FEMTOSECOND LASER IRRADIATION FOLLOWED BY CHEMICAL ETCHING - VERSATILE METHOD FOR FABRICATION OF INNOVATIVE 3D STRUCTURES IN GLASS MATERIALS

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The glass materials are widely used in the microsystems technology due to attractive combination of their excellent physical and chemical properties, long-term stability, close CTE match to Si, and relatively low cost of high quality substrates. Various applications take advantage of their remarkable optical transmission (MOEMS, gas microcells for time-frequency devices), natural hydrophilicity and biocompatibility (Lab-on-chip, Bio-MEMS), good electrical insulation (micro-sensors) or high thermal/chemical resistance (microreactors). However, the micromachining of glass is challenging because of its high hardness and brittleness as well as easy crack formation. Great effort has been made to develop new laser-based methods, capable of overcoming these technological challenges for new emerging applications, such as microrobotics for minimally invasive surgery [1], where small structures with 3D complex geometries need to be fabricated.

The subtractive machining by femtosecond laser irradiation followed by chemical etching (FLICE) is one of the recently developed hybrid methods that has proved to be a powerful tool for 3D glass micromachining [2,3]. The FLICE process relies on the local and permanent modification of glass caused by high-energy focused laser beam irradiation (Fig.1a). At specific set of process parameters, high increase of etch rate of irradiated glass (typ. x200) may be observed in standard etchant (HF, KOH). Depending on writing objective, complex high aspect (AR>40) structures may be obtained with high spatial resolution (typ. 1.5µm in XY plane, 8-40µm in Z-axis) and in relatively thick glass layers, up to few millimeters. In this work, a great potential of FLICE method will be demonstrated on the example of various devices, fabricated in different glass materials (Fig. 1b-e). Characteristic features of FLICE machining and some process limitations will be also presented.

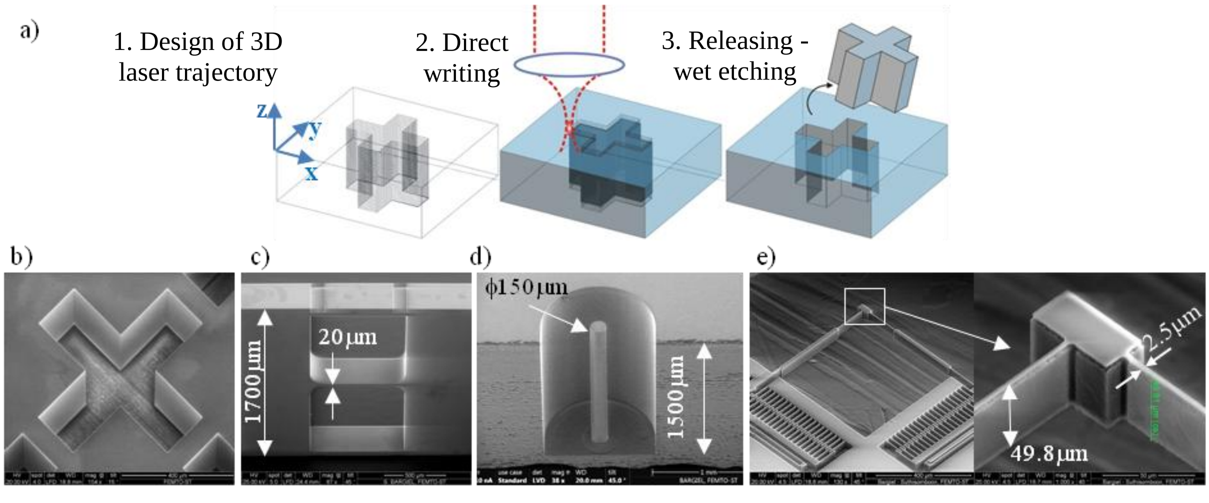

Figure 1. Main fabrication steps of the FLICE method (a) and some examples of microstructures: 15µm-thick membrane at the bottom of 500µm substrate (b), flexible part of glass microgripper with 20µm-thick central spring (c), 1500µm high glass rod with diameter of 150µm (d), transparent platform with high aspect ratio suspensions (AR=20) to be driven by comb-drive actuators.

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