HIGH-SPEED PACKAGING FOR SILICON MODULATOR

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This paper reports a high-speed packaging for Silicon Mach-Zehnder modulators (MZMs). The radio frequency (RF) input port of the package is commercially available GPPO type. High-frequency ceramic substrate is designed to shorten the length of gold wire to suppress the RF attenuation. Gratings and single-mode fibers using inclined-surface coupling are used to realize low-loss and large tolerance coupling. In measurement, clear eye diagrams with ER of 10.1 dB and 7.6 dB were obtained at 25 Gb/s and 40 Gb/s modulations.

Silicon photonics has become a hot research topic in the field of optoelectronics in recent years, since silicon–based optical device can achieve high density integration, low power consumption, low cost photonic devices, realize monolithic integration with electronic devices, and it is compatible with traditional CMOS processes [1]. Silicon electro-optic modulators which are key devices in optoelectronic information transmission and processing have got great developments in recent years. High speed OOK silicon modulators have been demonstrated [2-4]. The silicon modulator packaging has also been studied [5-6]. However, the operating speed of packaged silicon modulators still need to be improved.

Our butterfly package for silicon modulator is illustrated in Figure 1. Two main designs were applied for high speed packaging: the modulator chip was designed with reverse PN mode, whose PN junction capacitance is smaller and the modulator electrode was carefully designed using CPW travelling-wave electrodes; GCPW transmission lines with metallic holes were adopted to fabricate the high-frequency ceramic substrates to make the high-speed electrical signal effective loading on the electrode of the MZM chip. Since micro-strip-like line (MSL) mode in GCPW line might exist, which usually cause energy coupling of CPW mode and prompt a microwave resonant of transmission response in high frequency range [7], we made metallic holes on a transmission line to suppress the microwave resonant [8-9].

Grating coupler and single-mode fiber with inclined-surface are used in optical coupling. The advantages of this optical coupling method is larger misalignment tolerance and cheap cleaved fiber packaging. Nickel metal tube is installed close to the inclined-surface of single-mode fiber, the position and angle of the optical fiber is adjusted by special fixture clamping nickel metal tube and adjusting the special fixture. Assuming the optical fiber is parallel to the chip surface, there is a relation of $\theta=2*\varphi-90^{o}$. We choose the $\varphi=51$ deg. as our grating incidence angle is 12 degree.

Eye-diagram measurements were carried to demonstrate the high-speed operation of the packaged modules. Experimental results were presented in Fig. 4(a) and 4(b). Clear eye diagrams with ERs of 10.1 dB and 7.6 dB were obtained at 25 Gb/s and 40 Gb/s modulation speed. By improving the welding between the pin of GPPO connector and ceramic substrates, further reducing the length of gold wires from the ceramic substrates to the modulator pads, the speed of the packaged MZM module could be higher.

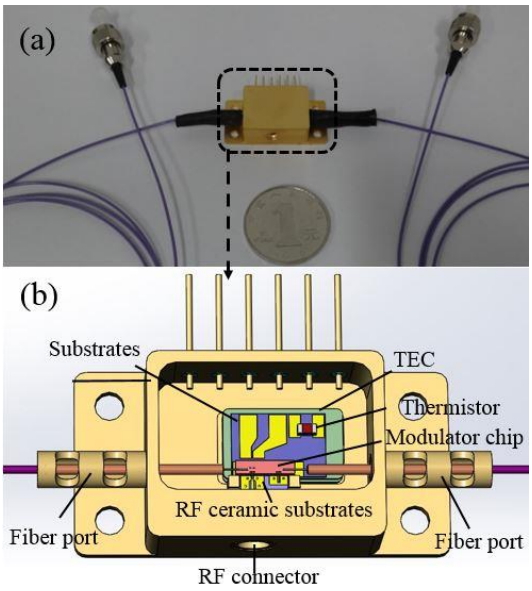

Fig.1 (a) Photograph and (b) Schematic view of the main structure of the high-speed package for silicon MZM.

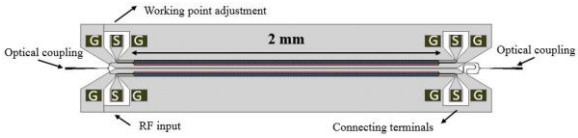

Fig. 2 Schematic view of the silicon MZM chip with CPW electrodes.

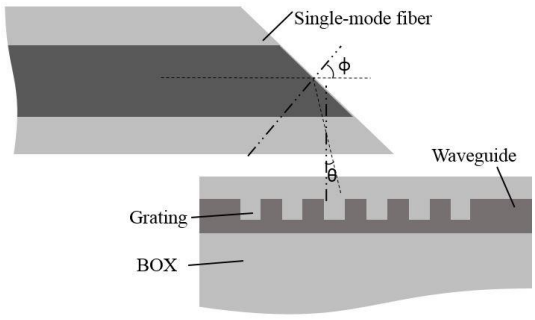

Fig. 3 The schematic picture of optical coupling condition.

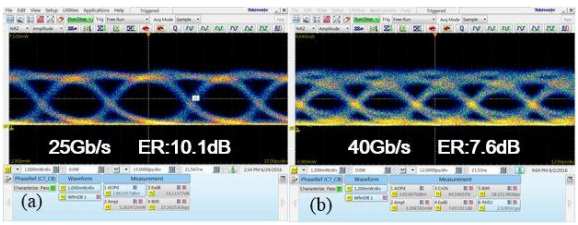

Fig. 4 Measured eye diagram of the packaged silicon Mach-Zehnder Modulator.

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