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Advanced GeSi components for next-generation silicon photonics applications

SiPho-G

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Deliverable report

D2.1 (D4) - Report on device modelling and PDK

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About SIPHO-G

By developing 100Gbaud Germanium-Silicon (GeSi) Quantum-Confined Stark-Effect (QCSE) modulators and highly sensitive 100Gbaud avalanche photodetectors (APD), SIPHO-G will bring breakthrough optical modulation and photodetection capability to the world of Silicon Photonics. The newly developed compact, waveguide-coupled modulator and detector building blocks will be monolithically integrated in a high-yield cutting-edge 300mm Silicon Photonics platform, propelling the bandwidth density, power efficiency, sensitivity and complexity of silicon photonic integrated circuits to the next level. Supported by an elaborate simulation and design enablement framework, SIPHO-G will demonstrate an extensive set of application-driven prototypes across the O-band and C-band.

By bringing together the entire Silicon Photonics value chain, SIPHO-G will accelerate the development of next-generation co-packaged optics, long-haul optical communications, as well as emerging PIC applications such as optical neuromorphic computing, with performance levels of 4x-20x beyond current state of the art.

SIPHO-G consortium members

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APPLIED MATERIALS
nextnano Software for semiconductor nanodevices
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Publishable summary

In Deliverable 2.1 (D4), we report on the realisation of the initial Process Design Kit (PDK) for imec's 300 mm SiPho platform and the associated modelling capabilities in this regard. It is closely linked to MS2 of WP2, entitled "Initial PDK for building block design run 1".

The SIPHO-G PDK is a piece of software that is used together with the IPKISS software of Luceda Photonics and enables users to create the layout of the integrated optical devices they designed. It also allows the users to perform dedicated circuit simulations of those devices in order to assess their performance. This version of the PDK is considered "initial" as it is the first to be released in the context of the SIPHO-G project. It contains optical building blocks that rely on, among others, black box and white box GDS cells released by imec for the layout realisation and on preliminary performance metrics on which the associated circuit models were built.

In the development of the initial PDK, we first added the technology (layers for GDS export and layer stack for virtual fabrication), the semi-autorouting capabilities of the optical waveguides and electrical wires, layout implementation of the waveguides and the black/white box building blocks being the bondpads, electro-absorption modulators, electro-optic phase shifters, thermal phase shifters grating couplers, MMI splitters, photodetectors, waveguide transitions and DC/RF metal wires. We then added the circuit models for all components (apart from the floorplan, metal DC wires, GSG wires, bondpads and transitions) based on the available data released by imec. Although the PDK was successfully released on the shared folder, there was a delay of about 2 – 3.5 months as compared to the target (March 2021) due to delay in PDK release of imec.

This PDK has been used by several design partners (AUTH and Mellanox) to create their first demonstrator designs. Luceda also offered support and training to the design partners so that they were able to use the IPKISS software and start designing as well as fix DRC errors that showed up during imec's review of the designs.

As a follow up to the PDK, we have started working on the link between the nextnano software and IPKISS. The motivation behind this work is to be able to combine both the physical quantum mechanical simulations of the nextnano software together with the circuit simulations of IPKISS Caphe into one flow. This will allow the user to calculate, from the layout properties of the active devices like the EAMs and PDs (such as width and length, doping concentration, etc.), the eventual electro-optic performance metrics used within the IPKISS Caphe circuit simulator in automated fashion. This work is currently still under development and will be finished soon.

The nextnano software is used to model optical properties of the active region of QSCE device. The overall goal of the nextnano contribution is to provide the tool to simulate QSCE optical behaviour and device efficiency including all relevant quantum mechanical effects. For this, accurate modelling of the optical features in a wide photon energy range with a focus on local features close to absorption edge are important. These problems were addressed by adding the complex refractive index calculation into the 8-band k.p model (Milestone MS 3) and the exciton calculation (Milestone MS 5)

into the nextnano software. The added features were benchmarked against test cases from literature and tested against experimental work of imec. Based on these preliminary results, we defined the next priorities to improve the current model, namely adding the 30-band k.p model and indirect absorption (Milestone MS 7).