Wavelength addressed intra-board optical interconnection using plug-in alignment technique by a micro hole array

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Abstract— We proposed a novel intra-board optical interconnection combining both a micro passive wavelength selector (MPWS) and a micro hole array (MHA) for a plug-in alignment. We found that the wavelength addressing operation of the MPWS was good solution for an intra-board interconnection by simulations and experiments.

Keywords- optical inerconnecton; wavelength addressing; plug-in alignment; optical pin; micro hole array; diffraction grating;

I. INTRODUCTION

Optical interconnections are suitable for high capacity LAN, asynchronous transfer mode (ATM) switches, and huge parallel processing computer systems because of their high data transmission rate, small crosstalk between the adjacent lines, small signal reflection, and high density mounting. For the purpose, optical surface mount technology (O-SMT) is the best solution of these applications because of their capability of both low cost and high density mounting [1].

Previously, we have proposed a board level O-SMT which was composed of micro optical pins and optoelectronic printed wiring board (OE-PWB) [2]. In this case, a reconfigurable interconnection technique is useful for intra-board optical interconnection between buried optical layers.

In this paper, we propose a novel intra-board optical interconnection combining both an optical wavelength addressing technique by a micro passive wavelength selector (MPWS), and a passive optical waveguide alignment technique by a micro hole array (MHA). And we also report experimental results of the MHA and the wavelength addressing operation of the prototype MPWS module.

II. CONCEPT OF MPWS

A module configuration of the MPWS module is shown in Fig. 1. The configuration was based on a simple free space micro optical system of a littrow monochromator mount. The optical waveguide channels were buried in the OE-PWB, and the MPWS module was plugged the optical waveguide channels in by using tapered micro holes of the MHA.

Transmitting light from an optoelectronic surface mount device (OE-SMD) propagates the optical waveguide channel, and radiates to the collimator lens. The collimated light from the collimator lens is diffracted by a diffraction grating, and is focused on the receiving optical waveguide channel which is guide to the other OE-SMD. So, we can select the receiving optical waveguide channel by the transmitting wavelength λ.

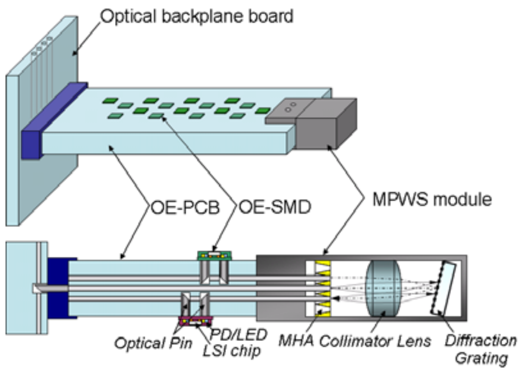

Fig. 1 Schematic figure of the OE-PWB with MPWS module

III. OPTICAL SYSTEM DESIGN

We designed and evaluated the optical system of the MPWS module by using an optical design software OSLO-EDU of Lambda Research Corporation.

We considered focusing spot positions corresponding to the wavelength dispersion from the reciprocal linear dispersion D;

$$D=d\cdot\cos\beta/m\cdot f \quad (1)$$

where d: groove spacing, β: diffraction angle, m: diffraction order, and f: focal length of the collimator lens, respectively. When we choose the array pitch Δp of MHA and the wavelength pitch Δλ of the channel, we can decide D as Δλ/Δp, and we also select the optical elements of the MPWS.

Examples of the simulation results of the MPWS were shown in Fig. 2. In this case, we assumed that the OE-PCB had three optical waveguide channel layers. And the diffraction grating of groove spacing d=1.67μm (600 line/mm), the collimator lens of focal length f=12.5mm, the MHA of array pitch Δp=0.5mm, and wavelength pitch Δλ=65nm (460/ 525/ 590nm) were selected, respectively. And we set the littrow wavelength λl=525nm, diffraction order m=+1, and incident angle in littrow α=β=9.06 deg, respectively.

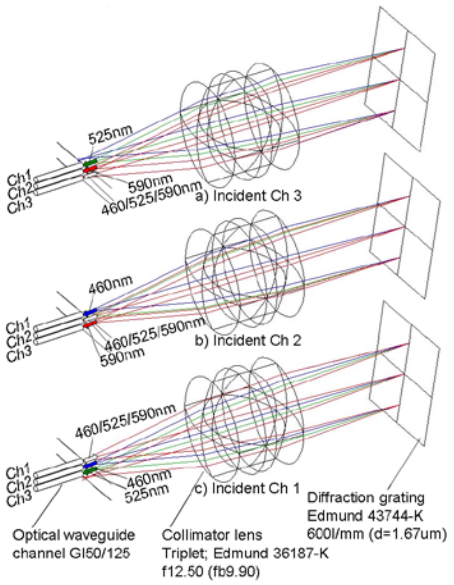

Fig. 2 Simulation results of the MPWS module

From Fig. 2, we could understand obviously, in the case of the incident channel was Ch2, Ch1 and Ch3 were addressed by 460 and 590nm, respectively. And we realized the interconnection from Ch3 to Ch1, or from Ch1 to Ch3 were addressed by the littrow wavelength of 525nm. And from the simulation, we evaluated that the spot diameter was within 60 microns and the maximum sift of the spots from the accurate positions were below 5 microns.

IV. Experimental Results

The MHA, which was the key device of plug-in alignment, was made of acrylic UV curable resin. We fabricated the MHA by the mask transfer method [3]. A microscope photograph of a fabricated 4 x 4 arrayed MHA is shown in Fig. 3.

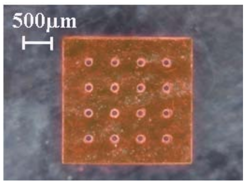

Fig. 3 Microscope photograph of a fabricated MHA

In this case, UV irradiation power and exposure time were 0.54 W/cm2 and 0.5 s, respectively. And the diameter, pitch, tapered angle, and thickness of the MHA were evaluated at 0.131 mm, 0.50 mm, 0.4 deg., and 0.95 mm, respectively.

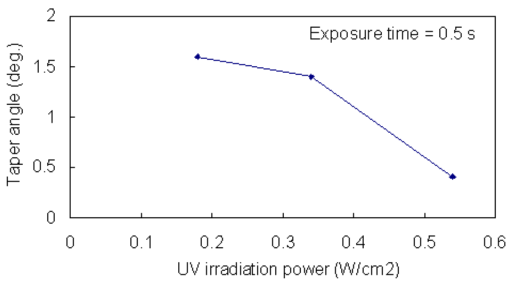

Fig. 4 Relationship of taper angle and irradiation power

The relationship of the taper angle and the irradiation power are shown in Fig.4. From the results, we found that it was applicable to control the taper angle from 0.4 deg. to 1.6 deg. by adjusting the UV irradiation power.

Fig. 5 shows a photograph of a prototype MPWS module, which was arranged on a test bench. In this case, we assumed that the OE-PCB had four optical waveguide channel layers of GI50/125 optical fibers. Other optical elements were same as Fig. 2, and the optical system size was about 8 x 8 x 30mm. The optical fibers were plugged in the MHA of the prototype MPWS module, passively.

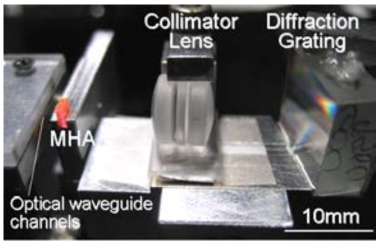

Fig 5 Photograph of the prototype MPWS module

The MPWS module was demonstrated as shown in Fig. 6. In this case, the transmitting channel was Ch1, and blue (λ 470nm), green (λ 525nm), and amber (λ 470nm) LEDs were lighted on, in order to interconnect to the receiving channels of Ch2, Ch3, and Ch4, respectively. From the results, we confirmed that the wavelength addressing operation of the MWPS module was effective for intra-board optical interconnection.

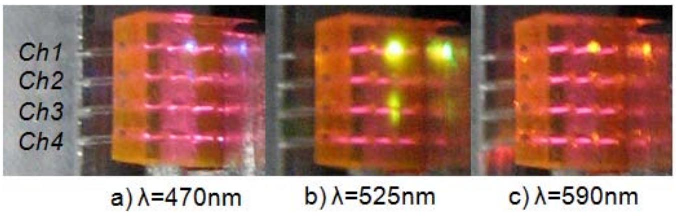

Fig. 6 Wavelength addressing operation of the MPWS module

V. Conclusions

We proposed a novel intra-board optical interconnection combining both an optical wavelength addressing technique by the MPWS, and a passive optical waveguide alignment technique by the MHA. It was found that the wavelength addressing operation of the MWPS was proved good solution for intra-board optical interconnection of the OE-PCBs.

References

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