# Special Symposium on Silicon Photonics Integration · Room: TR-A311

Friday-Sunday 2-4 December 2022 · OPTIC 2022

## Friday 2 December

**Room: TR-A311.....Fri 1:00 pm to 5:00 pm**

1:25 pm
**Opening Remarks**, San-Liang Lee, National Taiwan University of Science and Technology (Taiwan)

1:30 pm
**Millimeter Wave Si Photonics Interposer**, Ming-Chang Lee, National Tsing Hua University (Taiwan)
**Abstract:** Integrated Si optoelectronics and photonics are the key technology platform for developing large-scale integrated optics for various optical applications. Meanwhile, these technologies are also exploited for implementing compact sensor chips, spatial light modulation, metalenses and quantum photonic circuits. In this talk, I will introduce a new direction of application by using Si photonics components to implement a compact mmWave-over-fiber antenna for in-building 5G/6G mmWave wireless transmission.

5G NR band in mmWave has the advantage of wide data transmission bandwidth. However, due to the nature of short wavelength of millimeter waves, the transmission is easily blocked by objects, resulting in an issue of data transmission inside a building. One solution is to use a fiber-wireless network to deploy a large number of femtocells in the rooms and hallways. However, traditional mmWave components are expensive and consume a lot of power, so they are not suitable for large-scale indoor deployment. Here, we demonstrated an integrated mmWave radio-over-fiber antenna module comprising silicon photonic chips, CMOS RF chips and phased array antennas. This antenna module is advantageous in small size, low power consumption, and is potential for mass production, which can be massively deployed inside a building to form a mmWave local area network.

2:00 pm
**Silicon Photonics Coherent Transceiver Modules for Communication Applications**, Yinchieh Lai, National Yang Ming Chao Tung University (Taiwan)
**Abstract:** Coherent optical communication technologies have many advantages compared to conventional direct detection schemes. The required complexity has made the coherent optical transceiver an excellent application target for integrated photonics. Silicon photonics has been recognized as the most promising technology to manufacture the coherent optical transceivers due to its potential large-scale integration capability. The international standards for 400G coherent transmission have been published and commercial 400G coherent optical transceivers based on silicon photonics or other integrated photonics platforms have also become available. In view of these trends, we have started our own development work at National Yang Ming Chiao Tung University a few years ago. The development includes the various aspects of related technologies including: (1) silicon photonics coherent transmission (Prof. J. Chen); (2) silicon photonics active devices (Prof. J.-W. Shi); (3) silicon photonics passive devices (Prof. C.-W. Chow); (4) silicon photonics coherent transceiver ICs (Prof. W.-Z. Chen); (5) silicon photonics coherent transceiver packaging (Prof. C.-C. Lin); (6) heat dissipation techniques for silicon photonics coherent transceivers (Prof. R.-H. Horng); (7) integrated simulation/design platform for silicon photonics & advanced communication applications (Prof. Y. Lai). In this talk I shall present some of the representative achievements obtained by our team members.

2:30 pm
**Heterogeneous Silicon Photonics Gyroscope Chip and Miniaturized Module Development**, Yi-Jen Chiu, National Sun Yat-sen University (Taiwan)
**Abstract:** This work is mainly to develop a Gyroscope chip based on hybrid Si photonics processing and the related module. A compact optical interferometric circuit has been designed and demonstrated in a Si photonic chip. The Mach-Zehnder optical modulator, detector, optical polarization splitter, and passive elements are included in the Si photonics chip, performing the optical signal processing interferometric fiber optical gyroscope (IFOG). By integrating optical fiber loop and package, the tactical level with 0.34 deg/hr of bias stability has been demonstrated, indicating the endorsement of Si photonics chip into gyro function. The noise reduction through fiber-related photonics have been also shown for further improving signal-to-noise ratio of sensing capability. In integrating optical source, a broadband semiconductor super luminance diode (SLD) with built-in reflection mirror has also successfully integrated in Si photonic chip through grating coupler, where a mW order of power level coupled into waveguide has been shown. In this work, low-loss optical waveguide, ASIC driving circuit, and the fiber-related package with noise reduction technique have also been realized for further advanced package of IFOG. Through CMOS-compatible processing and procedure, the mass production of IFOG chip has been shown to lower the price to one third cost of conventional IFOG module, suggesting the potential for future market and applications.

Break.....Fri 3:00 pm to 3:15 pm

3:15 pm
**Silicon Photonics Based Rapid Multi-Module Medical Sensing: Investigation and Implementation**, Shien-Kuei Liaw, National Taiwan University of Science and Technology (Taiwan)
**Abstract:** This talk will describe the silicon-based photonics integration (SiP) into optical coherence tomography (OCT) and Raman spectroscopy, which are vitally important for medical multi-module detection of tissue and blood coagulation factors.

We developed a fast scanning silicon photonic chip for ultra-broadband optical amplifiers. Meanwhile, the key components and technologies are developed, such as fast scanning laser light source, narrow linewidth Raman light source, medical detection chip for blood micro fluid and wafer bonding. The fiber array was also developed to optimize the coupling efficiency for silicon photonics. We also applied artificial intelligence (AI) to analyze biomedical images and Raman spectroscopies. For application technology, there are cell-level tissue imaging, high-sensitivity coagulation factor detection and AI intelligent analysis issues; For system technology, we focus on fast multi-module silicon photonics medical testing with OCT and Raman spectral analysis ability; For modules technology, there are silicon photonic resonance/modulation/coupler, medical detection chip and swept source issues.

For the past four years, our team created considerable academic-industrial cooperation projects and technology transfer. More than 100 journals and conference proceeding are published and 10 related patents were invented so may help to promote the silicon photonics related market in Taiwan.

3:45 pm
**Toward New-Era 1.6-Tbps Si-Photonics Transceiver Platform**, Tien-Tsorng Shih, National Kaohsiung University of Science and Technology (Taiwan)
**Abstract:** Due to the huge demand of the data transmission inside data centers, a novel transceiver structure with four wavelengths by four singlemode fibers is proposed. Total 16 signal channels are realized in a compact silicon photonic chip. Every channel transmits 100Gb/s and the aggregated transmission rate is 1.6Tb/s. The transmission chip includes the splitters, Mach-Zehnder modulators (MZM), and optical wavelength division multiplexers (WDM). The environmental temperature and the injected wavelength change the optimized operational point of MZM. However, we adjust the voltage bias on the both arms of MZM carefully to get the best performance of very MZM in the chip. The MZM is driven by commercial linear ICs. A clear optical eye diagram of 50Gb/s NRZ or 60Gb/s PAM4 is obtained. Under 100Gb/s QAM16-OFDM modulation, a clear constellation diagram is shown and maintains the performance after transmitting for 1km singlemode fiber. The receiving chip includes WDMs and 16 Ge photodiodes. The detected optical signal is amplified by linear trans-impedance amplifier (TIA) ICs. The receiving part shows a matching performance with the transmission side.

4:15 pm
**IMEC isipp50/isipp200 Experience and TSRI Technology Platform**, Ming-Wei Lin, Taiwan Semiconductor Research Institute (Taiwan)
**Abstract:** TSRI's silicon photonics service platform provides design, manufacturing and measurement services, recently covering high frequency/high speed testing, optoelectronic chip R&D and integration, optical fiber packaging, etc. This report will highlight TSRI's tape-out execution experience at imec and explain the technical highlights of the TSRI platform.

4:45 pm
**Discussions**