MB2.2
11:00 am – 11:15 am

Performance Evaluation of Fully Embedded Board Level Optical Interconnection

Jinho Choi, Li Wang, Xiaolong Wang, David Hass*, Jerry Magera*, and Ray T. Chen, *Fellow*, OSA, IEEE

University of Texas at Austin, Sanmina-SCI*

Summary

We have made a thin flexible waveguide film for fully embedded board level optical interconnections[1]. Fig. 1 shows the schematic diagram of a flexible waveguide film with optoelectronic devices. First, the master waveguide structures are formed on a silicon wafer using a standard photo-lithography process. SU8-2050 (MicroChem^{TM}) is used as the waveguide structures having 12 channel guides with a square shape cross-section (50 μm x 50 μm) and a total length of up to 100 cm.

45° total internal reflective (TIR) micro-mirrors are adopted to couple light from the VCSELs into the waveguide array, and then to the PIN photodiodes[2]. To get a soft mold with 45° micro-mirror couplers, the master waveguide structure is cut on both ends by a specially designed tool. PDMS (Sylgard 184, Dow Corning) is chosen as a soft mold material. The PDMS is poured on the master waveguide structure and cured. Surface relief waveguide patterns with 45° micro-mirror couplers are transferred from the master waveguide structure to the soft mold.

A flexible waveguide film is fabricated by the soft molding process. The core material (SU-8) is poured on the heated soft mold and then excess SU-8 is scraped out. The soft mold filled with SU-8 is covered with Topas^{TM} 6015 (cyclo-olefin-copolymer) film, as a bottom cladding layer. The core waveguide structure is transferred from the soft mold to Topas^{TM} 6015 film using a hot-press machine. A flexible waveguide film without the top cladding layer is exposed to UV light to cross-link the SU-8 and the surfaces of the 45° micro-mirrors are deposited with aluminum (Al) to ensure the total internal reflection. Finally, the top cladding layer is spin-coated on the film. Measured propagation loss of the waveguide is below 0.5 dB/cm for both TE and TM modes at 850nm.

Two 12-channel, 850 nm VCSEL arrays (2.5Gb/s and 10Gb/s) and a PIN photodiode array are used as I/O sources on a flexible polymeric waveguide film. The initial substrate thickness (200 μm) of the VCSEL is reduced to facilitate thermal management of the VCSEL and the fully embedded structure. Fig. 2 shows the L-I characteristics of two 12-channel VCSEL arrays. Apertures of optoelectronic devices are precisely aligned with I/O windows of the 45° micro-mirror couplers and fixed by a UV curable adhesive. The performance features of the 10 Gb/ses 12-channel VCSEL array are summarized in table 1. Fig. 3 shows an integrated VCSEL and PIN photodiode arrays. Conventional PCB lamination processes are applied to interpose a flexible waveguide film between PCB layers to form the fully

embedded structure in Sanmina-SCI. Further experimental results will be presented in the conference. This research is sponsored by DARPA, MDA, ONR and Sanmina SCI.

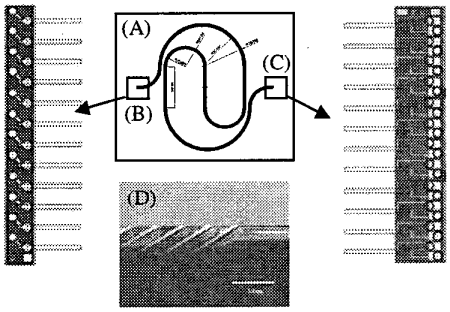

Figure 1. (A)A flexible optical waveguide film, (B)12-channel VCSEL array, (C)12-channel PIN Photodiode array, (D) 45° micro-mirror couplers.

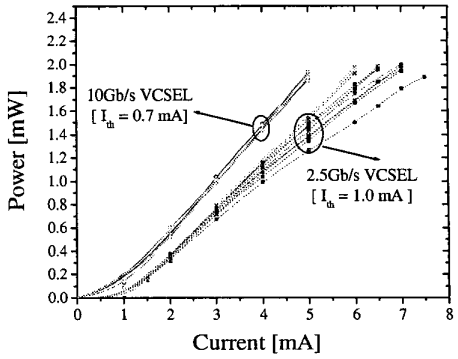

Figure 2. L-I characteristics of 12 channel VCSEL array for the 10Gb/s (Both top contacts) and the 2.5 Gb/s (Top and bottom contacts)

Threshold Current	0.5 ~ 1.5 (mA)
Slope Efficiency	0.35 ~ 0.55 (mW/mA)
Central Wavelength	848 ~ 860 (nm)
Spectral Width(RMS)	0.45 ~ 0.6 (nm)
Forward Voltage (I_f=5mA)	1.4 ~ 2.0 (V)
Beam Divergence	27 ~ 32 (deg)
Reverse Leakage Current	5 ~ 20 (pA)
* Conditions: T_{sub} = 25°C, I_f = 2 ~ 5 mA	

Table 1. Electro-optical characteristics of the 10Gb/s 12-channel VCSEL array.

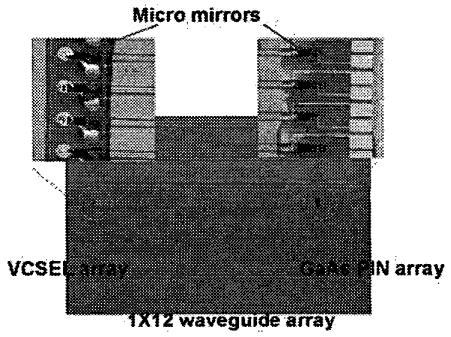

Figure 3. Integrated VCSEL and PIN photodiode arrays on a flexible optical waveguide film.

References

[1] Ray T. Chen, Lei Lin, Chulchae Choi, Yujie Liu, B. Bihari, L. Wu, R. Wickman, B. Picor,M. K. Hibbs-Brenner, J. Bristow, and Y.S. Liu, "Fully embedded Board-Level Guided-Wave Optoelectronic Interconnects," Proc. IEEE, **88**(6), pp780~793, 2000, .

[2] Y. S. Liu, H. S. Cole, J. Bristow, and Y. Liu, "Hybrid integration of electrical and optical interconnects," in Proc. SPIE, vol. 2153, pp337~343, 1994