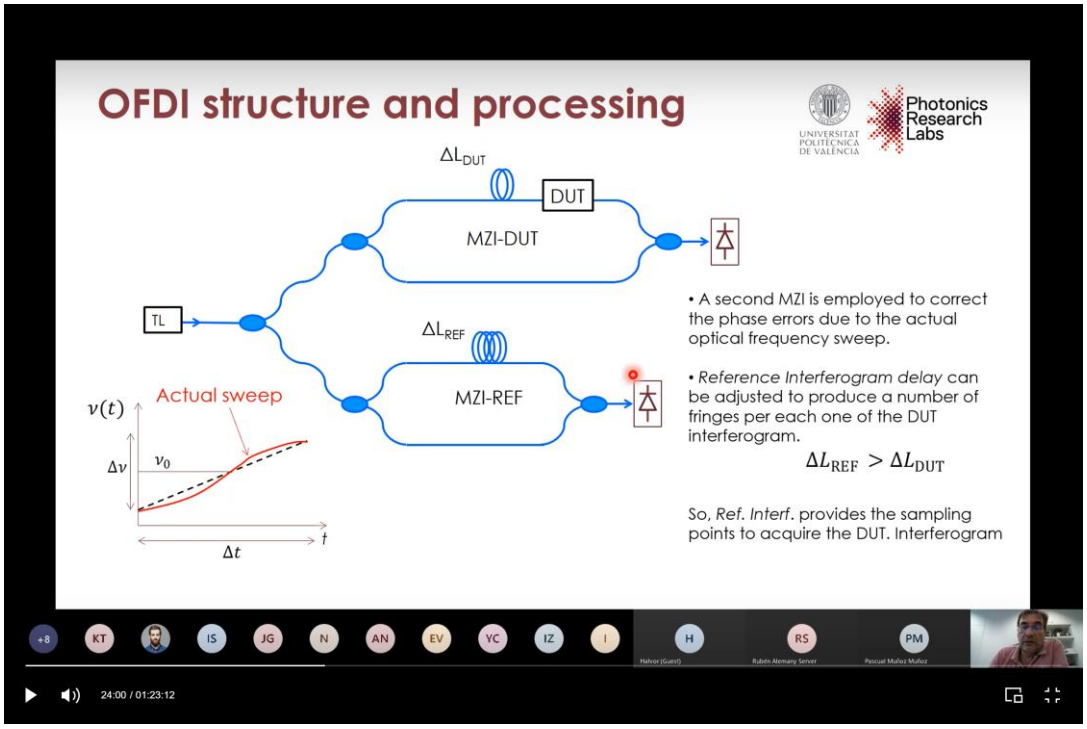

Figure 1 a snapshot from the part 1 of the training session on Thursday 17 September 2020

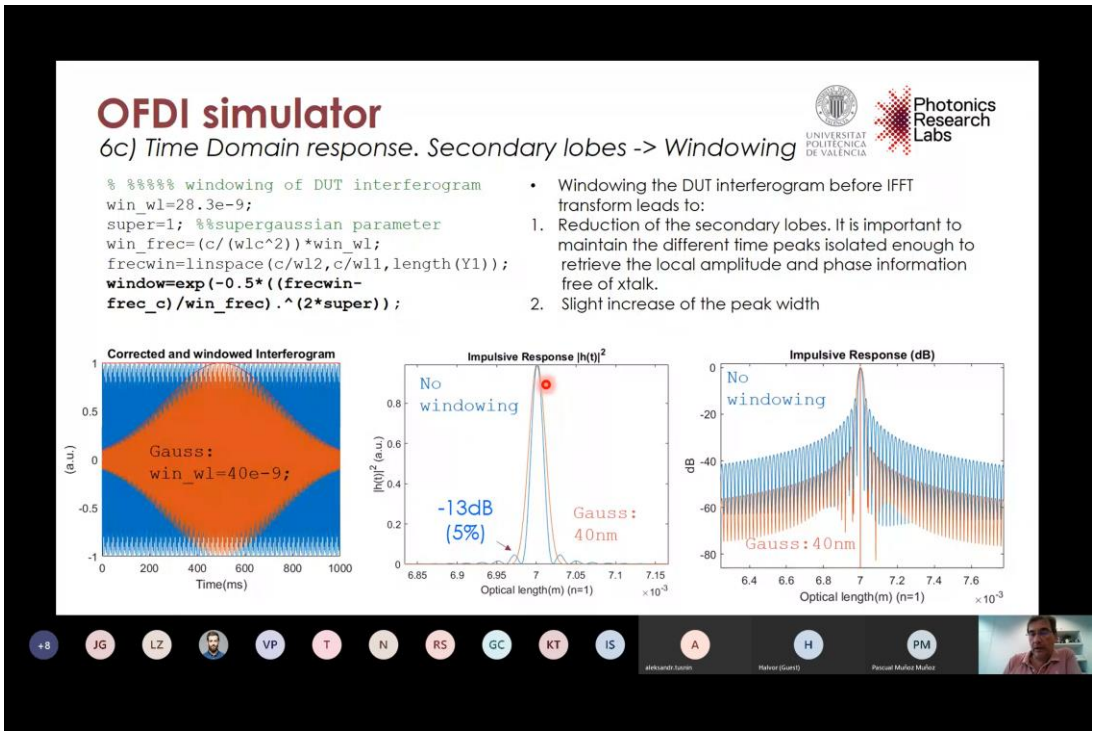

Figure 2 a snapshot from the part 2 of the training session on Thursday 17 September 2020