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고분자 광도파로를 이용한 광배선 시스템

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Fully Optical Backplane System Using Polymeric Waveguides

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Abstract

A practical optical backplane system was prepared with transmitter/receiver processing boards and an optical backplane made of polymeric waveguide embedded optical printed circuit boards. As connection components between the transmitter/receiver processing boards and backplane board, optical slots were used to enable easy and repeatable insertion and extraction of the boards with micrometer precision. We report an 8-Gb/s data transmission between transmitter processing board and optical backplane.

1. Introduction

As the demand for network bandwidth grows, there is a parallel need to improve data transmission inside network systems and equipment, such as high-speed routers and switches. Traditionally, backplanes have been based on copper wiring. Compared to electrical signals, optical signals can offer enormous capacity with relatively low loss and are unaffected by electromagnetic interference[1]. In recent years, many studies have reported developing optical chip-to-chip interconnects in order to reduce the microelectronics interconnection problem[2]. In addition to studies on board and backplane solutions[3], plastic-optical-fiber-based chip-to-chip interconnection concepts are also under development [4]. Furthermore, solutions for optical free space interconnects for chip-to-chip[5] and backplane applications[6] have been demonstrated.

In this letter, an optical backplane system constructed with transmitter/receiver processing boards and an optical backplane board made of waveguide embedded optical printed circuit boards(PCBs) is demonstrated for the first time. The transmitter/receiver processing boards are designed as plug types, and can be easily plugged in and out at an optical backplane board. The optical backplane boards are prepared by employing the lamination processes for conventional electrical PCBs. We successfully achieved an 8-Gb/s data transmission with this system.

2. The basic concept of optical backplane system

The basic concept of a board-to-board optical interconnection system is as follows. A metal optical bench (MOB) is integrated with optoelectronic devices, driver and receiver circuits, polymeric-waveguide, and access line. A multimode polymeric−waveguide is embedded inside the optical backplane of a PCB. An optical slot structure is employed for the vertical insertion of processing boards into a backplane board.

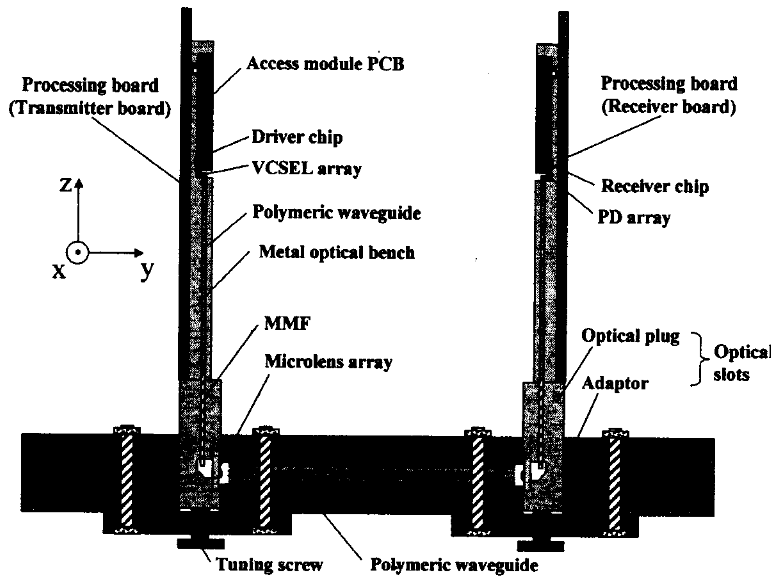

Fig. 1. Architecture of an optical interconnection system using optical slots.

Fig. 1 depicts the architecture of the optical interconnection system,including transmitter/receiver processing boards and a waveguide−embedded optical backplane. The main components are low−loss tapered polymeric−waveguides and novel optical slots for board−to−board interconnections. The optical interconnection system has two processing boards, the transmitting and receiving boards, and one optical backplane. The processing boards contain transmitter and receiver modules that consist of MOB, vertical−cavity surface−emitting laser diode (VCSEL) array, photodiode (PD) array, polymeric−waveguide, and high−speed access lines. The MOB was employed for passive alignment of chips and thermal dissipation. The optical backplane consists of an 8−layered PCB, optical plug/adaptor, and tapered polymeric−waveguide that is embedded at the center of the PCB.

3. Fabrication and measurement

To have a differential impedance of 100Ω, the width and thickness of the trace and the separation of the inter−channel were determined as 75 μm, 40 μm, and 90 μm, respectively, by ADS Momentum simulation. MOB has a three−step trenched structure. Use of this stepped trench structure can provide high−speed bandwidth by shortening the length of wire bonding to less than 600 μm, and this MOB packaging provides safe ground and heat spreading effects for high−speed circuit boards.

The multimode polymeric−waveguides were fabricated by a hot embossing process. UV curable resin was used as the core material. The surface roughness of the hot embossed bottom and sidewall areas is approximately 2 nm and 10 nm, respectively.

This result is about equal to the surface roughness of the silicon master. The propagation loss of the tapered waveguide was 0.1dB/cm at 850 nm. And the press for lamination was heated to 150 ℃ and 25 kg/cm^2 of pressure and was then applied and held for 90 min.

Fig. 2 shows the principle of optical coupling between the processing boards and the optical backplane.The emitting beams from VCSELs are guided to multi-mode fibers (MMFs) with a core diameter of 62.5 μm, mounted on the optical plug through a polymeric-waveguide array on the MOB. Subsequently, the beams are refracted with a 45-inclined mirror and then focused into the waveguide in the backplane using microlens array with a diameter of 230 μm attached to the optical plug.

To insert the processing boards, rectangular holes were made by mechanical drilling in the waveguide-embedded optical backplane.For accurate alignment and easy assembly, we employed optical slot components consisting of a plug and an adaptor made of micro-machined metal. Optical plugs were installed at the end of the processing boards and the optical adaptor was mounted in the rectangular hole in the backplane, as illustrated in Figs. 1 and 2. The optical adaptor mounted with the plug and the processing board was initially installed into the hole of the backplane by active alignment using a xyz stage and then the adaptor was fixed in the backplane by bolts and nuts seen in Fig. 1. Once the optical adaptor is installed, the processing board can be extracted from the adaptor and also reinserted by rejoining the tuning screw. Since the mechanical tolerance of the metal optical plug and adaptor was about ±2 μm, the alignment of the processing board in the reinsertion into the backplane can be maintained as accurate as this mechanical tolerance in x and y directions of the optical backplane. This tolerance could not affect signal degradation, and it makes optical coupling automatically between the waveguide in optical backplane and the fiber on the optical plug.However, after reinsertion of our processing board, minute alignment was required in vertical z direction and it was achieved by manual tuning of the screw.

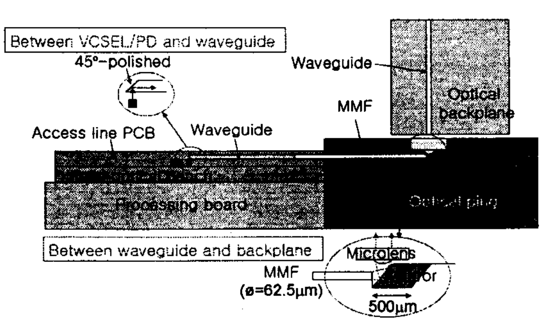

Fig. 2. Optical coupling between the processing boards and the optical backplane.

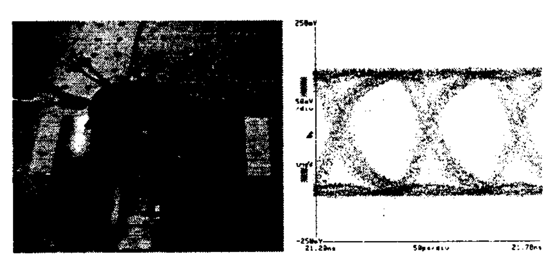

Fig. 3. (a) Prototype system for optical link between transmitter board and backplane. (b) Eye-diagram measured for 5 Gbp/s data transmission

Fig. 3(a) shows a transmitter board assembled with a prototype optical backplane. Fig. 3(b) shows an eye-diagram for the transmission of 5 Gb/s PRBS NRZ data from the VCSEL of the processing board to the end of a waveguide-embedded optical backplane. In the transmission characteristic seen in Fig. 3(b), the eye is symmetric without any significant relaxation oscillation. The power budget of the optical interconnection system was −14dB.

In our system a large portion of the loss, roughly about 7dB, was induced in the coupling of the reflected beam at the 90 mirror on the optical plug to the waveguide of the backplane through the microlens. Further research is needed to devise optical components connecting the board edges with a high coupling efficiency.

Conclusions

We have developed an active optical backplane system using waveguide-embedded optical PCBs. We employed a metal optical bench and metal optical slots for the packaging of optoelectronic chips and connection between boards. Using this system, we demonstrated a 5 Gb/s data transmission between the transmitter processing board and the optical backplane board.

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