HORIZON 2020

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

Informe

Información del proyecto

PLASMOfab

Identificador del acuerdo de subvención: 688166

Sitio web del proyecto

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10.3030/688166

Proyecto cerrado

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ARISTOTELIO PANEPISTIMIO THESSALONIKIS
Greece

Periodic Reporting for period 2 - 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)

Período documentado: 2017-07-01 hasta 2018-12-31

Resumen del contexto y de los objetivos generales del proyecto

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, CMOS 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. 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, 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 functionalities with low dimensions and mass-manufactured electronics while offering unique features and functional advantages.
Through PLASMOfab, a harmonic and balanced mixture of CMOS compatible plasmonics with photonics was expected to transform plasmonics from a scientific hypothesis to a true technological revolution in integrated circuits. In this context, PLASMOfab aimed 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 was successfully used as the tool to develop functional modules of unprecedented performances in the areas of data communications and biosensing.

Trabajo realizado desde el comienzo del proyecto hasta el final del período abarcado por el informe y los principales resultados hasta la fecha

During the project lifetime, the consortium has focused on three core action lines to meet its technical objectives.
1. Materials and waveguides: The consortium has focused its efforts on the theoretical and experimental investigation of materials used in large IC manufacturing lines (CMOS) and their deployment for the design and development of fundamental plasmo-photonic waveguides and components. In this context, the optical properties of aluminum, copper and titanium nitride were thoroughly investigated as the basic technology ingredients of plasmonic waveguides. The co-integration methodology of such waveguides with photonic materials in monolithic structures was established while optimum structures have been fabricated and experimentally validated, practically demonstrating the plasmo-photonic integration proof-of-concept using both noble and CMOS-compatible metals. The outcomes of this activity were practically demonstrated by using them to

successfully develop two validation vehicles as follows
2. Electro-optic transmitter prototype: The second core action line of the project was to develop an electro-optic transmitter using advanced plasmonic modulators and ultra high speed electronics. To maximize success potential, the consortium has streamlined the development of two transmitter variants. The first prototype involved the heterogeneous integration of modulator chip and electronics chip in a single miniaturized device package. 2D integration was deployed by using ultra-short wire bonds to demonstrate experimental operation at 100 Gb/s NRZ data. The second prototype involved the monolithic integration of the plasmonic modulator onto the back-end of line of the high speed electronics chip, compatible to the standard wafer scale BiCMOS process.
3. Biosensor prototype: The third core action line involved the detailed design and the manufacturing of the biosensor chip using outcomes from activity 1. 3 sensors were fabricated on a single chip using both gold and aluminum as the plasmonic elements. CMOS fabrication of the sensor chip was successfully demonstrated by fabricating functional chips entirely within a CMOS foundry. The plasmo-photonic biosensor chips were functionalzed with antibodies to detect C-reactive Protein, a critical inflammation biomarker present in the human blood. Experiments successfully demonstrated the proof of concept, detecting CRP protein in concentration of the order of ug/mL and pg/mL, potentially addressing limits of detection at the low pg/mL range or below.

Activities related to the development and integration of the transmitter led to the follow-up H2020 project plaCMOS targeting transceivers with even higher data rates up to 200 Gb/s as well as to the founding of a start-up company by ETHZ that aims to commercialize plasmonic modulator technology. In addition, those activities led to the publication of 13 journal articles, the preparation of one patent application while it appeared in 23 conference proceedings.
Activities related to the development and integration of the biosensor module led to the publication of 9 journal articles, a PCT patent application while it appeared in 17 conference proceedings. Finally this activity has led to the founding of the start up company bialoom supported by AUTH and AMO that aims to commercialize plasmo-photonic biosensing technology in the point of care diagnostics market.

Avances que van más allá del estado de la técnica e impacto potencial esperado (incluida la repercusión socioeconómica y las implicaciones sociales más amplias del proyecto hasta la fecha)

PLASMOfab exhibited impressive progress and technology advancements beyond the state-of the art in multiple fronts. Specifically, the CMOS compatible metals were for the first time thoroughly investigated in a common theoretical and experimental context providing for the first-time solid interpretation of their optical properties for use in plasmonic waveguides when compared to commonly used noble metals like gold. In parallel, the electronic circuitry demonstrated already in PLASMOfab has broken the barrier of 100 Gb/s paving the way for ultra-fast and low-cost ICs. Towards the same direction, it is shown that the plasmonic modulator using PLASMOfab technology may exceed operation speeds of 170 Gb/s using simple on-off modulation of light intensity on a single wavelength. The above modules were combined to show for the first time a complete miniaturized transmitter operating at XX Gb/s using a single optical channel. As far as the biosensor application is concerned, it was shown that using PLASMOfab PIC technology ultra-sensitive sensors can be built outperforming current state-of the art. For the first time PIC-based biosensors combining plasmonic transducers with photonics multifunctionalities were shown. CMOS-compatible plasmonics were used in integrated biosensors while methods and design to reach unprecedented sensitivities and limits of detection were demonstrated.

The revolutionary technology of PLASMOfab and the staggering progress witnessed are expected to impact all industrial sectors of semiconductos, ICT and medical diagnostics of the future. PLASMOfab technology will boost the production capabilities of the semiconductor industry by introducing additional services with extra-ordinary functionalities. In parallel the speed capabilities of the transmitter module can already change the future expectations of data center and cloud infrastructures towards the big-data transformation age. Last but not least, the sensitivities demonstrated and the unmatched potential for further improvement of the PLASMOfab biosensor chip will disrupt medical diagnostic equipment and point-of-care applications. In this context, 2 spin off companies were launched during the last phase of the project to further develop and commercialize the PLASMOfab outcomes on optical communications and biosensing.

Project Logo

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