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The VCSEL Based Array Optical Transmitter (ATx) Development Towards 120 Gbps Link for the High-Luminosity LHC (HL-LHC) Experiments.

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A compact radiation-tolerant Array Optical transmitter module (ATx) integrating micro optics, a VCSEL array and a custom driver is demonstrated. ATx uses an edge warp substrate for the electrical interface and micro-lens array for the optical interface. A simple, high-accuracy and reliable active alignment method for micro-lens assembly is introduced. The coupling insertion loss is less than -3 dB with channel-to-channel variation less than 1 dB. Data transmission of 8Gbps per channel is measured. ATx will be irradiated under x-ray to 10 Mrad(SiO2) total dose to evaluate the radiation induced power penalty.

Summary

High-speed, low-power, radiation-tolerant optical data links development is critical for the LHC upgrade as well as other collider detector developments. VCSEL-based technology has been widely adopted by short-range data transmission links and compact parallel modules have seen surged commercialization in recent years. In this paper, we will report the continuous development of integrating a VCSEL array with its driving ASIC in a custom optical transmitter module (ATx). A simple, high accuracy and reliable active alignment method which is most critical for the array optics assembly performance will be introduced. The data transmission performance will be presented and the X-ray irradiation of the integrated module will be conducted.

ATx comprises a 16 mm x 21 mm x 1 mm substrate with high-density wiring and half-via structures around the substrate for the electrical interface. Both bare dies of the VCSEL array and the array driver are epoxied to the substrate. The optical interface is composed of two array optical components: a Mechanical Optical Interface (MOI) and a Prizm LightTurn Connector. The light output of the VCSEL array is collimated by micro-lens in the MOI. The Prizm Connector, which can be clipped onto the MOI, deflects the light by 90 degree and couples the light into the fiber ribbon. The MOI needs to be aligned with the VCSEL array within a tolerance of 10μm, and tackled down to the substrate using epoxy.

One of the most challenging and crucial aspects of developing array optics module is the alignment process. Current commercially available solutions are too expensive for research and development, and the final coupling efficiency cannot be detected until the MOI is epoxied after the alignment process. A custom simple and reliable active-alignment method is developed to solve this problem. Currently we can complete the MOI alignment of each module in the lab using manual stage within 15 minutes, and ensure that the insertion loss of each channel is less than -3 dB, the variation of all channels is less than 1dB, and the light crosstalk is less than -50 dBm in adjacent channels.

ATx module is a versatile array optical transmitter module that can accommodate different array drivers. A commercial 12-channel, 10 Gbps/ch array driver was used last year, and now it is replaced by a custom VCSEL array driving ASIC (LOCld4). The LOCld4 is a four channel radiation-tolerant VCSEL array driver fabricated in a commercial 0.25-μm Silicon-on-Sapphire (SoS) CMOS process with each channel operating at 8 Gbps.

With updated driver, the whole ATx module is designed to be radiation-tolerant and operate at 8 Gbps/ch. Data transmission of 8 Gbps per channel has been measured. Detailed link test will be conducted, and both optical and electrical crosstalk will be fully evaluated. ATx including VCSEL array, VCSEL driver and optical

components will be irradiated under x-ray with a total dose over 10 Mrad. The test results will be presented in the paper.

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