New Hot Embossing based Fabrication Method for Micropillar Enhanced QCM Sensors

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Introduction

The micropillar-based quartz crystal microbalance (QCM) sensor demonstrates significantly enhanced mass sensitivity (~27x) compared to traditional QCM sensors.

This sensor holds promise for detecting COVID-19 prevalence in wastewater with the lowest possible Limit of Detection (LOD).

Current micropillar fabrication methods rely on nanoimprinting lithography (NIL).

Proposal

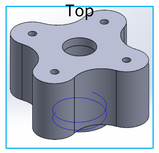
Enhancing a homemade hot embossing device to

- Rival NIL standards in a non-cleanroom environment
- Reduce equipment costs by a 10,000-fold
- Improve microfabrication flexibility

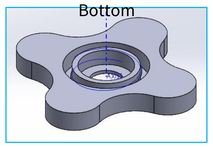
Materials & Methods

- SolidWorks — Design the hot embossing device
- 3D printer — Print the SolidWorks Clamp set-up design
- PA6-GF — 3D printing filament, heat resistance of 150°C
- Standard weights — 1.5kg used to generate pressure, 0.5kg x 4 used to ensure balance

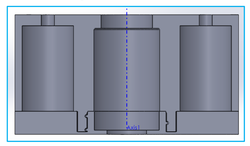
Trimetric View of Top



Trimetric View of Bottom

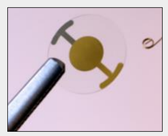


Assembly Cross Section View

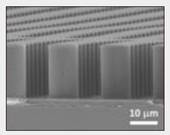


Results

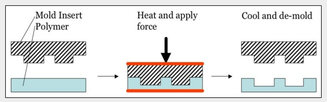
Centered Force	Assemble	Heat
Secured by four 0.5 kg Weights	via Screw Connection	No Pressure Change on 1.0kg Weight



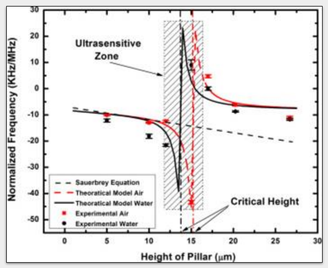
QCM[1]



Micropillars[2]



Hot Embossing Process[3]



Resonant Frequency of QCM-P Devices[4]

[1] *Quartz Crystal Microbalance with Dissipation monitoring openQCM*. (n.d.). Quartz Crystal Microbalance with Dissipation Monitoring: Open Source QCM-D. https://openqcm.com/

[2, 4] Su, J., Esmaeilzadeh, H., Zhang, F., Yu, Q., Cernigliaro, G., Xu, J., & Sun, H. (2018). An ultrasensitive micropillar-based quartz crystal microbalance device for real-time measurement of protein immobilization and protein-protein interaction. *Biosensors and Bioelectronics*, *99*, 325–331. https://doi.org/10.1016/j.bios.2017.07.074

[3] *MNX Capabilities*. (2021). Mems-Exchange.org. https://www.mems-exchange.org/capabilities/embossing

Next Steps

1. 3D Print Official Design
2. Fabricate Micropillars with Design
3. Collecting & Analyzing Data
4. Revise

PDMS-based Microfluidic Devices for Precise Temperature Control in Biofluid Applications

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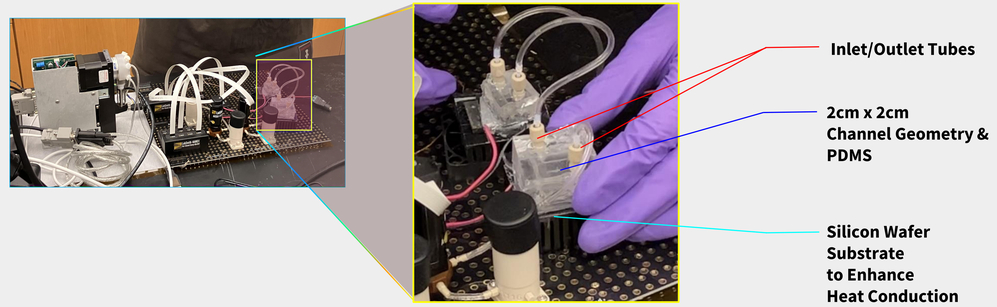
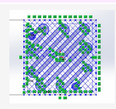
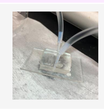
Introduction

The objective of this project is to develop a PDMS-based microfluidic device capable of precisely regulating the temperature of wastewater samples using thermoelectric cooling and heating.



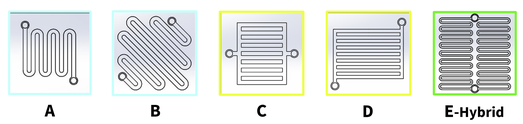
Performance of a Microfluidic Device in a System for Detecting the Presence of COVID-19 RNA

Materials & Methods

Calculations	Design	Mold-Making	PDMS Fabrication	Silicon Wafer Cutting	Plasma Bonding	Leakage Testing	Performance Testing
							

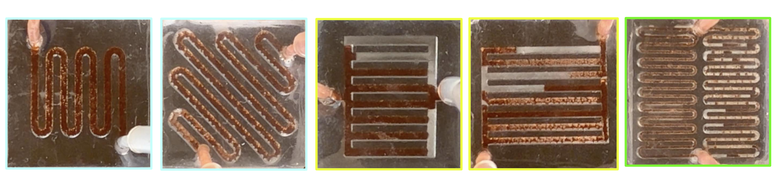
Design

- Serpentine geometries increase channel length and heat transfer area.
- Parallel models minimize fluid pressure drop.



Heat Transfer Efficiency Results

- All serpentine models successfully achieved a 50°C temperature difference with room temperature.
- Parallel models struggled with pressure changes and uneven flow due to trapped vapor.



A	B	C	D	E-Hybrid

Next Steps

1. CFD Simulation
2. Minimize Assembly Failure
3. Wetting Microfluidic Channels
4. Employing a Degasser

Northeastern University College of Engineering
Northeastern University Michael B. Silevitch and Claire J. Duggan Center for STEM Education

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Ibrahim Zeid, *Principal Investigator*
Claire Duggan, *Co-Principal Investigator*