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High-Accuracy Optical Subassembly for High Speed Data Transmission above 10 Gb/s/ch

Sung Hwan Hwang[1,a], Jung Woon Lim[1,b], Hyo-Hoon Park[2,c], Myung Yong Jeong[3,d], Byung Sup Rho[1,e]

[1]Korea Photonics Technology Institute, 971-35, Wolchul-dong, Buk-gu, Gwangju, Korea
[2]Information and Communications University, 119, Munjiro, Yuseong-gu, Daejeon, Korea
[3]Pusan National University, 50, Cheonghak-ri, Samnagjineup, Miryang-si, Gyeongnam, Korea
[a]shhwang@kopti.re.kr, [b]jungwoon@kopti.re.kr, [c]hhpark@icu.ac.kr, [d]myjeong@pusan.ac.kr, [e]kalparho@kopti.re.kr

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Abstract. An optical subassembly which is suitable for high speed and parallel optical modules was introduced. The optical subassembly has features of low optical coupling loss less than 1.5 dB and wide 3-dB bandwidth more than 20 GHz in the view of the transmission line. And it was fabricated with a vertically stacked structure cost-effectively and precisely.

Introduction

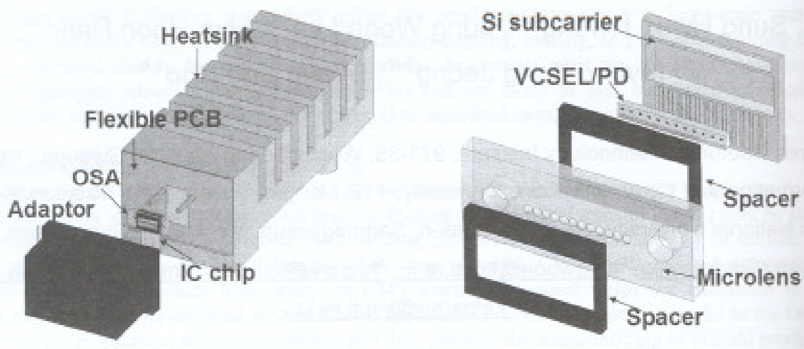
With the development of high-speed internet, data rates among network equipments have been dramatically increased. Many researchers have focused on parallel optical interconnection between the network equipments, which makes it possible to communicate the high capacity and high speed data from several giga to several tera bites per second total throughput [1-3]. In this paper, the fabrication process and the characteristics of an optical subassembly (OSA) which is a key component in parallel optical interconnection modules (POIMs) were described. The POIMs are multi-channel arrayed optical to electrical (OE) and electrical to optical (EO) converters. Thus, the design and fabrication issues of the OSA are: low optical and electrical crosstalk, and low optical coupling loss as well as wide bandwidth.

Fabrication and Performance of Optical Subassembly

Figure 1 (a) shows a drawing of the POIM. The POIM is composed of an adaptor, an OSA, an IC chip, a flexible printed circuit board (PCB), and a heatsink. Among the components, the OSA is the most important component; determining the performance of optical and electrical conversion.

The OSAs for POIMs are divided into transmitting and receiving parts. The transmitting OSA is a device directly modulating coherent light using a "vertical-cavity surface emitting laser" (VCSEL) array, and the receiving OSA is a device demodulating the light using a PIN photodiode (PD) array. Our suggested OSA has same structure for the transmitting and receiver OSA; and has a structure vertically stacking a silicon (Si) subcarrier, a VCSEL or PIN-PD array, a spacer, and a microlens array in sequence, as shown in Fig. 1 (b). The Si subcarrier was composed of transmission lines and a groove where the VCSEL or PD chip was positioned. The Si subcarrier was prepared through the following procedures. First, the groove was formed by etching using KOH solution. Then, we deposited wire-bonding available metal (Ti/Ni/Au) for transmission lines.

Meanwhile, the spacer was fabricated by Si deep reactive ion etching. The commercial VCSEL, PD, and microlens having 1×12 channels were used in the OSA.

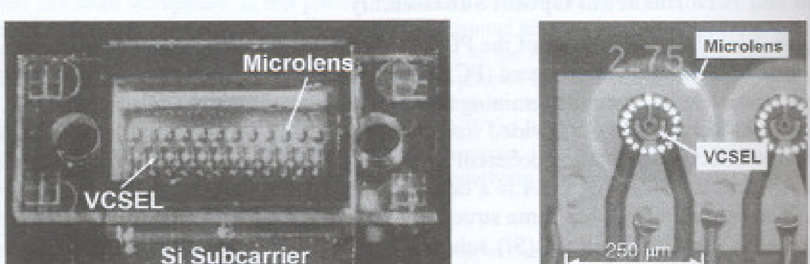


(a) (b)

Fig. 1. Drawings of (a) the parallel optical interconnection module (b) the optical subassembly.

Seeing the fabrication process of the OSA, the VCSEL or PD array was first die-bonded on the Si subcarrier with a conductive silver epoxy. Next, we wire-bonded the VCSEL or PD array to the transmission lines on the Si subcarrier. Then, the spacer and the microlens array were mounted on the Si subcarrier with a thermal curing epoxy, sequencely. Here, the important packaging issue is to mate exactly between the active center of the VCSEL or PD array and the microlens' center so that a misalignment should be minimized because the misalignment causes the additional optical coupling loss. Thus, we aligned and fixed the microlens array using TRIAD 05 flip-chip bonder of Suss MicroTec with less than ±1 μm bonding accuracy on the condition of 150 °C and 50 gf during 90 seconds.

Figure 2 (a) shows photograph of a fully packaged optical subassembly with an accurately boned microlens. Due to the high alignment accuracy, as shown in Fig. 2 (b), a low optical coupling loss of less than 1.5 dB was achieved. The experimental setup is shown in Fig. 3. Through the G-S-G probe, external current and voltage were induced to emit the beam of VCSEL and then the beam output power was measured using the 50 μm multi-mode fiber. Figure 4 shows L-I (light power versus current) curve data of the VCSEL OSA and that of coupling loss. As the optical results at room temperature, we obtained very low coupling loss of 0.75 dB at the operating current of 8 mA.



(a) (b)

Fig. 2. Photograph of (a) a fully packaged optical subassembly and (b) micrograph of the high-accurately bonded microlens.

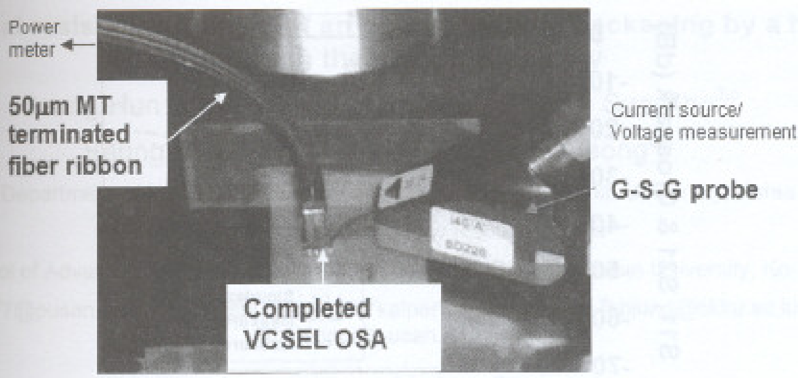


Fig. 3. Photograph of VCSEL OSA optical coupling loss measurement setup.

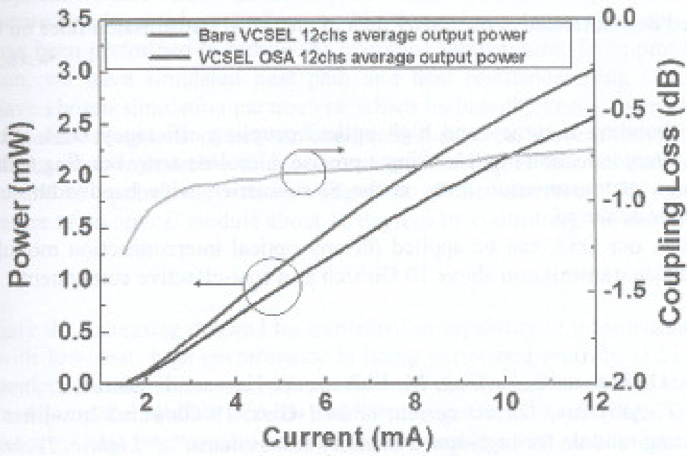


Fig. 4. Measured coupling loss of VCSEL OSA.

Meanwhile, in order to achieve the high speed electrical transmission, special attention was given to control crosstalk and signal integrity about the transmission lines on the Si subcarrier. The transmission lines were coplanar waveguide type and were fabricated by e-beam evaporating Ti/Ni/Au with 0.1/0.2/2.5-µm thickness respectively on the Si substrate. As has been reported by [4-6], we also used etched 1-µm SiO_2 as an insulating layer and a 10 kΩ-cm high resistivity Si substrate. The good characteristics of the transmission lines were measured using *Lightwave Component Analyzer (LCA) 86030A* as insertion loss of 1.5 dB/cm at 20 GHz, return loss of less than -20 dB, and crosstalk less than -30 dB for each channel in the range of 500 MHz to 26 GHz, as shown in Fig. 5. Simulated and the measured data are in agreement in Fig.5. These results show that the transmission lines of the Si subcarrier are available for high speed optical subassembly of more than 10 Gb/s. As an additional experiment, using *LCA 86030A*, O/E response (A/W) of the OSA mounting 9-GHz bandwidth PD array was measured as approximately 8.85 GHz bandwidth.

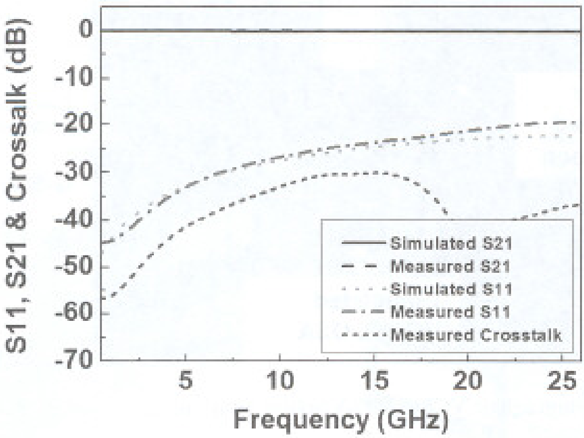


Fig. 5. Measured and simulated S-parameter data of electrical transmission lines on the Si subcarrier.

Summary

A high bonding accuracy and high optical coupling efficiency OSA was fabricated for parallel optical interconnection module using a precise microlens array bonding technique. Through the careful design of transmission lines on the Si subcarrier, wide bandwidth and low crosstalk performances were achieved.

Therefore, our OSA can be applied for any optical interconnection modules and systems with high speed data transmission above 10 Gb/s/ch as a cost-effective component.

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