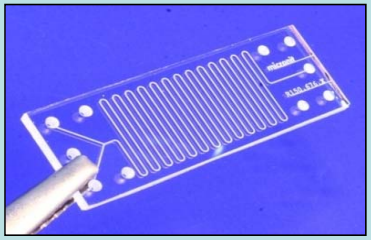
Exploration of Low-Cost Implementation of Reactive Systems in Microreactors

Elsie Deland, Kari Varin, and Derek Weber
School of Chemical, Biological, and Environmental Engineering, Oregon State University

What Are Microreactors?

A device that contains micro-sized channels where chemical reactions take place


[3]

Why Use Microreactors?

- High heat and mass transfer rates
- Easy scale up using multiple identical reactors
- Increase reaction yields
- Improve process safety

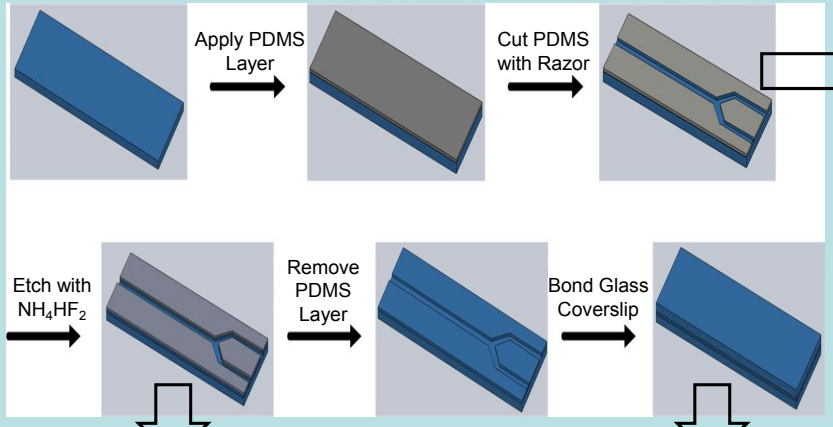
Motivation

- Microreactors can be made using many different substrate materials including metals, glass, silicon, and polymers
- Channels are mechanically or chemically etched into the substrate using lasers, mechanical tools, or acids and bases
- Traditional materials and methods often require the use of a clean room and expensive equipment
- Low-cost methods of manufacturing microrectors are needed to expand research in smaller universities and the classroom

Objective

Develop a low-cost method for producing microreactors on glass microscope slides using wet chemical etching for use in smaller universities

Process Overview

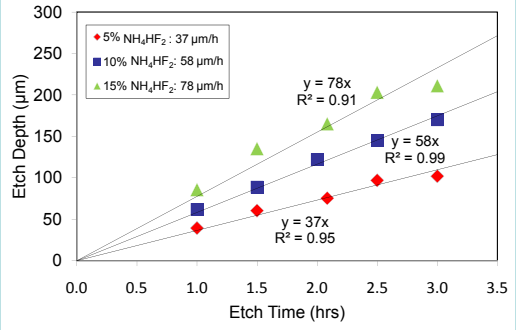


Wet Etching

- Creating microchannels via etching is preformed with NH_4HF_2 by the following chemical reaction[2]:

$$4(NH_4)HF_2 + SiO_2 \rightarrow SiF_4 + 4(NH_4)F + 2H_2O$$

- Target channel depth of 100 µm
- Linear relationship between etching depth and time

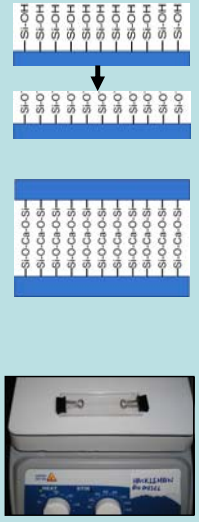


Glass-Glass Bonding[1]

Silanol groups on the surface of the glass are deprotonated with a basic solution

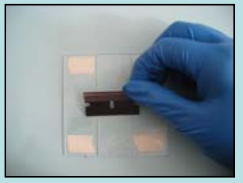
The glass surfaces are scrubbed with calcium acetate and placed within close proximity. The Ca^{2+} ions bond to the deprotonated silonal groups

The slides are clipped together and heated to evaporate the water in between them, which then creates the final bond



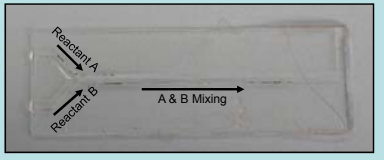
PDMS Patterning

Apply PDMS on glass slide



Place the PDMS-coated slide into the oven at 120°C for 10 minutes to cure

Cut PDMS with razor to form an etching guide



Cost Analysis

Product	Quantity	Price	Amount Used per Reactor	Price for 1 Microreactor
Glass Slides	72	$14.39	2	$0.40
NH_4HF_2	250 g	$54.70	5 g	$1.10
Sylgard 184	0.5 kg	$51.86	5.15 g	$0.53
Syringes	1	$0.16	2	$0.32
Epoxy Glue	25 mL	$4.69	1 mL	$0.20
0.5" OD Tubing	1 ft	$0.55	1.5 ft	$1.10
1/6" syringe tubing adaptors	1	$0.39	3	$1.17

Manufacturing Cost: $4.80 / microreactor

Path Forward

- Determine optimum UV dosage for SU-8 photoresist
- Investigate other glass-glass bonding methods
- Etching depth uniformity analysis
- Reproducibility of reaction inside microreactor

References

[1] Allen, Peter B. and Chiu, Daniel T. "Calcium-Assisted Glass-to-Glass Bonding for Fabrication of Glass Microfluidic Devices" *Analytical Chemistry*, Vol. 80, No. 18, 2008

[2] Jean Aigueperse, Paul Mollard, Didier Devilliers, Marius Chemla, Robert Faron, Renée Romano, Jean Pierre Cuer, "Fluorine Compounds, Inorganic" in Ullmann's Encyclopedia of Industrial Chemistry 2005 Wiley-VCH, Weinheim.

[3] Micronit Microfluidics. <http://www.micronit.com/Static/Images/UserUpload/232_microreactor_light.jpg>. 1 May 2009.

Acknowledgements

- Faculty Sponsor, Alex Yokochi, for the project introduction and general assistance.
- Dr. Phil Harding for providing the project assignments and guidance during weekly meetings
- Dr. Chien-Hua Chen, Hewlett Packard Expert-Level Engineer, for help on glass to glass bonding techniques.
- Dr. Alex Chang for use of a surface profilometer