《微纳光电子材料与器件工艺实验》
Laboratory of Micro- and Nanofabrication for Electronic and Photonic Devices

Lab 4 Microfluidic Devices（微流体器件）

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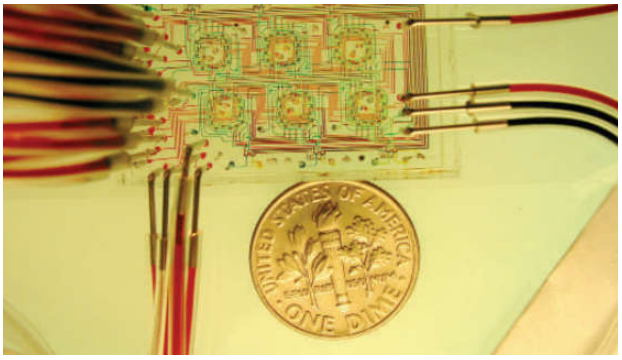
1. Objectives

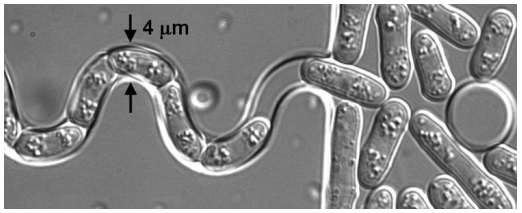
In this lab, we introduce the fabrication process of microfluidic devices. We will go through some basic steps of microfluidic device. Students will learn to prepare PDMS structures using patterned SU-8 molds, bond them with glass substrates to form microfluidic channels, and use them to observe the movements of PS microspheres in solvents.

2. Introduction

Microfluidics studies the flow of liquids inside micrometer-size channels. These micro channels allow us to exploit chemical reactions and biological process within a small amount of fluids. It offers fundamentally new capabilities in the control of concentrations of atoms, molecules, cells and tissues in space and time. Such 'Lab-on-a-Chip' based devices create potential applications in wide areas including chemical sensing, cell manipulation, diagnostics, etc.

A microfluidic chip is a set of micro-channels etched or molded into a material (glass, silicon or polymer such as PDMS, for PolyDimethylSiloxane). The micro-channels forming the microfluidic chip are connected together in order to achieve the desired features (mix, pump, sort, control bio-chemical environment). This network of micro-channels trapped into the microfluidic chip is connected to the outside by inputs and outputs pierced through the chip, as an interface between the macro- and micro-world.





An example of microfluidic channels with cells cultured inside.

3. Materials and Equipments

Poly-dimethylsiloxane (PDMS) kit (Dow Corning Sylgard 184) (> 400 g)
Silicone mold release spray
SU-8 molds with patterns (>5)
rubber toy molds (>5)
precleaned glass pieces 1*1 inch (>10)
alcohol (a full bottle)
DI water (a full bottle)
paper cups (>10)
plastic folks (>10)
glass petri dish, 6 inch (>2)
aluminum foil (>2)
gloves (>2 boxes)
face masks (>20)
cleanroom white papers (>1 bag)
dust blowers (>2)
tweezers (>5)
scissors (>2)
razor blade (>10)
syringes and needles (>10, needle diameter ~ 0.7 mm)
PDMS punchers (>10, inner diameter ~ 0.84 mm, outer diameter ~ 1.26 mm)
PTFE tube (>1m, inner diameter ~ 0.6 mm, outer diameter ~ 1.0 mm)
PS microsphere, diameter ~ 10 um in DI water (>1 bottle)
red ink
plastic pipette (>10)

Digital scale
Oven
hot plate
Vacuum desiccator
Vacuum pump
N_2 gas gun
chemical hood
UV Ozone cleaner
optical microscope

4. Procedures

PDMS preparation

- Use 3 paper cups, in each cup, weigh ~40 g PDMS pre-polymer + 4 g PDMS curing agent (10:1)
- Use plastic folks, mix vigorously for 5-10 minutes until milkwhite
- Put PDMS in vacuum chamber, turn on the pump, degas for ~ 30 minutes to remove bubbles

while waiting for degas:

- turn on the oven, set to 85 °C
- turn on N_2 gas gun
- clean SU-8 molds and glass substrates with alcohol, dry with N_2 gun, observe under microscope, bake on the hot plate at 110 °C for 10 mins

when PDMS degas is complete:

- Open the vacuum chamber, take out the PDMS cup, use dust blowers to remove the rest bubbles
- place SU-8 molds in glass petri dishes, pour PDMS mixture slowly in the dishes (PDMS thickness ~ 8 mm), degas in vacuum chamber for ~ 15 minutes
- spray some mold release agent on the toy molds, pour the rest PDMS inside
- place the dishes in 85 °C oven, cure for about 1 hour
- use razor blades to cut surrounding PDMS, slowly peel PDMS off from the SU-8 molds
- observe PDMS patterns under microscope

Microfluidic device

- cut the surrounding PDMS, make sure the patterned side is flat
- drill holes on the PDMS channels with punchers
- clean the surface of PDMS with scotch tapes
- treat the surfaces of PDMS and glasses with UV Ozone cleaner (~ 20 mins)
- carefully bond the PDMS with glass
- bake the samples on the hot plate at 110 °C for ~ 10 mins

Device test

- insert the PTFE tubes into the holes of PDMS
- use syringes to intake ~ 0.1 mL PS microsphere solution and ~ 1 mL red ink, shake and mix them
- drive the fluid into the micro channels with syringes
- observe the microfluid and microspheres under microscope

Lab cleanup

- turn off hot plate, oven, vacuum pump, N_2 gas
- dispose the trash, be careful about the needles and glass sharpies
- save the SU-8 molds and toy molds for future use

References

[1] G. M. Whitesides, The origins and the future of microfluidics, Nature, 442, 368 (2006).
[2] M. A. Lake, Microfluidic device design, fabrication, and testing protocols, Protocol Exchange (2015). http://dx.doi.org/10.1038/protex.2015.069
[3] http://www.elveflow.com/microfluidic-tutorials/