MD2 (Invited)
4:00pm - 4:30pm

Micro-optics for micromachined fiber optic switches

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Modern micromachining enables the fabrication of passive and active optical components, such as lenses, gratings and fan-out elements. These components are ideal for building compact micro-optical systems [1]. We will summarize the potential and limitations of these elements, as well as their integration into systems for the case of fiber optic interconnects and switches.

Micro-optical elements: The typical procedure to fabricate micro-optical elements is to realize a surface-relief pattern into photoresist by multiple mask projection or by direct writing methods (e-beam, laser beam) [1]. The surface-relief is then transferred into quartz by etching, or into plastic by replication. Different types of elements are available. Diffractive elements (DOE's) can perform various optical functions, such as deflection, focusing, multiple beam-splitting (Fig. 1) and wavelength demultiplexing. Refractive lenses can be manufactured by melting resist technology (Fig. 2). The lenses have a diameter of a few μm up to a few mm and an f-number below f/5. Highly interesting for building compact systems, are hybrid (refractive/diffractive) elements. They can perform multiple functions at once and they can compensate for aberrations. Figure 3 shows an example of a hybrid element which can be used for wavelength demultiplexing. The element has been fabricated by interference on top of a microlens [3]. Limitations of micro-optical elements are the diffraction efficiency, stray-light and the resolution of the fabrication process.

Systems: Our goal is to realize a 3-D system for fiber optic switches, as shown in Fig. 4. The system connects one input fiber to 6 or 8 output fibers. An advantage of the system is that the distances between input fiber and output fibers are equal. In addition, the configuration can be extended to switch which conncets 8 input fibers to 8 output fibers. A key problem in such systems is the alignment of the different components. We have built a first test system (Fig. 5) to study the alignment of refractive microlenses with respect to a fiber array. A high lateral precision is required for single mode fiber injection, typically better than 1 μm. The alignment along the optical axis is less critical. Our system consists of a microlens placed between one input fiber and one output fiber. The fibers are held in V-grooves and the microlens is mounted on an XY-stage. The lens is fabricated by the melting resist technology. The mechanical parts are realized by wire electro-discharge machining (wire-EDM) at AGIE Losone. Two piezo-electrical actuators make the flexible bearings of the stage move in X and Y direction (Fig. 6). A feedback loop allows an accurate lateral adjustment in order to optimize the fiber injection. We will present the results obtained with this system and the progress made in the final 3-D switching system.

[1] H. P. Herzig, ed., *Micro-Optics: Elements, Systems, and Applications*, (Taylor & Francis, London, 1997), ISBN: 0 7484 0481 3 HB.

[2] Ph. Nussbaum, R. Völkel, H. P. Herzig, M. Eisner, S. Haselbeck. "Design, fabrication and testing of microlens arrays for sensors and microsystems", Pure Appl. Opt. **6**, 1-20 (1997).

[3] P. Ehbets, H. P. Herzig, P. Nussbaum, P. Blattner, R. Dändliker, "Interferometric fabrication of modulated submicron gratings in photoresist", Appl. Opt. **34**, 2540-2547 (1995).

[4] S. Traut, I. Philipoussis, Ph. Nussbaum, H. P. Herzig, "Holographically recorded gratings on microlens arrays", Topical Meetings Digest Series (European Optical Society, 1998), Vol. 16, pp. 32-33.

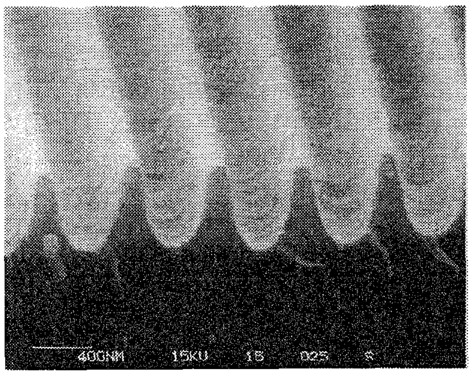

Fig. 1 Scanning electron microscopy picture of a grating structure. This element is an off-axis fan-out element that generates 9 equal spots in the first diffraction order [3]. The grating period is 577 μm.

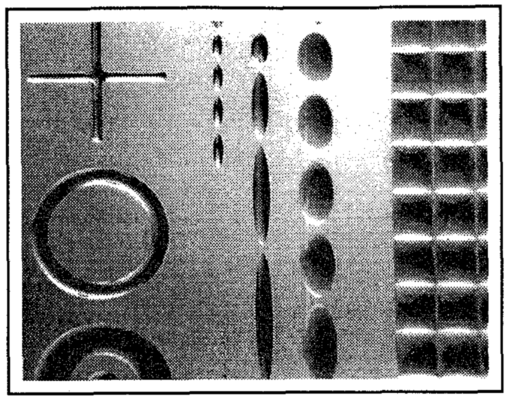

Fig. 2 Microlenses fabricated by reflow technique: elliptic, rectangular and ring lenses [2].

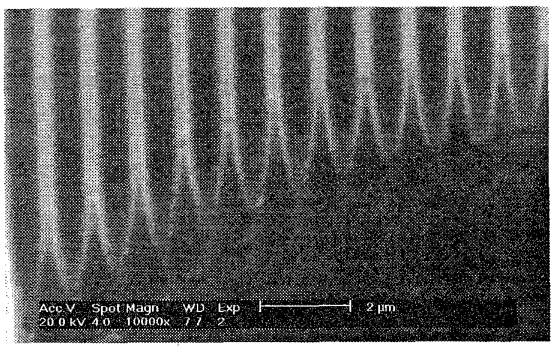

Fig. 3 Cross section of a grating on top of a microlens [4].

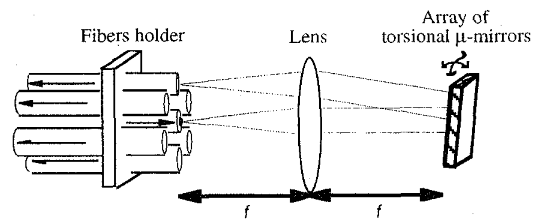

Fig. 4 Schematic drawing of a 3D optical switch with a fiber bundle (one input fiber and six output fibers).

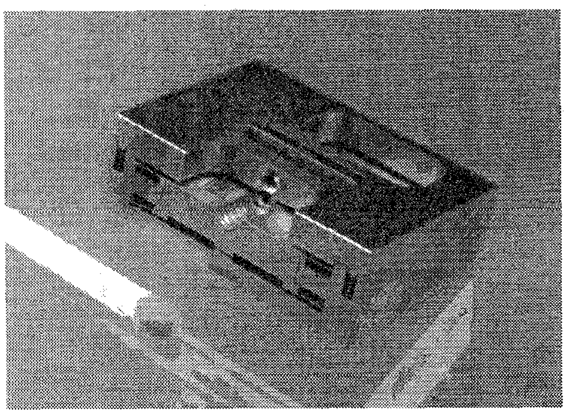

Fig. 5 Miniaturized X-Y stage: electro-eroded translation stage for fiber alignment, fabricated at AGIE, Losone by S. Bottinelli, EPFL.

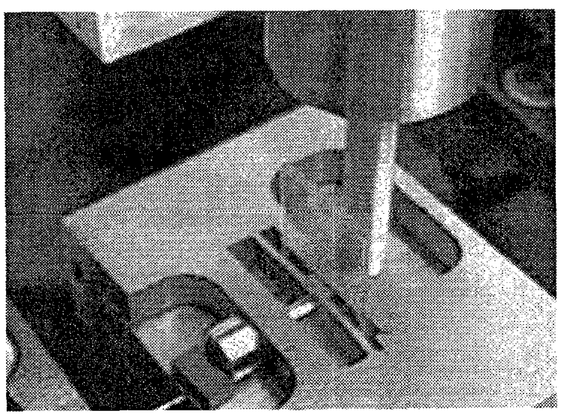

Fig. 6. Setup of the AGIE XY-table.