Novel integrated micro-optics system for the fabrication of Active Optical Cables

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For the fabrication of new fiber optics-based communication systems, factors like feasibility with available technology, costs and the possibility of automation of the fabrication and adjustment processes have to be considered. In this paper the fabrication of the optical devices and the integration with the electronic system, considering these criteria, is presented.

1 Introduction

The integration concept is based on the construction of modular optical and electronic systems that can be tested separately. Optical couplers, VCSEL-Driver, VCSEL-Array, Transimpedance-Amplifier and Photodiode-Array are integrated in a 22x25 mm^2 and 3mm height PCB. On this PCB there is an electrical connector, the electrical signals are converted to optical ones and are transmitted optically over fiber optics. The reverse process for the receiver takes place on the same system. With commercially available devices it is possible to achieve up to 12,5 Gbit/s per channel and in the complete AOC (Active Optical Cable) up to 300 Gbit/s duplex.

2 Fabricated optical coupler

The fabrication of the optical coupler is a two-step process. First, a metal master has to be manufactured [1] and afterwards it is replicated using UV-curable polymers. The process is shown in Fig.1.

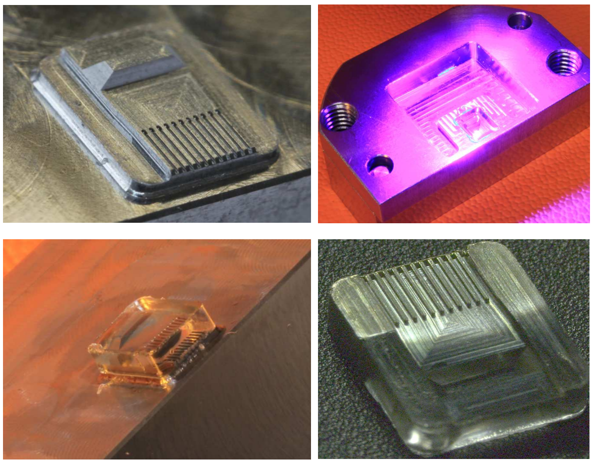

Fig. 1 *Fabrication process of the optical coupler*

In Figure 1 from left to right and from top to bottom the manufactured metal master, the UV-exposure, the cured polymer on the master and the fabricated coupler are shown.

3 Integration concept

The optical- and the electronic sub-systems can be constructed and tested separately. After the functionality has been proven, the systems are aligned using standard mechanical systems with 5 degrees of freedom, those are: the Cartesian coordinates and two tilt angles that are critical to achieve the desired coupling efficiency. The tilt angle around the transversal axis of the VCSEL array is the most critical one (see Fig. 2). Measurements show that this angle is up to 2.3° in the worst case.

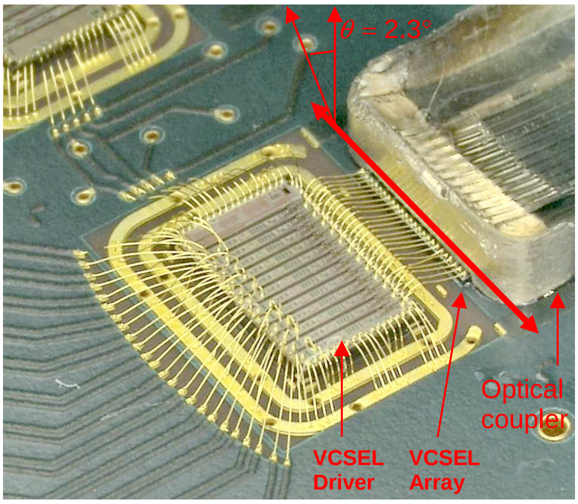

Fig. 2 *Adjustment of the coupler on the PCB*

With this angle adjusted, a coupling efficiency of about 50% can be assured. For systems that are some meters in length (up to 10m), this coupling efficiency is acceptable. In order to reach higher coupling efficiencies, an active adjustment is required. The Fig. 3, shows the coupling efficiencies that can be reached with passive alignment and the improvement if active alignment is made. When using active alignment the coupling efficiency is, in the worst case, about 90%; which represents a considerably higher efficiency than that reached using passive alignment.

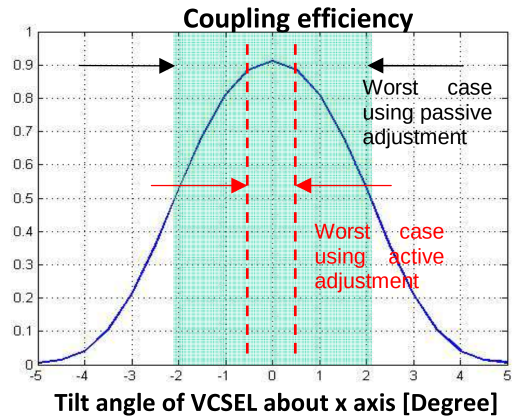

Fig. 3 *Passive adjustment*

The passive adjustment is made using markers on the PCB and mechanical stops in the coupler [2]. For the active adjustment a measurement of the optical and electrical signal is needed. For the adjustment of the coupler and the VCSEL array, the optical signal is measured as shown in the diagram of the Fig. 4.

For the adjustment of the optical coupler and the photodiode array, only the electrical signal after the transimpedance amplifier can be measured (see Fig. 4).

Because the fiber has to be cut for the measurement of the optical signal, after the adjustment, the optical signals need to be coupled into the fiber connected to the coupler on the photodiode again. For this purpose, butt coupling is used. This system was manufactured lithographically in a standard SU-8 process.

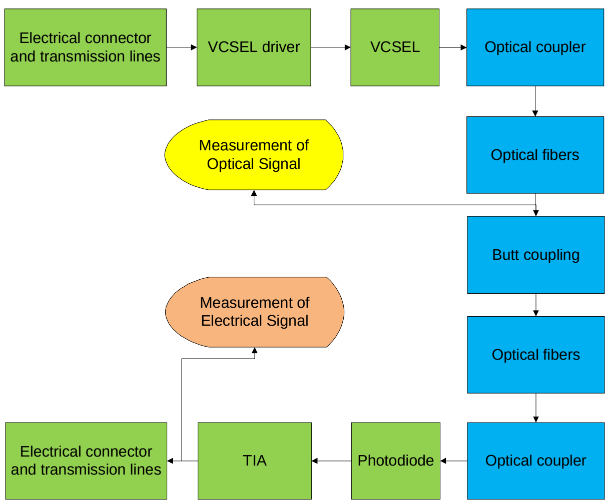

Fig. 4 *Block diagram and measuring point for the active adjustment*

The fabricated active optical cable is shown in Fig. 5.

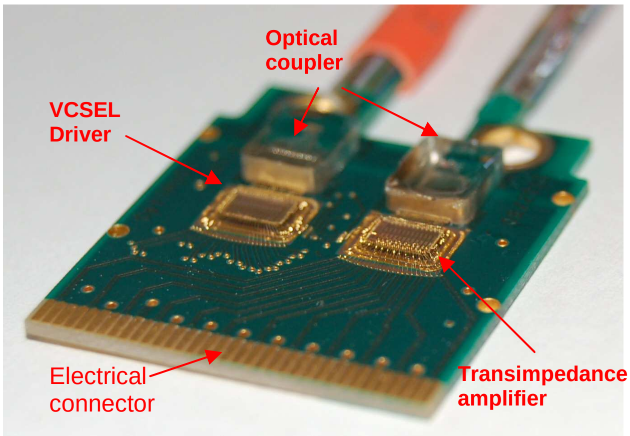

Fig. 5 *Fabricated integrated system*

4 Summary

A multi-channel communication system on the basis of fiber optics was constructed. The AOC-like system combines the advantages of electrical connectors and of fiber optics.

The use of standard methods for the assembly of the optical and electronic systems and the implementation of a modular design make the integration concept specially efficient concerning costs and reliability.

References

[1] F. Merchán, K.-H. Brenner, R. Börret, U. Berger, „Cost optimized fabrication of Micro-Optical Couplers", Optical Fabrication and Testing (OF&T), OSA, 13.-16-06.2010, Jackson Hole, Wyoming, USA, (2010). OWC3: OSA / IODC/OF&T 2010

[2] F. Merchán, K.-H. Brenner, "A concept for the assembly and alignment of arrayed microelectronic and micro-optical systems for Optical Multi-Gigabit Communication", Optoelectronic Interconnects and Component Integration XI Conference OE112, 22.-27.01.2011, San Francisco, California, USA, Proc. of SPIE Vol. 7944.