FORMATION OF MICROLENSES ON FUSED SILICA‘S SURFACE BY EMTOSECOND LASER PULSES

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It is possible to form micro lenses on fused silica’s surface by using femtosecond laser pulses, which can be used in fiber optics. Such formation of lenses is based on fabricating nanogratings modifications in transparent material and material elimination of modificated areas [1]. For making lenses it is necessary to reach quite good roughness, so they are etching in HF acid.

To define roughness the structures with different marking parameters, with 110 µm focusing depth, are fabricated in fused silica. Energy must be selected so that the sample through the entire depth of the structure could be made from nanogratings [2]. Fabricated structures are etched in HF 10% acid for 30 minutes, then the etching depth and the roughness are measured with profilometer. In the last step the structure is melted by hot concentrated flame and measured again to compare differences of the structure shape and roughness.

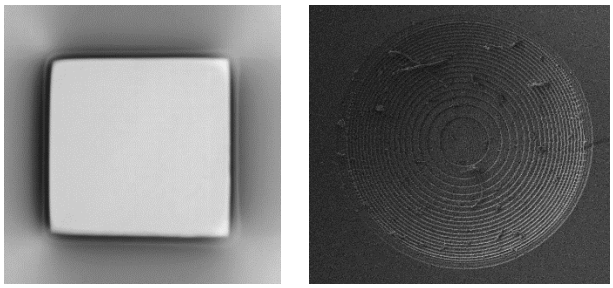
Using the results obtained before, spherical lenses on fused silica‘s surface is formed with radius of 1 mm and depth of 100 µm. Such formation of lens is based on concentric circles with different radius fabrication, except the circles are hatched with lines. After the fabrication the sample is etched in acid. Later the sample is measured with a profilometer and melted with hot flame. In the results the radiuses and focal lengths of lenses are calculated by formula:

$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2}\right]. \quad (1)$$

Micro lenses array is made from 7 lenses. Here lenses are formed so that after reaching 100 µm all circles are touching themselves forming one common area. The sample is also etched in acid and melted with flame. Such type of sample is characterized by certain wavelength because the area is wide enough for laser beam radius.

Tab 1. Parameters of structure.

Focusing depth, µm	*f*, kHz	*E*, nJ
100	500	100–150
Pulse density, mm/s	*dy*, µm	*dz*, µm
500-2000	1-5	5



a) b)

Fig. 1. a) The view of square structure from its bottom, after 60 min of etching and 2 second of melting. b) The view of spherical lens after etching and melting. (E = 200 nJ, dy = 2,5 µm, v = 5 mm/s).

Tab. 2. Spherical lenses radiuses and focal leghts after last machining.

Nr.	1	2	3	4
R (mm)	1,08	1,05	1,12	1,07
F (mm)	2,34	2,29	2,44	2,31

- The best surface roughness after etching is reached with 1000 imp/µm and distance of 2,5 µm between lines.
- In order to repeat the same micro lenses, melting should be more stable.
- In comparison of radius before and after last machining the result is 10% error.

[1] C. A. Ross, D. G. MacLachlan, D. Choudhury, R. R. Thomson, Optimization of ultrafast laser assisted etching in fused silica, Optics Express, **26**(19), 2018.
[2] V. Stankevič, *Formation and characterization of micro-opto-mechanical 3D devices for sensor application in transparent materials* (Doctoral dissertation, Technology Science, Material Engineering (08T), Vilnius, 2017.