Nanonuggets – Tips and tricks for the Nanoscribe printing

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(1) Mechanical stability

We found that the drying process is critical to the final mechanical stability. The last liquid to be dry in the standard drying process is IPA (to remove SU8 developer). During IPA drying, the surface tension created by the solvent could potentially collapse the delicate structure. To deal with this issue, we implement two approaches to minimize the structural deformation during drying.

The first approach is using HFE7100, or hydrofluroether, for drying. HFE consists of some complex cleaning solvent that does not occur naturally in the environment. However, with the advantage of the very low surface tension of HFE solvent, metalens can avoid collapsing and preserve their structural integrity. The second approach is using a critical point dryer to remove IPA. It eliminates surface tension associated with liquid drying by avoiding the phase transition boundary from liquid to gas. In Figure 1, we demonstrate the effect of using HFE as a rinse solvent to preserve an overhanging structure for microlens from collapsing.

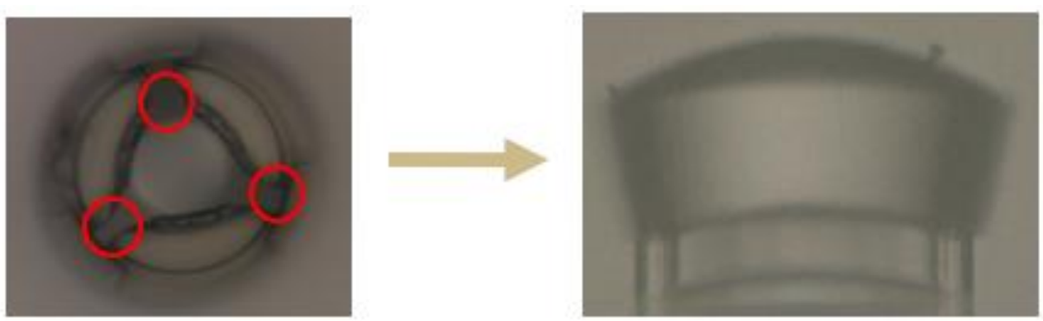

Figure 1. The less tension drying methods improve the mechanical stability of the overhanging structures.

(2) Bubble reduction

Our first few trials of two-photon lithography often generated random bubbles in the writing process. Those bubbles formed randomly and affected the reproducibility of the writing. By preheating the IP-S resin on a hotplate under 60 degrees for 20 min, we significantly reduced the bubbling formation and strongly increased the writing repeatability (Figure 2).

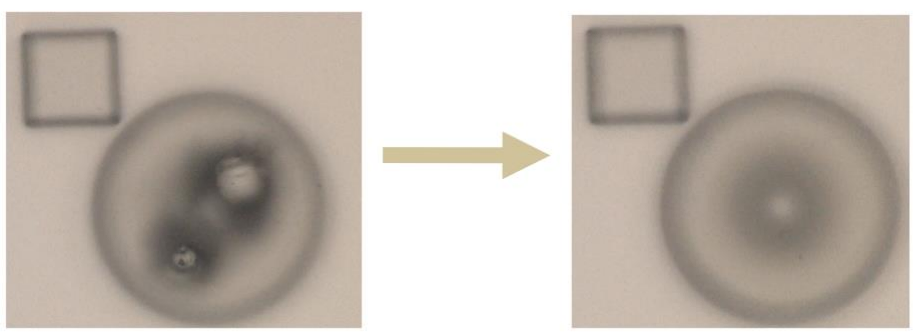

Figure 2. Preheat is a useful tip to reduce bubble formation in writing.

(3) Writing overhanging structures

In order to print microlens with better image quality, we aim to print doublet lens as our final target. However, the doublet lens has an overhanging structure, potentially leading to writing failure (Figure 3). The image on the left demonstrates the off-center issue after printing for the overhanging structures.

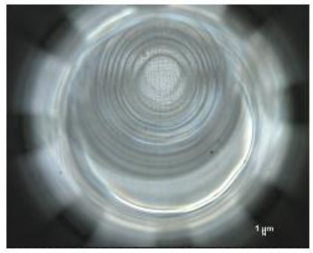

Figure 3. Off-center printing issue for a overhanging structures.

When the overhanging structure is printed in a regular +Z manner, the part of the lens facing down is floating without being connected with any existing structure. This structure disconnection causes the off-center problem. (Figure 4)

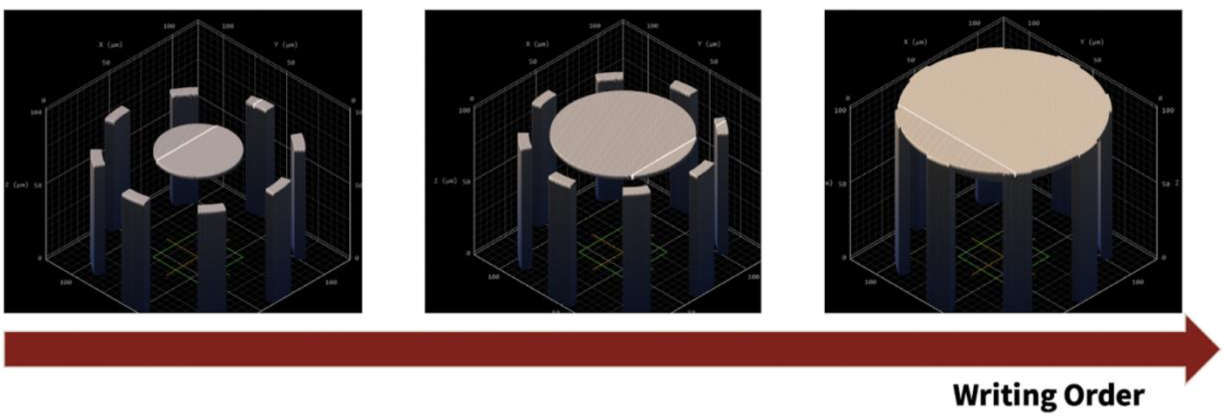

Figure 4. An illustration of explaining why normal writing order cause off-center issue for the overhanging structures.

In order to deal with this problem, we devise a small trick in Describe to prevent flying structures during printing. We generated two different GWL codes from two STL files for the supporting rod and lens and inserted a z movement in between. We also set the writing direction differently so the two structures can be connected during the writing.

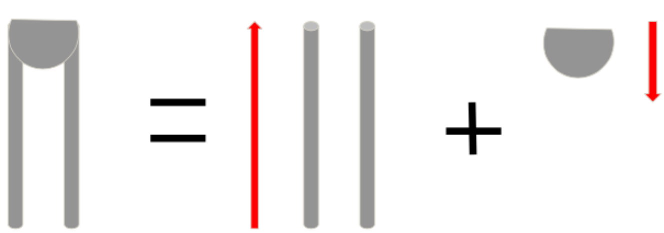

Figure 5. An illustration of writing direction strategy for a overhanging structure.

After applying this writing strategies, the off-center issue for the overhanging structures can be resolved quite nicely.

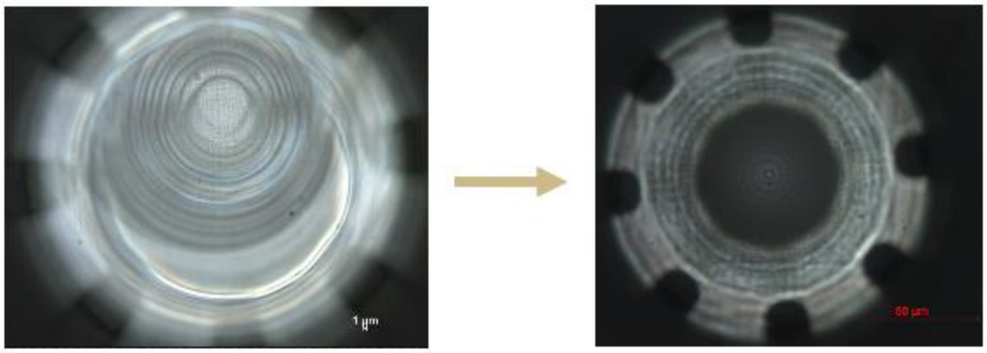

Figure 6. An off-center issue could be avoided by combine two GWL files with a different writing direction.

(4) Simple GWL coding

In this section, we want to demonstrate how to write a 2D pattern on the surface using Nanoscribe by programming the GWL. We use Stanford Logo and ENGR241 to show how we program the GWL code to achieve that.

We write Logo "S" and Logo "tree" separately by simply assigning vertices of the pattern. The Laser power of 55% and ScanSpeed 1000um/s are suggested settings from the Nanoscribe company, but a dose matrix could further optimize these values.

For the Text part, describe has a shortcut to generate that. By simply assigning several parameters such as font and line spacing, the text could be generated nicely.

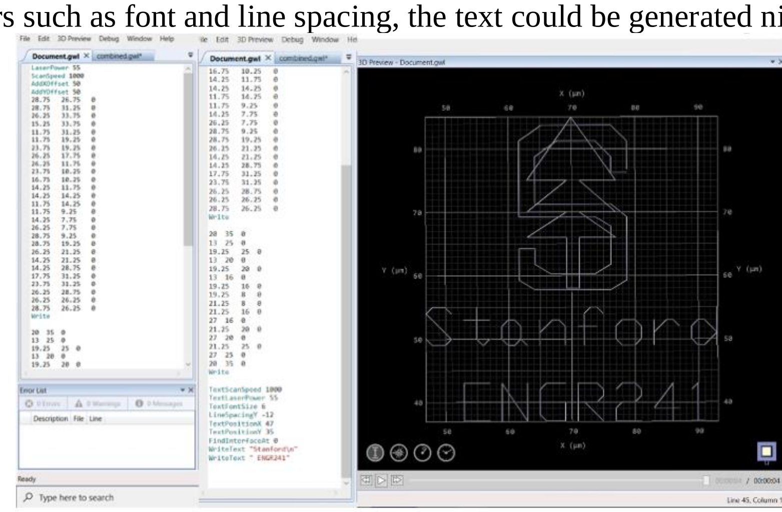

Figure 7. An example of using a simple GWL code to draw a Stanford Logo.