World Academy of Science, Engineering and Technology
International Journal of Electrical and Information Engineering
Vol:10, No:03, 2016

4-Channel CWDM Optical Transceiver Applying Silicon Photonics Ge-Photodiode and MZ-Modulator

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Abstract : In this study, we demonstrate 4-channel coarse wavelength division multiplexing (CWDM) optical transceiver based on silicon photonics integrated circuits (PIC) of waveguide Ge-photodiode (Ge-PD) and Mach Zehnder (MZ)-modulator. 4-channel arrayed PICs of Ge-PD and MZ-modulator are verified to operate at 25 Gbps/ch achieving 4x25 Gbps of total data rate. 4 bare dies of single-channel commercial electronics ICs (EICs) of trans-impedance amplifier (TIA) for Ge-PD and driver IC for MZ-modulator are packaged with PIC on printed circuit board (PCB) in a chip-on-board (COB) manner. Each single-channel EIC is electrically connected to the one channel of 4-channel PICs by wire bonds to trace. The PICs have 4-channel multiplexer for MZ-modulator and 4-channel demultiplexer for Ge-PD. The 4-channel multiplexer/demultiplexer have echelle gratings for4 CWDM optic signals of which center wavelengths are 1511, 1531, 1553, and 1573 nm. Its insertion loss is around 4dB with over 15dB of extinction ratio.The dimension of 4-channel Ge-PD is 3.6x1.4x0.3mm, and its responsivity is 1A/W with dark current of less than 20 nA.Its measured 3dB bandwidth is around 20GHz. The dimension of the 4-channel MZ-modulator is 3.6x4.8x0.3mm, and its 3dB bandwidth is around 11Ghz at -2V of reverse biasing voltage. It has 2.4V•cmbyVπVL of 6V for π shift to 4 mm length modulator.5x5um of Inversed tapered mode size converter with less than 2dB of coupling loss is used for the coupling of the lensed fiber which has 5um of mode field diameter.The PCB for COB packaging and signal transmission is designed to have 6 layers in the hybrid layer structure. 0.25 mm-thick Rogers Duroid RT5880 is used as the first core dielectric layer for high-speed performance over 25 Gbps. It has 0.017 mm-thick of copper layers and its dielectric constant is 2.2and dissipation factor is 0.0009 at 10 GHz. The dimension of both single ended and differential microstrip transmission lines are calculated using full-wave electromagnetic (EM) field simulator HFSS which RF industry is using most. It showed 3dB bandwidth at around 15GHz in S-parameter measurement using network analyzer. The wire bond length for transmission line and ground connection from EIC is done to have less than 300 μm to minimize the parasitic effect to the system.Single layered capacitors (SLC) of 100pF and 1000pF are connected as close as possible to the EICs for stabilizing the DC biasing voltage by decoupling. Its signal transmission performance is under measurement at 25Gbps achieving 100Gbps by 4chx25Gbps. This work can be applied for the active optical cable (AOC) and quad small form-factor pluggable (QSFP) for high-speed optical interconnections. Its demands are quite large in data centers targeting 100 Gbps, 400 Gbps, and 1 Tbps. As the demands of high-speed AOC and QSFP for the application to intra/inter data centers increase, this silicon photonics based high-speed 4 channel CWDM scheme can have advantages not only in data throughput but also cost effectiveness since it reduces fiber cost dramatically through WDM.

Keywords : active optical cable(AOC), 4-channel coarse wavelength division multiplexing (CWDM), communication system, data center, ge-photodiode, Mach Zehnder (MZ) modulator,optical interconnections, optical transceiver, photonics integrated circuits (PIC), quad small form-factor pluggable (QSFP), silicon photonics
Conference Title : ICCSSP 2016 : International Conference on Circuits, Systems, and Signal Processing
Conference Location : Singapore, Singapore
Conference Dates : March 03-04, 2016