OPTICAL MEMS DEVICES BASED ON WET ANISOTROPIC ETCHING OF SILICON

(invited)

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Optical MEMS found various applications over the last years due to the rapidly increasing data rates in optical networks [1]. As standard single-mode fibers are used, the required alignment tolerances are below 1 µm for optical fiber. The assembly and reliability of MOEMS devices requires increasing attention. Additionally, the trend is going from single-functionality devices to more complex subsystem units with a reduced number of fiber connections within the subsystem. Bulk silicon micromachining using wet anisotropic etching is a suitable tool to meet these requirements. It allows the fabrication of efficient and powerful actuators for switches, attenuators or filters as well as the realization of extremely precise alignment structures for optical components.

Fig. 1 shows the preferred etching shapes that are realized by wet anisotropic etching. On (100)-silicon, V-grooves, but also diamond-shaped channels and cantilevers are realized. Additionally, diagonal channels trough the wafer are possible. (110)-silicon is preferentially used for any type of parallel-plate configuration as required for electrostatic actuation. Improvements in KOH etching allow to fabricate diamond-shaped channels with tolerances as small as 0.15 µm and homogenous deep trenches in (110)-silicon with an aspect ratio of >75:1 (3-µm wide, 230-µm deep).

Typical applications are optical moving-fiber switches ([2], Fig. 2) and mirror-type switches [3] with large deflections that make use of the absence of plasticity in silicon at room temperature. New fiber alignment structures such as the diamond-shaped channels (Fig. 3, 4) that can be found in various directions within the crystal lattice allow the integration of more functionalities on a single silicon substrate.

[1] D. Bishop, R. Giles, V. Aksyuk, "Little machines make it big", OE Magazin May 2001, http://oemagazine.com/fromTheMagazine/may01/mems.html

[2] M. Hoffmann, D. Nüsse, E. Voges, „*An electrostatically actuated 1x2 moving-fibre switch*", accepted for IEEE Photonics Technology Letters, January 2003 issue

[3] M. Hoffmann, D. Nüsse, E. Voges, „*Bulk silicon micromachined electrostatic microactuators for use in optical MEMS*" Conference Proceedings: Actuator 2002, Bremen, Germany, 2002, 304-307

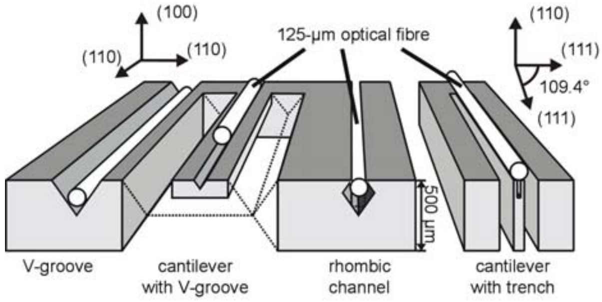

Fig. 1: Preferred wet anisotropic etching shapes in silicon

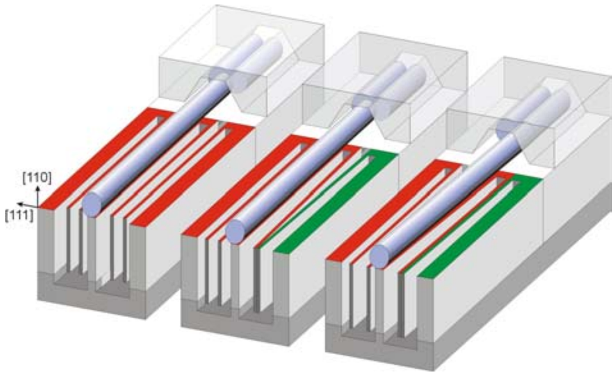

Fig. 2: Electrostatic moving-fiber switch based on (110)Si

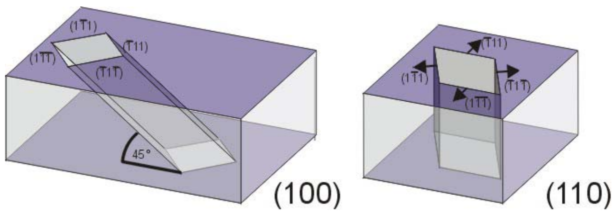

Fig. 3: Diamond-shaped channels in silicon: diagonal channels in (100)-Si, vertical channels in (110)-Si

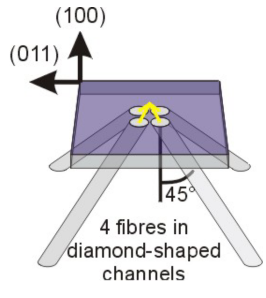

Fig. 4: Arrangement of four diagonal channels for through-the-wafer fiber supplies