Title	Silicon photonic transceiver array based on the transfer printing of III-V O-band photodetectors
Author(s)	Zhang, Jing; Abassi, Amin; De Groote, Andreas; Loi, Ruggero; O'Callaghan, James; Corbett, Brian M.; Trindade, António José; Bower, Christopher A.; Roelkens, Gunther
Publication date	2017
Original citation	Zhang, J., Abassi, A., De Groote, A., Loi, R., O'Callaghan, J., Corbett, B., Trindade, A. J., Bower, C. A. and Roelkens, G. (2017) 'Silicon photonic transceiver array based on the transfer printing of III-V O-band photodetectors', Proceedings of the European Conference on Integrated Optics 2017, Eindhoven, the Netherlands, 3-5 April.
Type of publication	Conference item
Link to publisher's version	https://www.ecio-conference.org/ecio-2017-papers/ Access to the full text of the published version may require a subscription.
Rights	**© 2017, the Authors.**
Item downloaded from	http://hdl.handle.net/10468/4003

Silicon Photonic Transceiver Array based on the Transfer Printing of III-V O-band Photodetectors

**Jing ZHANG*,[1], Amin ABASSI[1], Andreas DE GROOTE[1], Ruggero LOI[2],
James O'CALLAGHAN[2], Brian CORBETT[2], António José TRINDADE[3],
Christopher A. BOWER[3] and Gunther ROELKENS[1]**
[1]Photonics Research Group, Ghent University – imec, Technologiepark 15, 9052 Gent, Belgium
[2]Tyndall National Institute, University College Cork, Lee Maltings, Cork, Ireland
[3] X-Celeprint Limited, Cork, Ireland
* jingzhan.zhang@ugent.be

Silicon photonics is emerging as a promising platform for the integration of high-speed optical transceivers and transceiver arrays. The technology allows for the realization of compact optical circuits integrating devices with low power consumption and high bandwidth. In this paper we elaborate on the realization of a 4-channel silicon photonic transceiver array for point-to-point Fiber-To-The-Home (FTTH) optical networks, operating at 10 Gbit/s per channel. In point-to-point optical networks every subscriber has its own transceiver at the central office side. In order to keep size and power consumption of such a central office manageable for a large number of subscribers, the realization of integrated, low power consumption transceiver arrays is of paramount importance. This is exactly the focus of this paper. Figure 1a shows the schematic layout of the 4-channel central office transceiver, while Figure 1b shows the realized chip. A 1550 nm CW laser is coupled to the silicon photonic transceiver, where it is split in 4 channels, each of which has a 10Gbit/s silicon ring modulator to imprint the downstream data on the carrier. For the upstream O-band data signal sent through the same fiber, polarization independent detection is required. In order to achieve the duplexing of the O-band and C-band signal and the polarization independent detection of the O-band signal, O-band III-V photodetectors are integrated on top of the output fiber-to-chip grating couplers of the different channels, as shown in Fig. 2. While allowing polarization independent detection of the upstream O-band signal, the photodetectors are transparent for the C-band downstream signal, by selecting the cut-off wavelength of the III-V absorbing material to be 1.37um. This enables the realization of transceiver arrays for the central office.

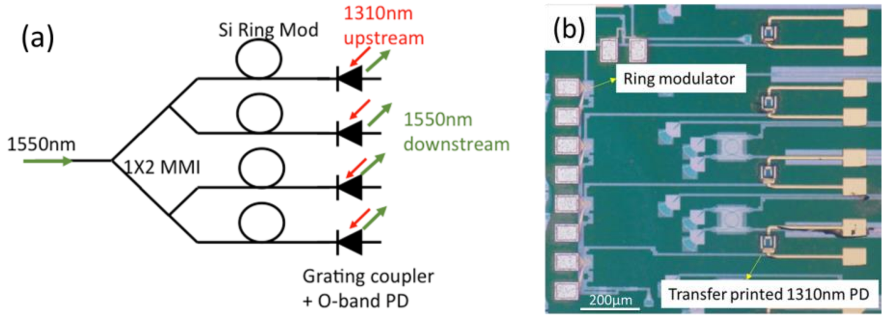

Fig. 1: (a) Schematic of the III-V-on-silicon FTTH central office transceiver array; (b) microscope image of the realized chip

The integration of the III-V photodetectors was realized using a transfer printing approach [1,2], allowing for an efficient use of III-V semiconductor material and enabling the low-cost, 200mm or 300mm wafer-scale integration of the O-band photodetectors on a silicon photonic wafer.

The photodetectors have an aperture of approximately 30 x 40um resulting in a 3dB bandwidth (at -3 V bias) of 11 GHz. Of key importance for the operation of the transceiver is the transparency of the photodetector for the downstream C-band signal. This was verified under CW conditions, as shown in Fig. 2. The responsivity for the O-band signal is 0.4-0.5 A/W, while that for the C-band signal was 0.025-0.03 mA/W, resulting in more than 40dB suppression of the C-band signal. The dark current of the photodetectors varied between 0.6-1.1 uA at -3V bias.

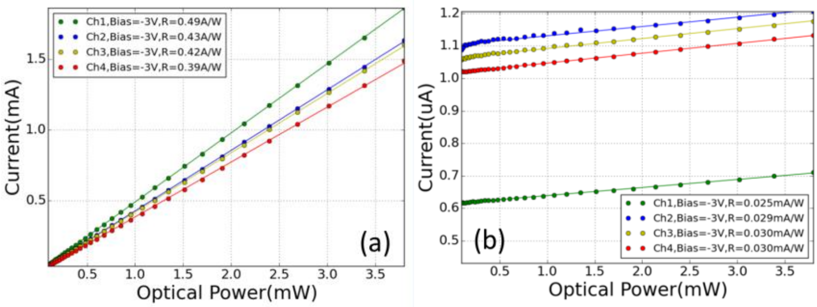

Fig. 2: (a) Photocurrent as a function of optical input power for the O-band signal; (b) Photodetector current as a function of optical input power for the C-band signal (-3V bias)

The ring resonator modulators had a 3dB bandwidth of 15 GHz, easily enabling 10 Gbit/s operation. A 2.5 Vpp voltage swing allows 12 dB extinction ratio of the 1550 nm carrier. Using this circuit we successfully demonstrated the operation at 10Gbit/s of all 4 channels, both upstream and downstream. Upstream wavelengths spanning from 1270 nm to 1350 nm were successfully used. Almost no polarization dependent loss was observed. Error-free operation for the upstream signal is obtained at 0dBm optical input power (due to the lack of an integrated transimpedance amplifier). The downstream signal quality was evaluated using a commercial C-band receiver, showing error free operation at a received power of -11 dBm. The overlayed 10G eye diagrams of the upstream and downstream signal are shown in Fig. 3.

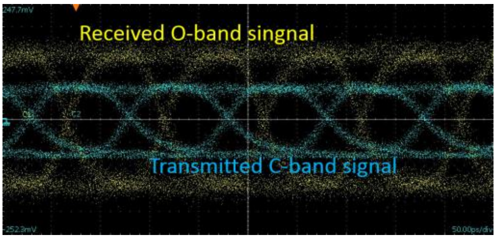

Fig. 3: Overlaid 10G eye diagrams of the upstream (O-band) data signal and downstream (C-band) data signal

Part of the work was supported by the H2020 project TOPHIT under the ICT2-2014 Smart System Integration program.

References

[1] J. Justice , C. Bower, M. Meitl, M. Mooney, M. Gubbins, B. Corbett, *Wafer-scale integration of group III-V lasers on silicon using transfer printing of epitaxial layers*, Nat. Phot. 6, 610-614 (2012)

[2] A. De Groote, A. De Groote, P. Cardile, A. Subramanian, A. Fecioru, C. Bower, D. Delbeke, R. Baets, G. Roelkens, *Transfer-printing-based integration of single-mode waveguide-coupled III-V-on-silicon broadband light emitters*, Opt. Express, 24(13), p.13754-13762 (2016)