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Generation of optical quality structured surfaces on borosilicate glass using 515nm picosecond laser pulses and a liquid-crystal-based spatial light modulator

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Introduction

Liquid-crystal-based spatial light modulators (LC-SLMs) are electrically programmable devices which allow us to modulate the phase and amplitude of the linear-polarised light. The high spatial resolution of LC-SLMs (typically more than 0.5 megapixels) coupled with their relatively high optical damage threshold and ease of programming mean that these devices have started to be used with commercially-available short-pulsed lasers to generate complex beam shapes for parallel processing of bulk metals and thin metal films.

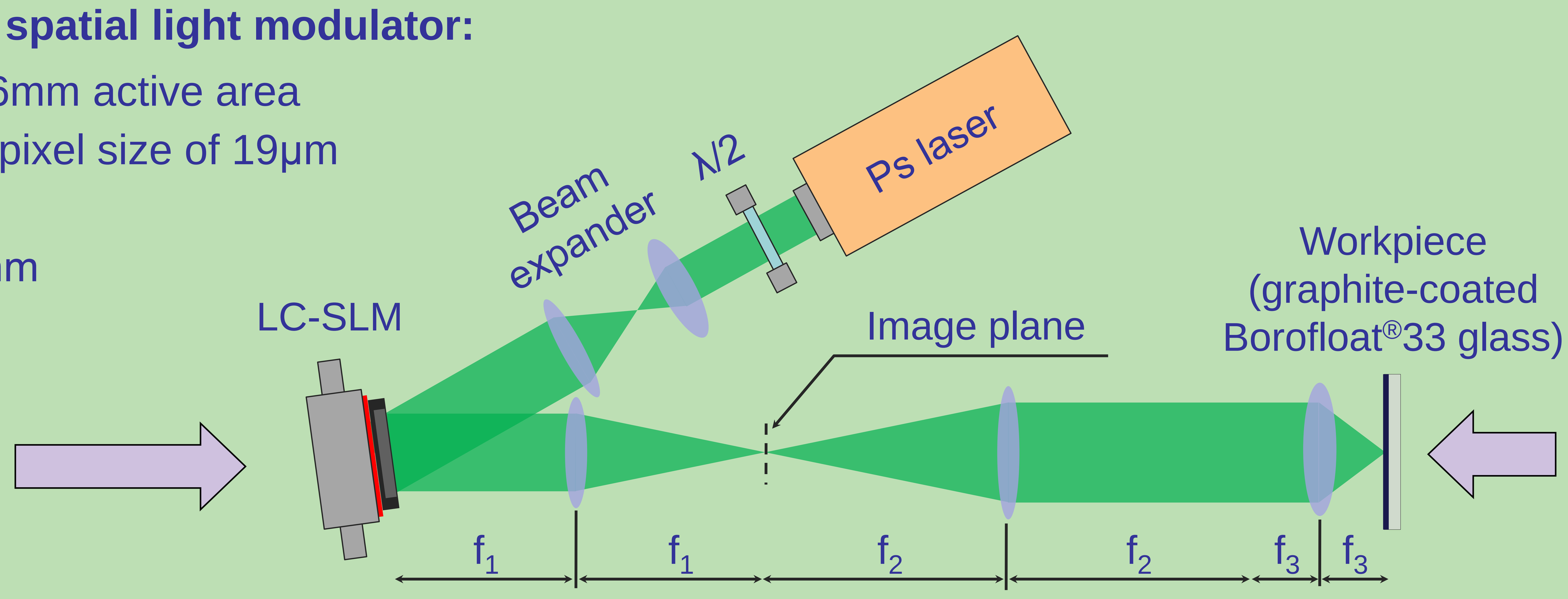
This poster presents work in which a LC-SLM operating in the visible spectral region is used for shaping the surface of optical glass (Borofloat®33 from Schott AG). The aim of this research is to produce structures with the optical quality on the glass surface, so that they can be used, for instance, as optical components. In this work, picosecond laser pulses at λ = 515nm are delivered to the SLM display in order to produce surface deformations whose contour corresponds to the SLM-generated image. Since glass is normally transparent at the wavelength of 515nm, the workpiece is coated with a thin layer of graphite prior to laser treatment in order to enhance laser-beam interaction with this material and obtain localised melting of its surface.

Experimental setup

Key properties of LC-R 2500 Holoeye spatial light modulator:

- reflective device with a 19.5mm x 14.6mm active area
- resolution: 1024 x 768 pixels with the pixel size of 19µm
- fill factor: 93%; frame rate: 75Hz
- 2π phase shift between 400 and 700nm

SLM display attached to a copper mount



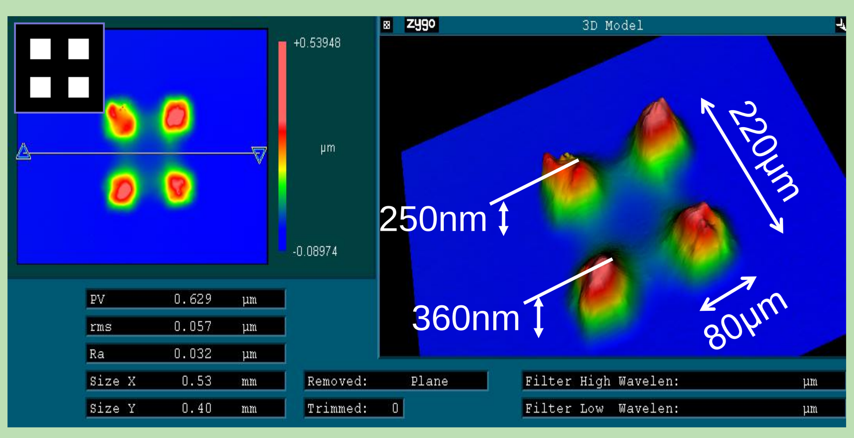
Results

Mechanisms involved in the formation of surface deformations in Borofloat®33 glass

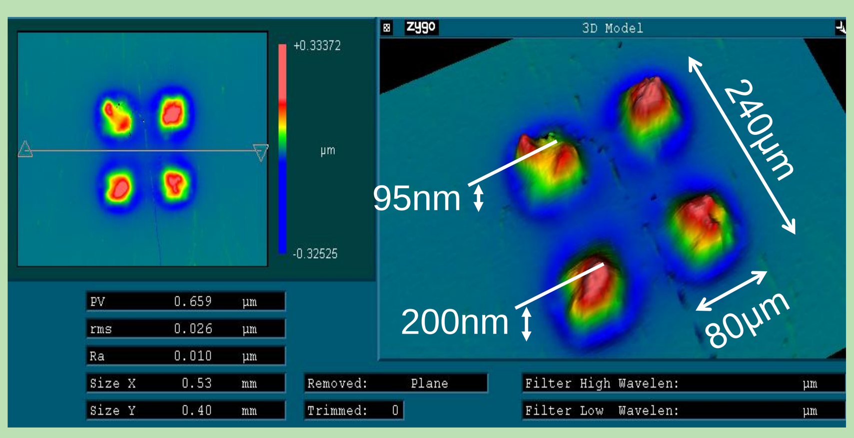
Experimental protocol:

- SLM generates an image containing four equal squares
- Exposure time of the SLM display: 13.33ms train of 6ps laser pulses (using a pulse rep-rate of 400kHz)
- Average output laser power: P = 3.4W
- After laser treatment, the remaining layer of graphite was removed and the sample was annealed for one hour at 560°C.

Before annealing



After annealing



Square-shaped bumps have been produced by:

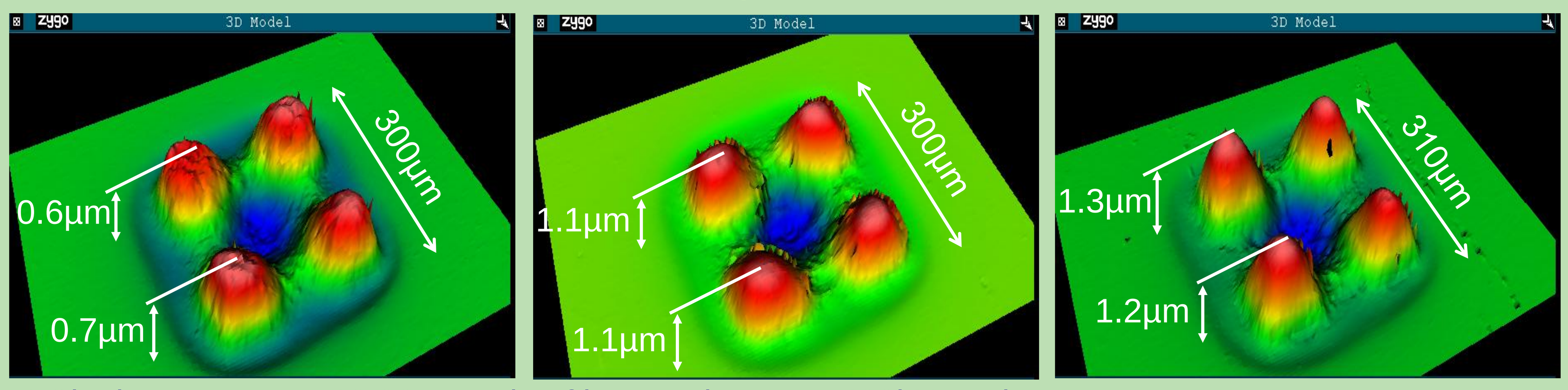
- ***Marangoni effect*** that caused flow of the melt towards the hottest sites
- ***An increase of fictive temperature*** that caused a local increase of the glass volume within the laser-irradiated area.

Influence of the laser exposure time and laser power on the shape of SLM-generated surface features

Experimental protocol:

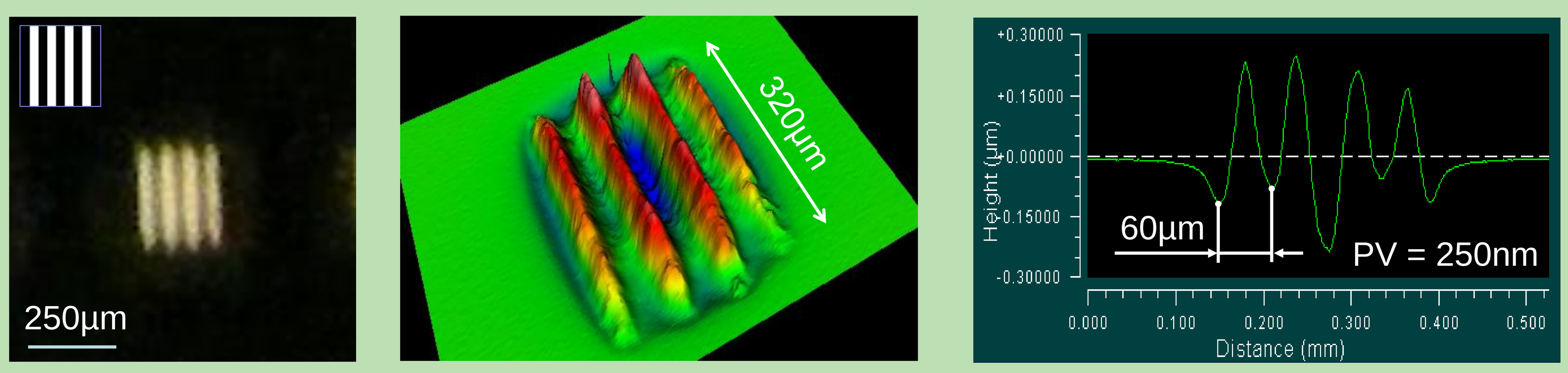
- Average output laser power was increased to 6.5W
- In case of multiple laser exposure, the speckle reduction technique was applied
- Surface profiles were taken after annealing.

*Single exposure** *4 exposures* *16 exposures*



* Single exposure = 13.33ms train of laser pulses at a 400kHz pulse rep-rate

Sinusoidal grating produced by the SLM and picosecond laser pulses



Summary

A novel technique for flexible shaping the glass surface has been presented. Using picosecond laser pulses and a LC-SLM, we are able to produce bumps which cannot be obtained simply by a focused Gaussian laser beam. We believe that this process may be used to fabricate optical components, such as micro-lens arrays and sinusoidal gratings.

Acknowledgments

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