PhotonHub Demo Centre

Course
Fabrication and characterization of an integrated Electro-Optic modulator

Course Provider

FEMTO-ST Institute,
Université Bourgogne Franche-Comté,
France

Course Overview

Integrated electro-optic (EO) modulators have become ubiquitous in the long-haul, high-capacity optical fiber telecommunications backbone, while they also find useful for a range of demanding applications like microwave/RF photonics, space/data communications, distributed sensing and lidar, inertial navigation, pulse shaping of industrial lasers, laser frequency stabilization and control, and now for photonic neural networks and quantum information processing.

This one-day training course provides industry with a practical know-how about all clean-room fabrication & characterization steps of an integrated $LiNbO_3$ EO amplitude modulator. Attendees will leave the course with their fabricated demo, a 3-inch wafer fitted out with 11 patterned modulators.

The course will focus on 4 steps; 1) tutorial on the operating principle of an EO modulator; 2) fabrication of the optical waveguides by sputtering, lithography and etching; 3) fabrication of the Cr/Au thin electrodes including mask alignment. During fabrication, the devices are step-by-step quality controlled and tested; 4) optical and transmission tests of a fully packaged modulator.

Target Audience

It is desirable but not essential that course attendees have a basic understanding of photonics and clean-room processes. The course and its hands-on work are ideally suited to those planning to design, develop and manufacture new integrated photonic products based on clean-room fabrication and suited to applications in telecoms, sensing, signal/data and pulse processing….

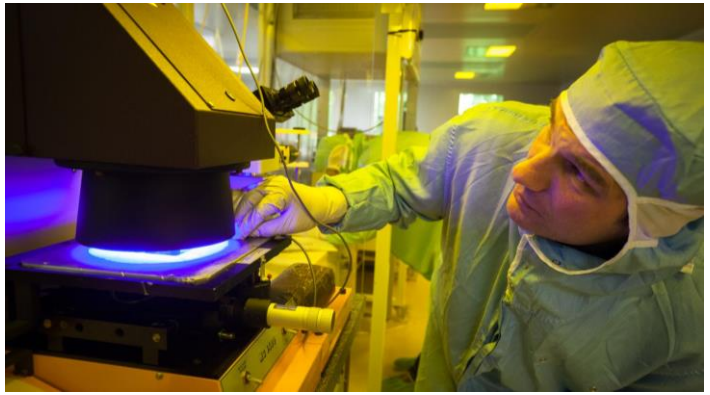
Expected Outcomes

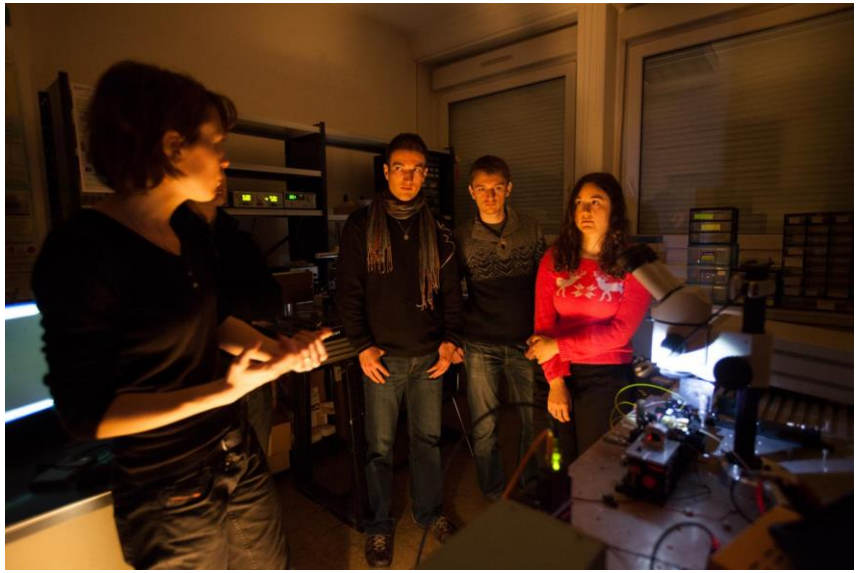
1) Understanding of key features and applications of an integrated electro-optic modulator.
2) Execute all the collective on-wafer fabrication steps to produce Mach-Zehnder optical waveguides with step by step quality control (hands-on activity)
3) Achieve all the fabrication and alignment steps of Cr/Au thin electrodes with step by step quality control (hands-on activity)
4) Perform characterization of a $LiNbO_3$ electro-optic modulator on an optical transmission bench.

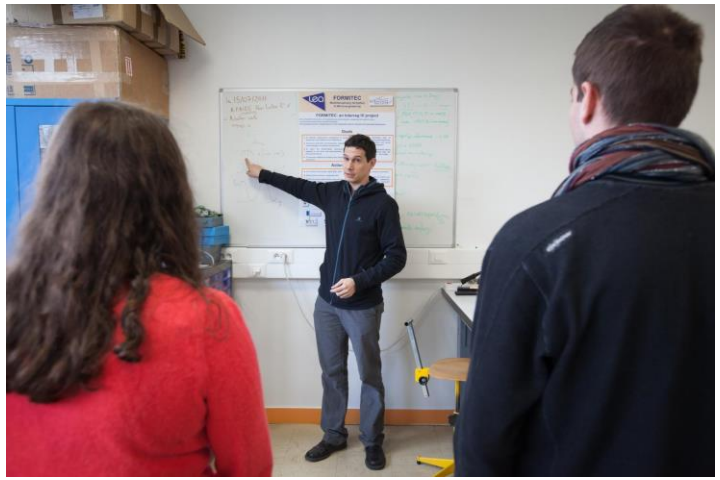
Course Schedule

Time	Demo Activity
08:00 – 9:00	**FEMTO-ST and course introduction with tutorial on electro-optic modulation, technology and use (lecture step 1)**
9:15 – 12:15	Practical work in clean room for fabrication of optical Mach-Zehnder waveguides by sputtering, lithography of positive photoresist and etching (hands-on step 2)
13:00 – 17:00	Practical work in clean room for fabrication and alignment of the Cr/Au electrodes by lift off, inverse photoresist, optical and thickness measurements (hands-on step 3 -> integrated demo wafer)
17:15 – 18:15	Electro-optical characterization of an integrated $LiNbO_3$ demo modulator in an optics lab (hands-on step 4)
18:15 – 18:45	**Follow-Up Questions & Close**

Course Trainers







Course Director: Dr. Ir. Jean Yves Rauch

Course Manager: Prof. Franck Chollet

Tutorial: Profs. Franck Chollet, Nadège Courjal

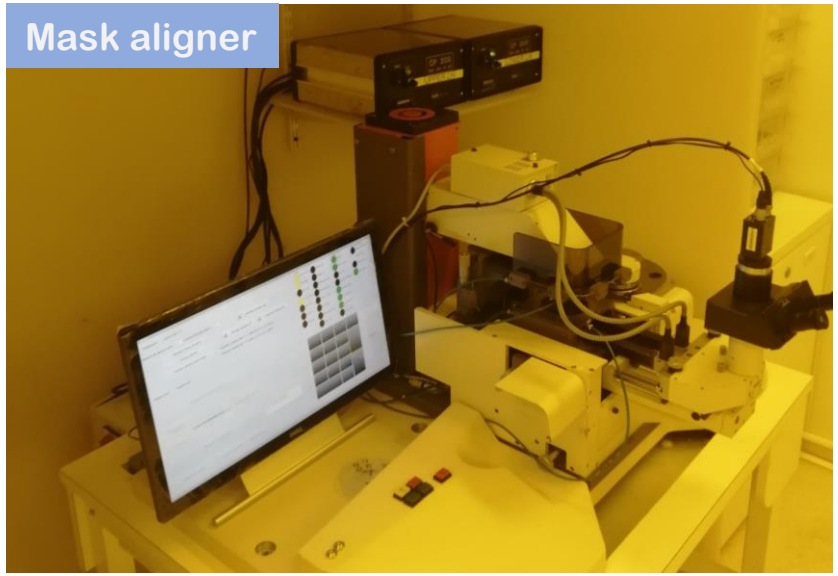
Fab. step 2: Dr. Ir. Jean Yves Rauch

Fab. step 3: Dr. Ir. Jean Yves Rauch

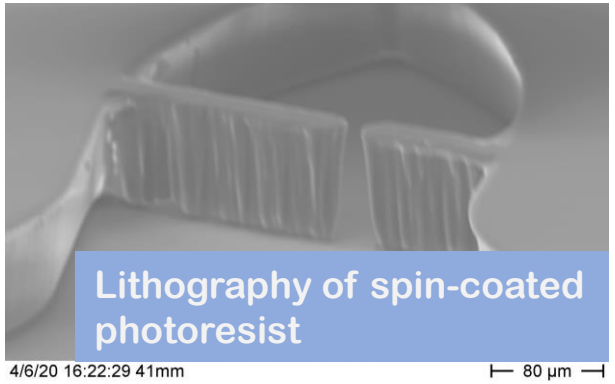
Charac. Step 4: Dr. Jean-Marc Merolla

Course Demonstrators

Mask aligner

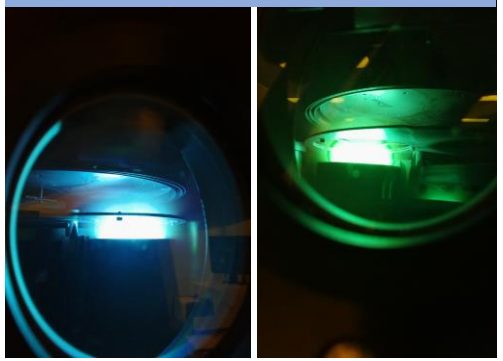


Sputtering equipment

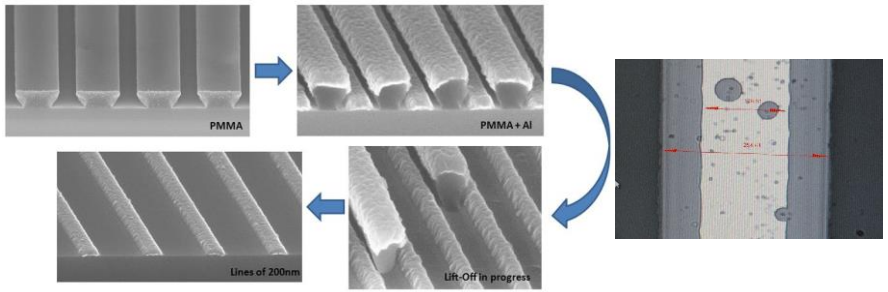


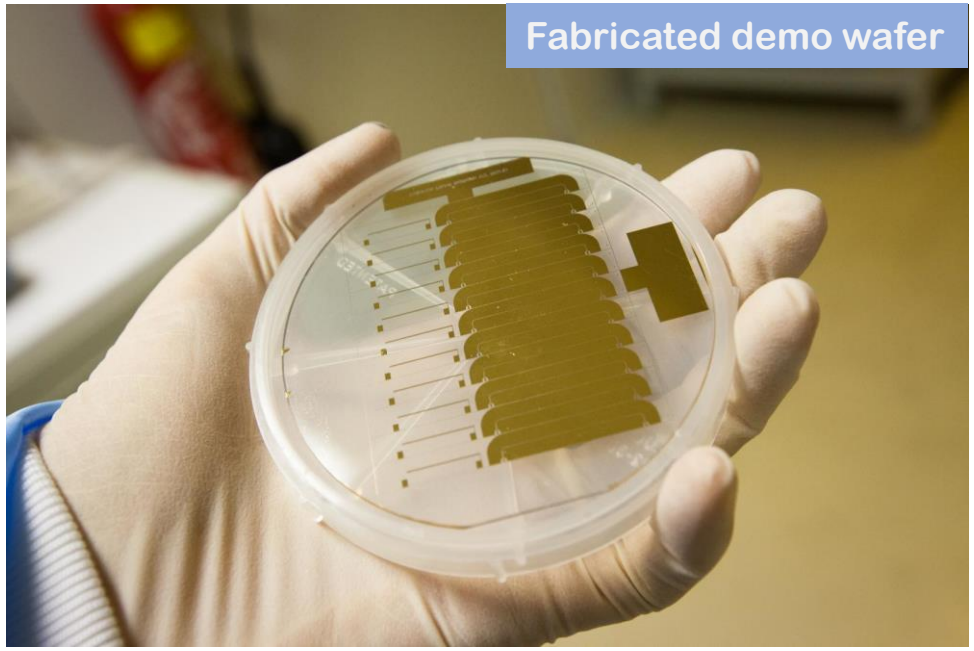
Lithography of spin-coated photoresist

Plasma observation during sputtering



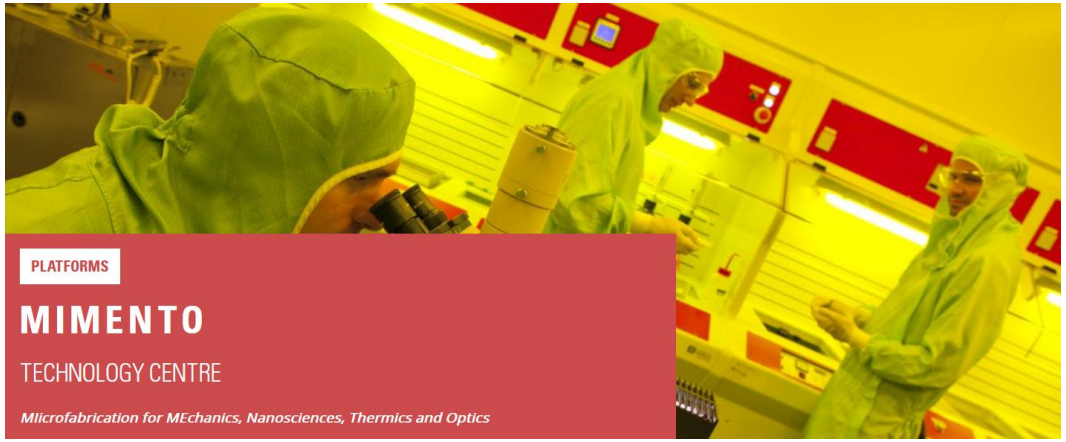
Lift-off in progress after Aluminium sputtering and optical control



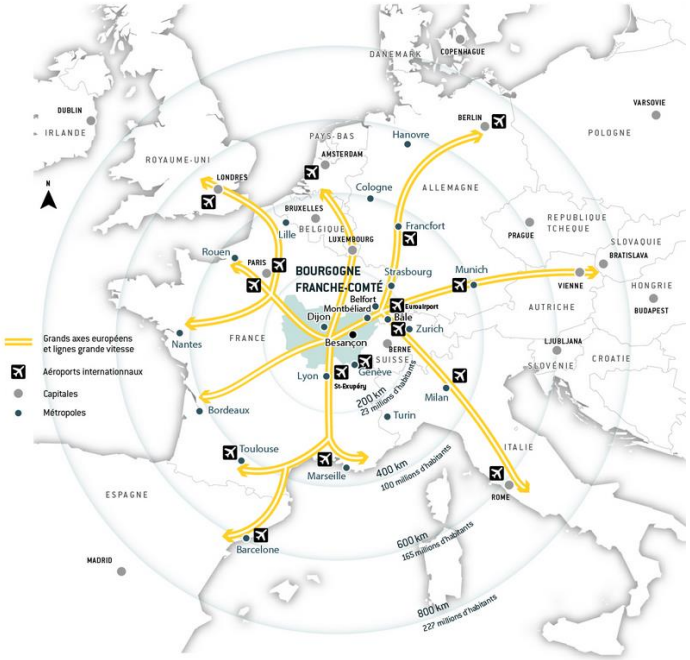


Fabricated demo wafer

Course Location, Schedule & Cost



- Course Schedule (January, December – exact dates to be confirmed)
- Number of people (Groups of 8-10 people per course)
- Course Cost (250 Euros per person, includes catering and project consumables)



Further Information

- jyves.rauch@femto-st.fr, franck.chollet@femto-st.fr
- https://www.femto-st.fr/en/contacts
- www.photonhub.eu/euphotonicsacademy

Course Material (technical hand-outs)

PHOTONHUB EUROPE

PhotonHub Demo Centre

Course ##
Fabrication & characterization of an integrated Electro-Optic modulator

Course Provider

CNRS, FEMTO-ST Institute
Université Bourgogne Franche-Comté
Besançon, France

Training course Notes

with Appendix I: lithographic masks for $LiNbO_3$ amplitude modulators
Appendix II: control & validation chart of the manufacturing steps

PRACTICAL WORK: CLEAN ROOM PROCESSES
FABRICATION OF INTEGRATED ELECTRO-OPTIC MODULATORS

This practical work aims to initiate to clean room techniques: lift-off, etching, depositions, lithography and standard methods of characterization. The attendees will follow a process flow dedicated to the production of lithium niobate electro-optic amplitude modulators.
To do so, lithographic masks will be used, which is provided in Appendix I. During the practical work, the students will perform the control steps listed in Appendix II. The idea of Appendix II is to carry out a process control and validation of the manufacturing steps.

I. FABRICATION STEPS

Traditionally, an electro-optic $LiNbO_3$ modulator is produced through titanium diffusion, followed by electrode deposition. Here we will follow these steps, but for financial and educational reasons, the substrates will be made of glass instead of lithium niobate. In addition, aluminium ribs will be used as optical waveguides, instead of diffused titanium waveguides. This choice makes initiation easier, because aluminium ribs are easier to see with a microscope than real optical waveguides.

The fabrication steps are shown in figure 1. Details of the processes are given in page 2.

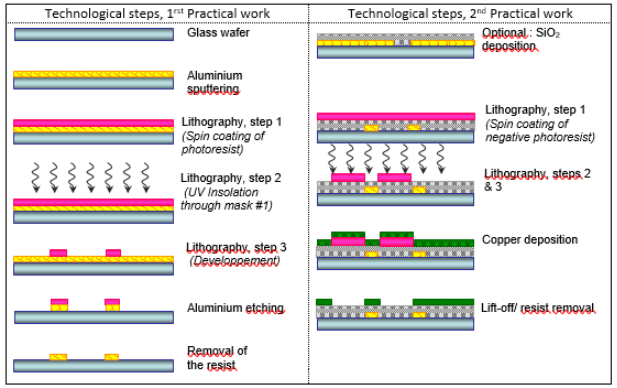


Fig. 1. Fabrication Process Flow

Keywords

Electro-optic modulator, Mach-Zehnder optical waveguides, Gold electrode, Lithium niobate integrated photonics, PICs, Packaging, Assembly, Optical Fiber, Micro-Optics, Laser, Optical transmissions, Telecoms, Sensing, Clean room facilities & processes, Equipment, Manufacturing, Quality control & validation

Relevant Technology & Application Domain

Technology: Free-space photonic components & systems, MOEMS (& hybrid photonic) systems integration, Silicon-based photonic integrated circuits, Si_3N_4 & SiO_2 passive waveguide technologies, Laser-based manufacturing

Application: Relevant to all application domains, especially information & communications, safety-security & space, mobility, industry 4.0, energy, biomedical, smart cities & smart living