PLASMOfab

A generic CMOS-compatible platform for co-integrated plasmonics/photonics/ electronics PICs towards volume manufacturing of low energy, small size and high performance photonic devices

PLASMOfab fact sheet

Grand Agreement: 688166

Duration:
Jan 2016 - Dec 2018 (36 Months)

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Project website:
URL: www.plasmofab.eu

Total Budget:
€ 4,150,246.25

EC contribution:
€ 3,580,691.25

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Aristotle University of Thessaloniki (GR)
Universite de Bourgogne (F)
Swiss Federal Institute of Technology in Zurich (CH)
AMO GmbH (DE)
ams AG (A)
MicramGmbH (DE)
Saarland University (DE)
Mellanox Technologies (IL)
PhoeniX BV (N)
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THE CHALLENGE

Photonic components constitute a major driving force of the European and global economies in a diverse range of technology sectors with a total world market estimate of 30 Billion Euro. To address those massive market demands, photonic integrated circuit (PIC) technologies have emerged as the means to realize mass production of photonics as an analogous to the production roadmap followed by the electronics industry. In fact, it is no secret that the PIC industry will have to take advantage of the currently dominant, best-in-class processes of electronic CMOS manufacturing infrastructures to decrease time-to-market and maximize return on investment. Nevertheless, photonics devices are large when compared to transistors keeping the fabrication process of each chip separate. To address the rapid manufacturability of complex photonic-electronic ICs that are demanded by a disproportionally large market the development paths followed by electronics and photonics will need to merge. Plasmonics has been proposed as the key technology that may exploit its metallic nature to mix optical functions with low dimensions electronics while offering unique features and functional advantages.

MISSION STATEMENT

Although the added value of plasmonics has been practically confirmed, an organized effort to transform plasmonics from an isolated technology into a high valued practical CMOS-compatible platform alongside photonics and electronics is yet unseen. Through PLASMOfab, a harmonic and balanced mixture of CMOS compatible plasmonics with photonics is expected to transform plasmonics from a scientific hypothesis to a true technological revolution in PICs.

OBJECTIVES

PLASMOfab aims to develop and practically validate the underlined integration technology and standardize the end-to-end fabrication process that will bring meaningful plasmonic functions, supported by CMOS compatible photonics and electronics closer to large-scale manufacturing. Driven by real application needs, the proposed platform will be used as the tool to develop functional modules of unprecedented performances in the areas of data communications and sensing satisfying all future requirements set by the biggest organizations and study groups of those business sectors. Specifically the core objectives of PLASMOfab are:

- **Establish a CMOS-compatible integration process for the development of plasmonic structures.**
- **Develop plasmonic waveguides integrated with planar photonics in Si_3N_4, Si and SiO_2.**
- **Use PLASMOfab platform to develop a high-performance modulator and a biosensor.**
- **Generate EDA tools for rapid design.**
- **Validate PLASMOfab's PIC technology advantages in:**

  1) *Data communication:* Integrate 100 Gb/s SiGe electronics and modulator in a monolithic 100 Gb/s serial Tx.

  2) *Biosensing:* Integrate Si_3N_4-plasmonic biosensors and microfluidics in a multichannel, ultra sensitive (sensitivity-150000 nm/RIU, Limit of detection-10^{-9} RIU) biomarker sensing device.
- **Demonstrate volume manufacturing and cost reduction by complying with large wafer-scale CMOS fabs.**
- **Establish a plasmonics/photonics/electronics fab-less integration service eco-system.**

INTEGRATION TECHNOLOGY CONCEPT

PLASMOfab will follow a systematic approach to naturally integrate low-loss plasmonic structures with the fast growing technologies of CMOS-compatible photonics and the well-established integration processes of electronics. As a result, the best features of plasmonics will be advanced and seamlessly combined with photonics and electronics onto a common integration platform unleashing unprecedented capabilities and functionalities on a large scale and at a low cost. In most common Si-based photonic integrated circuits, the waveguide cross-sectional dimensions are below or comparable to the transmitted light wavelength ensuring single mode guiding and a reasonably small mode size. In order to further reduce the photonic mode and stretch PIC functional density, Surface Plasmon Polariton (SPP) based waveguides have to be deployed. SPP waveguides have attracted intense research efforts in the last decade owing to their unique ability to guide light at sub-wavelength scales, as they make it possible to overcome the diffraction limit of light and confine light into a width of few nanometers due to coupling to electron plasma oscillations near the metal interface.

In all major past efforts to exploit plasmonics in practical configurations, gold was exploited as the plasmonic metal of choice not permitting CMOS fabs to embrace such an approach. In contrast, PLASMOfab aims to investigate CMOS compatible metals that can effectively replace gold and silver in meaningful plasmonic integrated waveguides. The metals that will be investigated in PLASMOfab are titanium nitride (TiN), aluminum (Al) and copper (Cu) and they will be investigated on SOI, Si_3N_4 and SiO_2 plasmonic and hybrid photonic/plasmonic waveguide structures.

BREAKTROUGH DEVICES

The PLASMOfab PIC technology will be used to demonstrate the following novel modules with unprecedented performance and features:

- 100 Gb/s (serial) non-return-to-zero (NRZ) transmitter by consolidating low energy and low footprint plasmonic modulator and ultra high-speed SiGe electronics in a single monolithic chip.
- Si_3N_4-plasmonic based multi-channel biosensor combined with electrical contacts, versatile surface functionalization techniques and microfluidics for concurrent detection of multiple inflammation biomarkers in the sub nmol/L range (surface coverages of a few pg/mm²).