



## **Pore/Molecular-Scale Measurements**

### **MEASUREMENT OF CONDENSATION IN NANOFLUIDICS**

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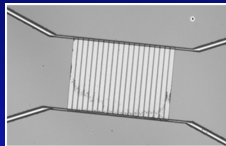
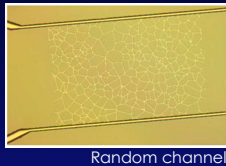
## **Outline**

- Nanochip profiling and inventory
- Nanochip preparation:
  - Chip cleaning
  - Chip bonding
  - Chip packaging
- Experimental setup and upgrade
- Research plan



## Nanochip Profiling and Inventory

### Silicon nanochip



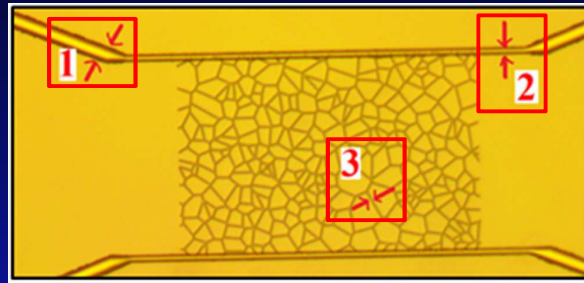
Parsa, E. (2017)

Inlet/outlet  
microchannel

1 Depth: 10  $\mu\text{m}$   
Width: 25  $\mu\text{m}$   
Length: 1.5 cm

Connecting  
microchannel

2 Depth: 10  $\mu\text{m}$   
Width: 12  $\mu\text{m}$   
Length: 800  $\mu\text{m}$



Parsa, E. (2017)

Nanochannel

3 Depth: 300 nm  
Width: 3  $\mu\text{m}$   
Length: random



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## Nanochip Profiling and Inventory (continued)

### Why chip profiling?

- Measures chip surface morphology
- Channel dimensions – width, depth
- Surface roughness

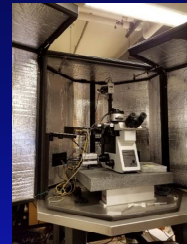
**Contact Profilometer**  
(nm - mm scale  
surface mapping)



Figure courtesy:  
LAAS, Toulouse, France

VS.

**Atomic Force  
Microscope (AFM)**  
( $\text{\AA}$ -scale surface  
mapping)



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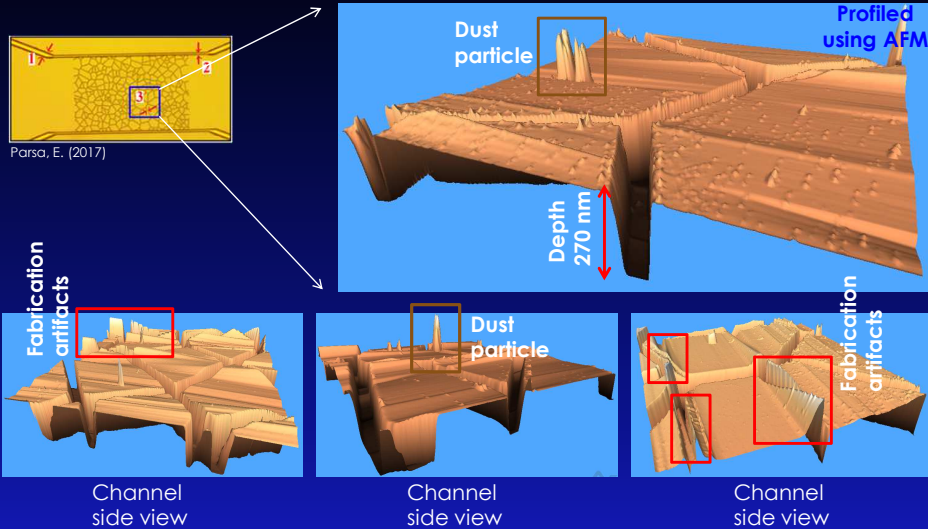


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## Nanochip Profiling and Inventory (continued)



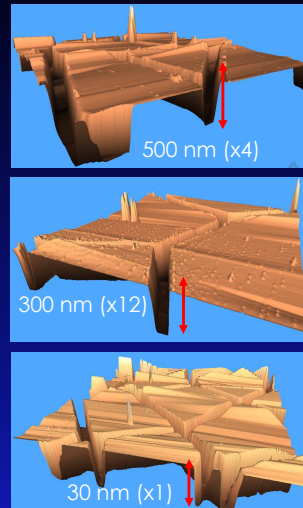
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## Nanochip Profiling and Inventory (continued)

### Nanochip Inventory

Chip number	Max. channel depth (nm)	Min. channel depth (nm)	Ave. channel depth (nm)	Remarks
1	300	250	270	AFM
2	335	297	316	Profilometer
3	356	310	333	Profilometer
4	283	339	311	Profilometer
5	294	356	325	Profilometer
6	23	45	34	Profilometer
7	NA	NA	NA	NA
8	NA	NA	NA (~ 500)	NA
9	NA	NA	NA (~ 500)	NA
10	26	41	32	Profilometer
11	283	294	288	Profilometer
12	264	297	280	Profilometer
13	283	293	288	Profilometer
14	204	295	250	Profilometer
15	283	291	287	Profilometer
16	NA	NA	NA (~ 500)	NA
17	NA	NA	NA (~ 500)	NA

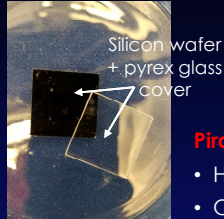


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## Nanochip Preparation - Cleaning

### Cleaning – Chip and Glass Cover Slip



#### Piranha solution

- $H_2SO_4 + H_2O_2$
- Organic decontamination



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#### Class 1000 clean room

- Clean room wash/dry
- Process optimization



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## Nanochip Preparation - Chip Bonding

### Anodic bonding apparatus

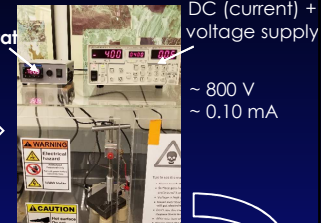


### Heating platform



### Thermostat

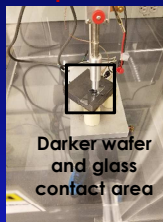
### Increase voltage + DC (current)



### Anodic bonding established



### Bonding taking place!



### Bonding taking place!



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## Nanochip Preparation - Chip Packaging

### Chip connection with flow lines



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## Experimental Setup and Upgrade

### Monitoring platform

- Optical microscope

### ISCO Syringe Pump

- Automated pressure control
- Accurate pressure data
- Digital inputs and outputs

### Data Acquisition (DAQ)

- Computerized pressure measurement
- Digital inputs and outputs

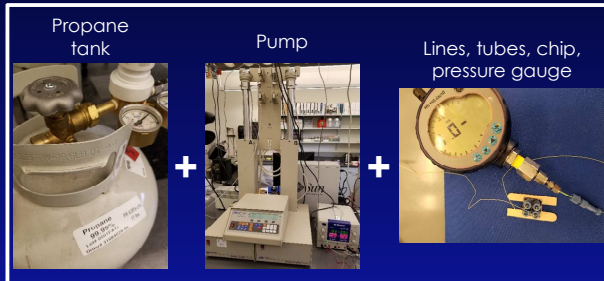


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## Lab Practices

### Connectivity inspection



### Leak inspection



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## Research Plan

### Present

- Study propane phase behavior
- Phase behavior in varying nanochannel depths
- Improvement of the data measurement capabilities

### Future

- Study phase behavior of ethane-heptane mixture

### Additional Tasks

- Improvement of temperature control
- Feasibility of nanoporous - silicon

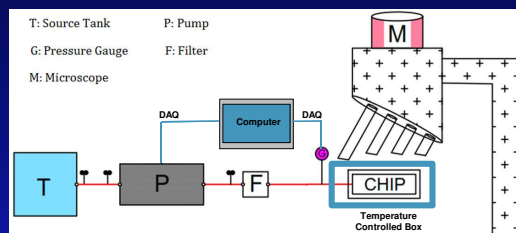


Figure: Cartoon depicting temperature controlled experimental set up. Figure modified after Parsa, E. (2017)



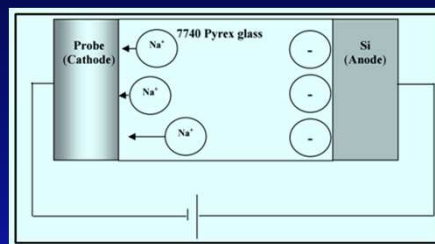
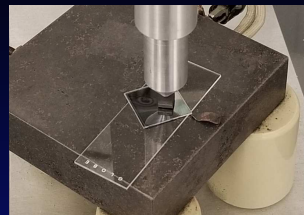
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Thank you



## Anodic Chip Bonding Procedures



Schematic of anodic bonding process between silicon and borosilicate glass

Parsa, E. (2017)

