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LAIDLAW SCHOLARS

Molding of 3D micro/nano scale glass structures with PDMS

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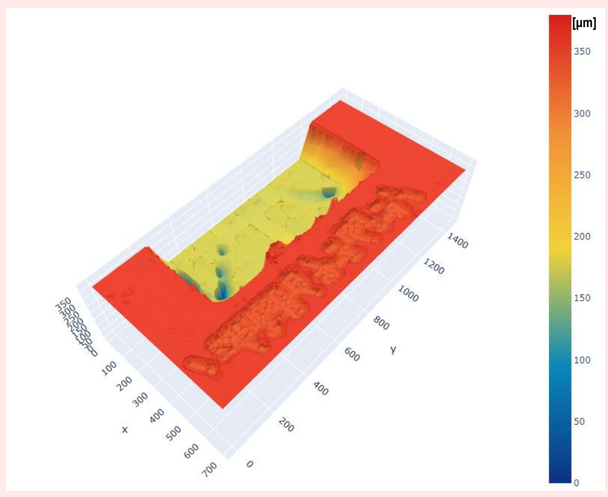
Introduction

- PDMS molding of in-glass laser inscribed micro and nano structures offers great potential for fabrication and characterization. However, this technique has challenges, such as:
    - Strong adhesion between the mold and the polymer
    - PDMS structural relaxation due to intrinsic stresses
- The goal of this project is to test these limitations and develop a protocol to overcome them.

Methodology

1. Characterization:

- It's very important to characterize the samples before molding, because:
    - It could be damaged during or after the molding
    - Some PDMS residues may stick to the mold
- Characterization involves measuring key features of a sample using optical and confocal microscopes.



Example of 3D image created using a confocal microscope

2. Molding step:

- The PDMS Sylgard 184 elastomer kit is mixed at a 10:1 ratio, poured onto the sample, degassed, cured at 90°C for 2 hours, and then cooled at room temperature for at least 2 hours before unmolding.

3. Examination step:

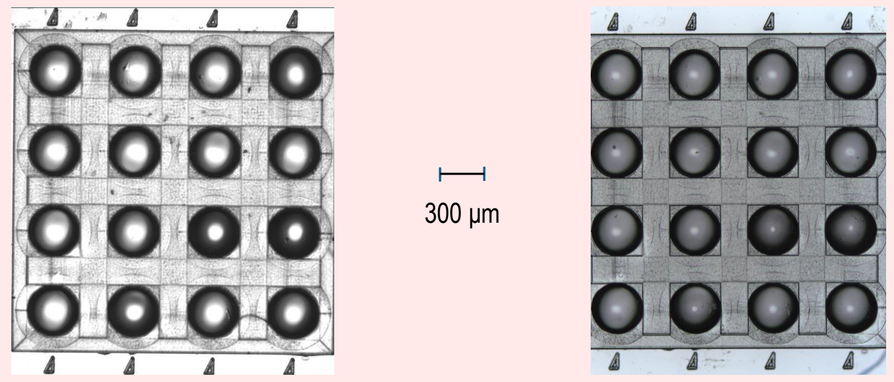
- PDMS molded parts are compared to their mold using the same tools as the characterization step.

References

- Madani-Grasset, Frédéric, et Yves Bellouard. « Femtosecond Laser Micromachining of Fused Silica Molds ». *Optics Express* 18, nº 21 (11 octobre 2010): 21826-40. https://doi.org/10.1364/OE.18.021826.
- Schaap, Allison, et Yves Bellouard. « Molding Topologically-Complex 3D Polymer Microstructures from Femtosecond Laser Machined Glass ». *Optical Materials Express* 3, no 9 (1 septembre 2013): 1428-37. https://doi.org/10.1364/OME.3.001428.

Results

1. Macro-Molding (100-300 µm features)

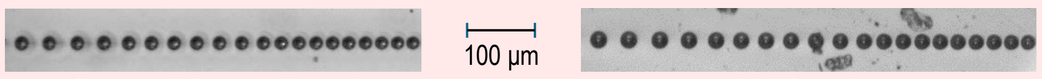


Fused Silica mold — *PDMS molding (reversed image)*

- Based on the 3D images of the lenses, the molding appears slightly elongated (2-3% of the initial height), which is compensated by a slight reduction in diameter.

Profile comparison reversed mold / PDMS molding

2. Micro-Molding (1-50 µm features)



Glass mold (reversed image) — *PDMS molding*

- These points were created using the ablation process, which resulted in a rough surface that could potentially tear the PDMS. To address this, after molding, the glass samples were placed in a Rhodamine B solution to dye any remaining PDMS residues without affecting the mold itself.

Rhodamine B dyed glass mold with PDMS residues under a fluorescence microscope

- The molding process has some limitations when dealing with small and rough features, as it tends to leave behind PDMS residues (fluorescent dots).

Conclusion

- The PDMS molding process produced promising results, although it exhibited slight structural relaxations and left some residues when handling rough features.

Future direction:

- Design "limitation testing" mold to precisely quantify the observed limitations, enabling the molding of nanoscale features.
- Coat fused silica samples with a nanometer-thick adsorbed PDMS monolayer, to reduce the adhesion between the mold and the molding.