High speed communication using micro optical integration

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Integration of optical and electronic systems has become important due to the increasing density of information needed to be transferred in modern high-speed systems like high-volume data acquisition and supercomputers. Miniaturization of optical paths can be achieved by constructing monolithic optical systems equipped with sub-systems like mirrors and guiding structures.

1 Introduction

Optical-fiber communication offers an almost unlimited bandwidth for transfer of high data volumes. Compared to electrical connections, it has many advantages: better handling, lower weight and lower production costs, but its interconnects are often difficult to fabricate and expensive. We present a fabrication method that miniaturizes and simplifies these interconnections by fabricating monolithic optical systems equipped with sub-systems like fiber guides and micro mirrors. Plastic replication of masters is a very accurate and cost effective method for manufacturing such monolithic optical systems. The masters are fabricated with lithographic methods or with diamond milling. An electronic circuit was designed in order to test the optical systems.

2 Concept

Often the difficulties of optical interconnects are present in the centering and adjusting mechanics. To couple the light from the light source into the fiber and from the fiber into the receiver, focusing lenses are needed in current systems.

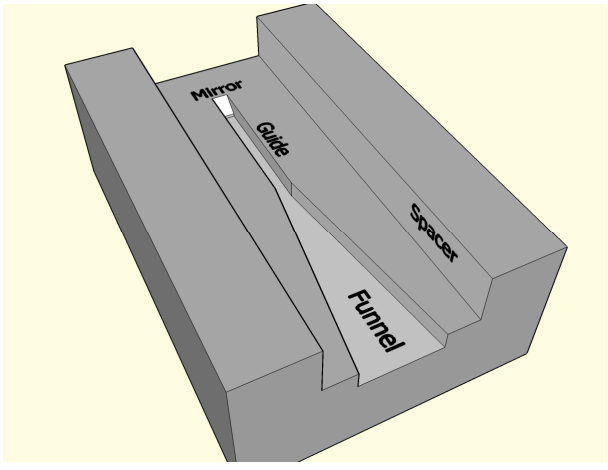


Fig. 1 *Model of the replicated structure*

In our miniaturized concept, self guiding structures are used for the optical fiber to meet the emitted beam coming from the VCSEL and being reflected by the mirror in the monolithic structure as shown in figures 1 and 2.

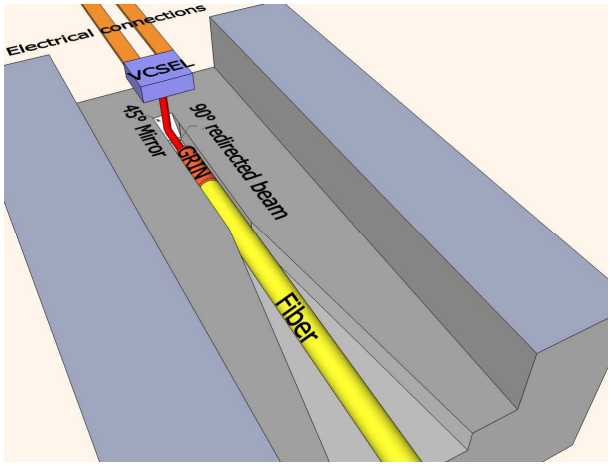


Fig. 2 *System with optical and electronic devices. PCB blinded out*

It is important to notice that the mirror has to be metal coated in order to maximize its reflectivity.

3 Test system

In figure 3 there is a block diagram of the electronic system. It is able to generate data-rates up to 3,125 Gbps and verify the received data with respect to bit error rate. Between blocks there is additional circuitry that allows measuring other values, like the eye diagram, decisive for the quantification of the performance of the whole system.

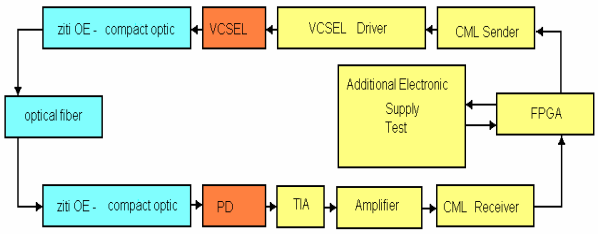
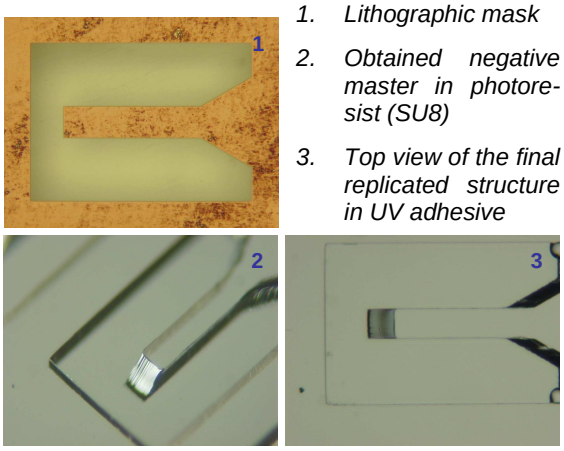


Fig. 3 *Block diagram of the test system*

We preferred a VCSEL to an edge emitting laser, because of its small package and its ability to emit perpendicular to the semiconductor surface.

4 Fabrication of micro optical fiber couplers

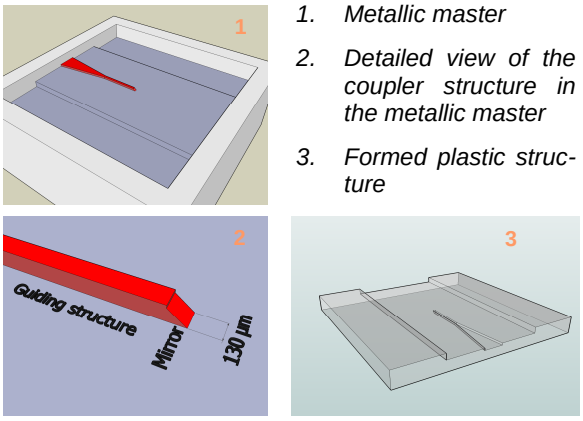
Lithographic methods achieve sub-micrometer lateral resolution and it is possible to make inclined structures by exposing the resist under different angles. In figure 4 the results of the fabrication of the master with this method are shown. Some grooves can be seen on the mirror surface. Fig.4.2.



1. *Lithographic mask*
2. *Obtained negative master in photoresist (SU8)*
3. *Top view of the final replicated structure in UV adhesive*

Fig. 4 *Fabrication using UV Deep Lithography*

Diamond milling is a method for processing metals that achieve sub µm precision on several degrees of freedom. Furthermore when applying diamond lapping, metal surfaces show optical quality. In figure 5 the 3D models of the metal master and the replicated plastic structure are shown.



1. *Metallic master*
2. *Detailed view of the coupler structure in the metallic master*
3. *Formed plastic structure*

Fig. 5 *Fabrication using Diamond Milling*

5 Measurements

The mirror's quality represents one of the most important factors when comparing the structures fabricated with lithography and diamond milling. When lapping is applied, the roughness of the surface has a maximum of 5 nm.

6 Conclusions

Diamond milling is a very reliable method for fabrication of metal masters for interconnect structures with optical quality.

By replicating the structure in a plastic substrate, low cost couplers are manufactured.

Simplification of assembling and adjustment procedures is an additional advantage of the system.

References

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