High Aspect Ratio Glass Microstructures by Laser Induced Etching

Jessica J. Cheng, Hinesh Patel, Elliot E. Hui

***Abstract*— Laser Induced Deep Etching (LIDE®)[1], developed by LPKF, is a maskless laser processing method capable of patterning glass microstructures similar to microfluidics created by PDMS soft lithography. Here, we demonstrate a self-digitized droplet microfluidics chip with high aspect-ratio features and fine resolution via the LIDE® technology. LIDE® provides the means to translate microfluidic designs into glass in a process suitable for low-cost and high-volume manufacturing.**

***Clinical Relevance*— LIDE® allows a variety of microfluidic devices to be manufactured in glass, providing advantages such as optical clarity, low autofluorescence, chemical compatibility, and temperature stability. These material properties are ideal for a variety of assays including PCR thermocycling with fluorescence readout.**

I. INTRODUCTION

Polydimethylsiloxane (PDMS) is widely employed for microfluidics, but the high permeability to gas, liquids, and small molecules may be problematic in some applications[2]. Thermoplastics are a common alternative but can present autofluorescence or chemical compatibility challenges.

Glass is optically, chemically, and thermally ideal in many situations but microfabrication of glass is much more challenging. Photolithography with isotropic wet etching can only create low aspect ratio structures. Bosch-process deep trench etching can be used to achieve high aspect ratio structures, but the process is slow and expensive, especially if deeper structures are required. Laser ablation is another common approach to glass micropatterning, but this process is lower resolution and susceptible to defects and cracks being generated along feature boundaries.

Laser Induced Deep Etching (LIDE®) achieves deep, high-aspect-ratio structures in glass similar to what can be obtained through SU-8 soft lithography. LIDE® employs laser pulses to modify regions of glass. Subsequent hydrofluoric acid etching selectively removes the modified regions.

II. METHODS

A self-digitized droplet microfluidics chip[2] was fabricated by LPKF in the commercially available LIDE® process. Device dimensions were characterized by white light interferometry (Keyence) as well as scanning electron microscopy (SEM). Food coloring was pipetted onto the inlets of the chip, followed by paraffin oil. Negative pressure was then applied at the outlets to fill channels and wells, then flush channels with oil, creating 60 nL volumes.

III. RESULTS

A 25-well array (*Fig. 1*) was fabricated in borosilicate glass with features reproduced with high accuracy (SD ~2 µm) (*Fig. 2*). 100% droplet digitization was successfully demonstrated on the device, where liquids are dyed in blue and oil stained in red (*Fig. 3*). The single layer was then placed under 95°C for 10 minutes to test for any evaporation effects, and no visible evaporation was observed *(Fig. 4*) compared to significant amount of evaporation in non-glass chips (*Fig. 5&6).*

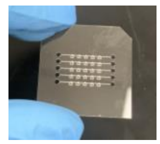

Fig 1. Glass microfluidics fabricated by LIDE®

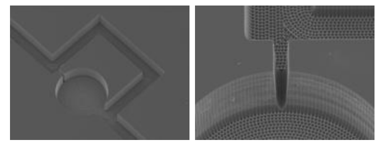

Figure 2. SEM image of channel features

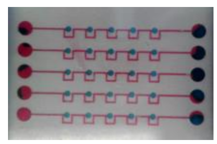

Figure 3. 5x5 self-digitized glass array before heating

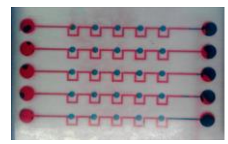

Figure 4. 5x5 glass array after heating

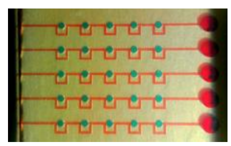

Figure 5. 5x5 self-digitized non-glass array before heating

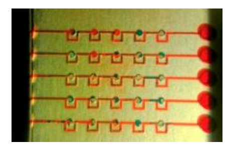

Figure 6. 5x5 non-glass *array after heating*

IV. DISCUSSION & CONCLUSION

The system requires a plug channel that is 40 um wide and 200 um deep, a 1:5 aspect ratio that would be impossible to create with wet etching. This feature is critical to the self-digitization function, and thus we demonstrate successful glass fabrication of a high-precision microfluidics device.

ACKNOWLEDGMENT

The authors would like to acknowledge support from the “PFI-TT: High-Throughput Plant Genetics Platform” by the National Science Foundation (NSF award number IIP-2016564), and the National Science Foundation and the industrial members of the Center for Advanced Design and Manufacturing of Integrated Microfluidics (NSF I/UCRC award number IIP-1362165 & IIP-1841509)

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*Research supported by the National Science Foundation and Center for Advanced Design and Manufacturing of Integrated Microfluidics

Jessica J. Cheng is with Department of Biomedical Engineering, University of California, Irvine, CA 92697 USA, and Center for Advanced Design and Manufacturing of Integrated Microfluidics, University of California, Irvine, CA 92697 USA, phone: 949-824-4308; e-mail: jiangnic@uci.edu