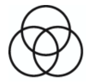
Alfried Krupp von Bohlen
und Halbach-Stiftung

DGaO
Deutsche Gesellschaft für angewandte Optik
The German Branch of the European Optical Society

Photonic Integrated Circuits: Technology and Applications

Joint Symposium of the German Association of Applied Optics (DGaO)
and the Helmholtz International Research School of Teratronics (HIRST)
supported by the Alfried Krupp von Bohlen und Halbach-Stiftung

Friday, 13. June 2014

Venue:

Konzerthaus Karlsruhe, Festplatz 9, 76131 Karlsruhe, Germany

Scope:

Photonic integration exploits wafer-scale mass-production and opens the possibility to realize powerful photonic integrated circuits (IC) that comprise hundreds of individual devices. Similar to fabless fabrication in microelectronics, photonic integration is based on an emerging system of photonic foundry services that can be jointly accessed by a large community of users. These photonic foundries offer standardized fabrication processes, software design kits with component libraries, packaging solutions and test facilities, thereby obviating the need for costly proprietary design and fabrication technologies. This significantly lowers barriers of entry for users from both industry and academia.
The symposium will give an overview on currently available integration and packaging platforms and introduce software tools for photonic IC design. Application examples will be presented to illustrate the versatility and potential of photonic integration and to trigger stimulating discussions on the opportunities arise from this emerging technology.

Programme:

8:30 – 8:55: **Low-Cost Access to Development and Manufacturing of Photonic Integrated Circuits**
Meint Smit, Eindhoven Technical University / COBRA, Eindhoven, Netherlands

8:55 – 9:20: **Access to Silicon Photonic Integrated Circuits**
Pieter Dumon, Ghent University / IMEC, Gent, Belgium

9:20 – 9:45: **TriPleX™: A Low-Loss Photonic Platform for Large-Scale Photonic Integration from Visible to Infra-Red**
Arne Leinse, LioniX B.V., Enschede, Netherlands

9: 45 – 10:10: **Photonic IC Design Software and Process Design Kits: Current Status**
Twan Korthorst, PhoeniX Software B. V., Enschede, Netherlands

10:10 – 10:30: **Coffee Break**

10:30 – 10:55: **Packaging Challenges for Silicon and InP Photonic Integrated Circuits**
Peter O'Brien, Tyndall National Institute, Cork, Ireland

10:55– 11:20: **Fiber Optic Sensing using Photonic Integrated Circuits**
Rolf Evenblij, Technobis Fibre Technologies, Uitgeest, Netherlands

11:20 – 11:45: **Biophotonic Application of Optical Coherence Tomography (OCT) on a chip**
Ton van Leeuwen, Academic Medical Center, Amsterdam, Netherlands

11:45 – 12:10: **Silicon-Organic Hybrid (SOH) Devices for Applications in Optical Communications, Metrology, and Sensing**
Robert Palmer, Karlsruhe Institute of Technology (KIT), Germany

12:10: **Lunch Break**

Abstracts

Low-Cost Access to Development and Manufacturing of Photonic Integrated Circuits

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Generic photonic integration technology is rapidly gaining popularity. It applies the methodology that is so successful in microelectronics (CMOS technology) to the domain of photonics: providing low-cost access to highly standardized high-performance processes that support integration in a single chip of a set of building blocks like optical amplifiers, lasers, modulators, detectors and a variety of passive components like couplers, filters and wavelength demultiplexers. Using these building blocks Photonic ICs can be designed and fabricated for a broad range of applications, such as telecommunications, data communications, sensor technology, medical diagnostics and metrology.
In the presentation it will be explained how the generic photonic foundry model leads to a dramatic reduction of R&D cost and time, by developing Photonic ICs in a well-established and characterised technology, by sharing the cost of the R&D runs with many users in so-called Multi-Project Wafer runs, by using libraries with accurate models for the building blocks and by designing the chips for low-cost generic packaging and testing. Further, it will be explained how to get access to this emerging technology.

Access to Silicon Photonic Integrated Circuits

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We will discuss access to advanced silicon photonic ICs, including prototyping, packaging, design services, software, training and R&D projects. We will focus on state-of-the art IC technology and packaging solutions, which enable high-data rate channel datacommunication applications as well as sensing and spectroscopy for medical and environmental applications.

TriPleX™: A Low-Loss Photonic Platform for Large-Scale Photonic Integration from Visible to Infra-Red

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In the emerging field of integrated optics the development of stable platforms becomes more and more important. A stable platform with design kits and libraries of building blocks allows users to design devices on system level similar to the electronic IC industry. The TriPleX™ technology of LioniX is one of the three main photonic platforms in Europe (next to InP and SOI) and the low loss properties over a large wavelength range (405 nm to 2.35 µm) make it extremely suitable for a variety of applications. The platform is based on LPCVD silicon nitride (Si_3N_4) and SiO_2, and adiabatic spot size converters can be realized on chip to achieve low-loss coupling to fibers and other photonic platforms. LioniX developed building blocks in this technology which are offered in Multi Project Wafer (MPW) runs allowing users to have easy access to the technology. In the presentation, an

overview of the technology, the MPW process, the buiding blocks and examples of applications over a broad wavelength range will be shown.

Photonic IC Design Software and Process Design Kits: Current Status

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To lower access barriers to photonic integration techniques, Multi-Project Wafer runs and design kits have been introduced by organisations active in InP (III-V), TriPleX and silicon photonics. This talk will focus on the development of the design environment and the introduction of design kits (PDKs) to allow less-experienced engineers in the field of integrated photonics to design their own Photonic Integrated Circuit for a variety of foundries. These PDKs contain all relevant information for simulations and layout, with a focus on manufacturability and are compatible with a variety of software tools.

Packaging Challenges for Silicon and InP Photonic Integrated Circuits

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Integration of photonic components is of great interest as it enables improved functionality and performance, supports new applications and can result in lower manufacturing costs, especially for complex photonic systems. However packaging of these systems presents many technical challenges which affect the overall cost, limiting the up-take and commmercialisation of integrated photonics. Packaging still dominates the cost per module and is often overlooked, especially at the initial design phase. This presentation will address key challenges associated with packaging Silicon and InP photonic integrated circuits, focussing on fibre coupling, active device integration and thermo-mechanical factors. We present details of packaging techniques that we have developed to address many of these challenges and ways to optimize them for volume manufacture. We will also present details of major European research programmes focusing on integrated photonics and especially programmes that address photonic packaging. In particular, we will provide an overview of the ePIXfab service that offers affordable access to silicon photonic modules, from chip design and processing to advanced packaging.

Fiber Optic Sensing using Photonic Integrated Circuits

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In the past few decades there is a rising awareness with regard to photonics as an enabling technology. The applications are extremely broad and will keep growing rapidly. Photonics is regarded not only as supplemental but also as a base technology similar to what electronics has

become nowadays. Integrated Electronics is already globally used in billions of applications and its functionality is still increasing according to Moore's Law. Similarly, Integrated Photonics is emerging as the generic development platform for many future applications - certainly not to replace electronics but to provide an enormous surplus in capabilities for an extremely wide range of applications. Integrated Photonics plays a major role in the transition of current conventional optical systems to next-generation instrumentation and provides all the advantages such as smaller size, lesser weight, lower power consumption and costs.

One example of a fast growing application field for Integrated Photonics is Fibre-Otic Sensing. For this area, Technobis has become a major solution and system provider as it addresses important value chain aspects and generic integrated photonics packaging standards.

Biophotonic Application of Optical Coherence Tomography (OCT) on a chip

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The interaction of light with living tissue can reveal information on the status of that tissue. Next to basic measurement of tissue reflectivity, localized quantitative measurement of optical properties such as refractive index, Doppler shifts, absorption coefficients, is also possible. These parameters can be linked to functional physiological parameters, e.g. flow, oxygenation, hematocrit (red blood cell volume fraction), and tissue composition. In this presentation, various examples of localized quantitative measurements will be presented. With optical coherence tomography (OCT), the optical analogue of ultrasound imaging, the optical properties of tissue can be quantified in a small sampling volume. We are currently investigating the relation between the optical attenuation of tissue and the grade of tumors, and the analysis of the time fluctuations of the OCT signals to determine locally the diffusion and flow of particles in scattering media. Finally, the use of integrated photonics can reduce the foot-print of OCT systems and thereby reducing their costs and increasing the potential applications.

Silicon-Organic Hybrid (SOH) Devices for Applications in Optical Communications, Metrology, and Sensing

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Silicon-on-insulator (SOI) is considered a viable platform for low-cost highly integrated photonic circuits. Silicon-organic hybrid (SOH) integration combines silicon chips with organic materials that have tailored optical properties, thereby adding new functionalities to the SOI platform with application fields ranging from communications to metrology and sensing. We give an overview on our recent progress in the field of SOH integration, comprising high-speed electro-optic modulators with fJ/bit energy consumption, frequency comb generators for high-speed , and integrated frequency shifters.