Shaping the surface of optical glasses with 10-ps laser pulses and adaptive optics

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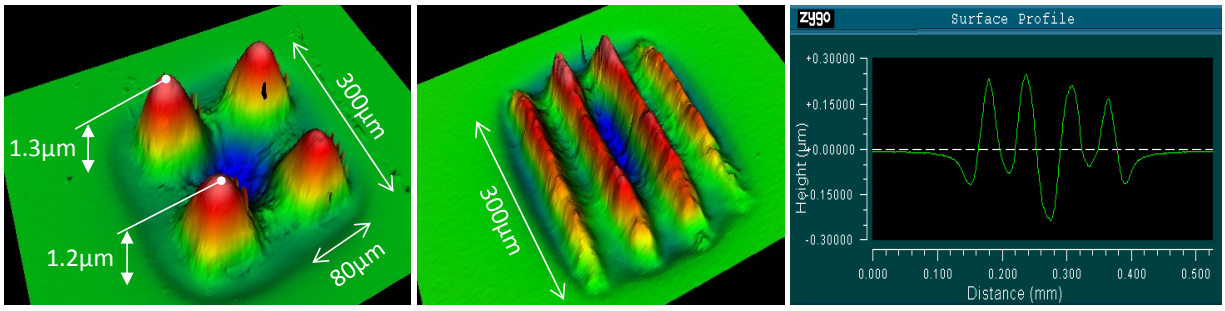
Adaptive optics (AO) is a technology which is widely used in astronomy [1]. AO is used to improve the performance of optical systems by reducing the effect of wavefront distortions which are induced by optical aberrations and atmospheric turbulences. In recent years, low-cost AO devices have also been applied to high-precision laser machining applications, e.g., parallel laser surface micro-structuring [2], beam shaping [3], and laser marking of metal surfaces [4]. AO devices include piezo-electric deformable mirrors, liquid crystal spatial light modulators (SLM), and electro-static membrane devices.

In this paper, we present an application of an SLM (model LC-R 2500 manufactured by Holoeye Photonics AG, Germany) for shaping the surface of optical glasses (e.g. Borofloat®33 glass). Different patterns, such as those shown in Figure 1, can be generated from the demagnification of the image produced by the SLM. For this purpose, we use a 6-f optical system. In order to enhance absorption of the glass at a 532 nm laser wavelength, the surface of the workpiece is coated with graphite prior to laser treatment. This solution allows a high temperature to be generated at the glass surface, even though this material is normally transparent at this wavelength. Advantages, disadvantages, and limitations of this approach are investigated in the work presented in this paper.

Generally, the structures produced at the graphite-coated glass surface are generated by two mechanisms: (i) the Marangoni effect and (ii) an increase of fictive temperature, both of which can occur within the laser-irradiated area. These mechanisms are investigated in detail in this paper. Potential applications of the structures generated by the SLM are also presented.



(a) (b) (c)

Figure 1 : (a) Square-shaped bumps and (b) sinusoidal grating produced on the surface of Borofloat®33 glass using 10ps laser pulses and the SLM. Cross-section of the grating is shown in (c). Profiles were measured after annealing of the glass.

To generate the patterns shown in Figure 1 (a) and (b), the graphite-coated glass was treated, respectively, by 16 and 4 trains of 10-ps laser pulses at a 400 kHz rep-rate and a 6.6 W average laser power. The duration of each train was chosen to be 13.33 ms. To eliminate the undiffracted zero order beam from the target, a thin metal wire was placed at the Fourier plane before the image (i.e. 2f after the SLM). Following the laser treatment, the residual graphite was removed from the surface using isopropanol, and finally the glass was annealed for one hour at a temperature of 560°C.

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