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B. Keiper, R. Ebert, H. Exner

Microstructuring of PYREX glass by excimer laser

Due to its anodic bondability to silicon Pyrex glass is an interesting material for many applications in the field of microsystems technology. The possibility of microstructuring of Pyrex glass using laser technologies will enlarge the number of potential applications considerably.

Small channel structures in glasses or polymers are needed for micro fluidic applications (i.e. Lab-on-Chip). Via small holes in the glass liquids can be supplied into the fluidic structures. We investigated the structuring of Pyrex glass to acquire the knowledge for the realisation of the required devices.

In our investigations we have used an ArF excimer laser workstation with an ExciStar S-500 (TUILASER AG) and a LightBench System (ATL Lasertechnik GmbH).

We investigated the dependence of the properties of micro channels in Pyrex glass on the laser processing parameters. In our experiments we varied the pulse distance from 1.5 to 3 µm and the laser fluence from 2.5 to 5.5 J/cm^2. We observed a strong dependence of the surface quality on the laser fluence and on the pulse distance. The roughness of the basement of the channels (single processed) was very small (Ra= 35…150 nm). Using low laser fluences (4.8 J/cm^2 and below) and high pulse distances (3 µm) the surface is very smooth only with a certain waviness due to the pulse distance. With decreasing pulse distance and increasing laser fluence we can observe inside the smooth channel a number of isles with a micro roughness. At high laser fluences (5.5 J/cm^2 and above) the whole channel shows this micro roughness. This behaviour can be used to adapt the surface properties to different requirements (i.e. adsorption properties, friction coefficient and wetting behaviour). The ablation rates vary between 150 nm/pulse (low laser fluences) and 250 nm/pulse. The ablated depth after single processing of the sample is about 5 µm (3 µm pulse distance and 3 J/cm^2). Deeper channels can be produced by repeated processing until the desired depth is reached. To generate larger cavities we processed a number of parallel lines with the same line spacing like the pulse distance.

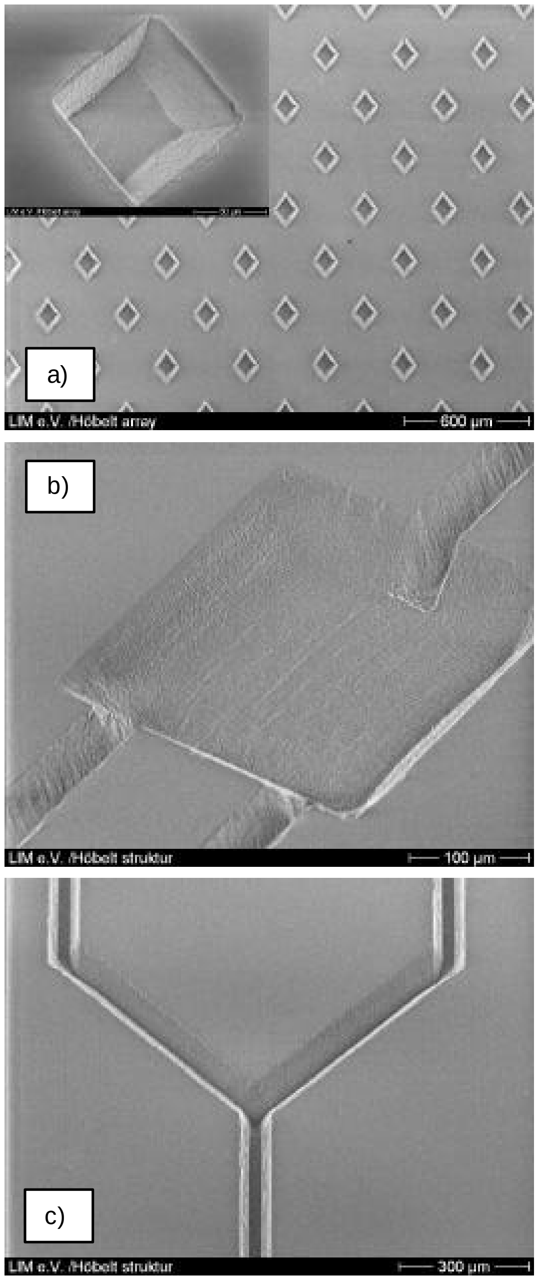
In the Fig. some examples of special structures, applicable in micro fluidics, diagnostics, analytics and kinetics, are displayed. The structures were generated using 4 J/cm^2 laser fluence and a 500 µm square mask (50 µm at the sample surface).

The array of micro wells (Fig.a) is generated using 250 laser pulses for every well. The depth of the wells amount to 50 µm. The distance between the wells is 300 µm.

The second example (Fig. b) represents a fluidic structure consisting of a cavity with three channels to supply respectively to drain liquids. The structure was generated using 2 µm pulse and line distance. The length and width of the cavity is 350 µm at the glass surface and 250 µm at the ground of the cavity. The cavity and the channels have a depth of 55 µm. The cavity is single processed and the channels have to be processed 25 times to get the same depth. The roughness of the base of the cavity is Ra=0.6 µm. This high roughness value compared to the results of the single processed channels is partly due to the larger depth of the structure but the chief cause is probably the use of laser parameters suboptimal for achievement of a smooth surface.

The third example (Fig. c) is a flow system, applicable in fluidics. The pulse distance was 2µm. The structure was processed with 24 repetitions to obtain a depth of 50 µm. The diagonally running lines have a V-shaped profile due to the diagonal shift of the sample relative to the square mask.

Holes with Diameters from 30 to 200 µm were drilled in 500 µm thick Pyrex wafers applying laser fluences from 3 to 15 J/cm^2.



SEM-views of Laser generated structures in Pyrex glass: a) Array of micro wells with 50 µm edge length and depth of the wells; b) cavity 350 x 350 x 55 µm^3; channels: 50 µm width, 55 µm depth; c) flow system with channels: 50 µm width, 50 µm depth; V-profile due to the 45° shift relative to the square mask.

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Contact: Dr. B. Keiper
Laserinstitut Mittelsachsen e.V. an der Hochschule Mittweida (FH),
Technikumplatz 17, D-09648 Mittweida
Tel.:03727 613345 / Fax:03727 613346
e-mail: keiper@htwm.de