Microsensors with Nanostructured Surfaces Fabricated by 3D Lithography

Biya Haile

- **PI: Dr. Oliver Brand**
- **Mentor: Devin Brown**

National Nanotechnology Coordinated Infrastructure

NSF

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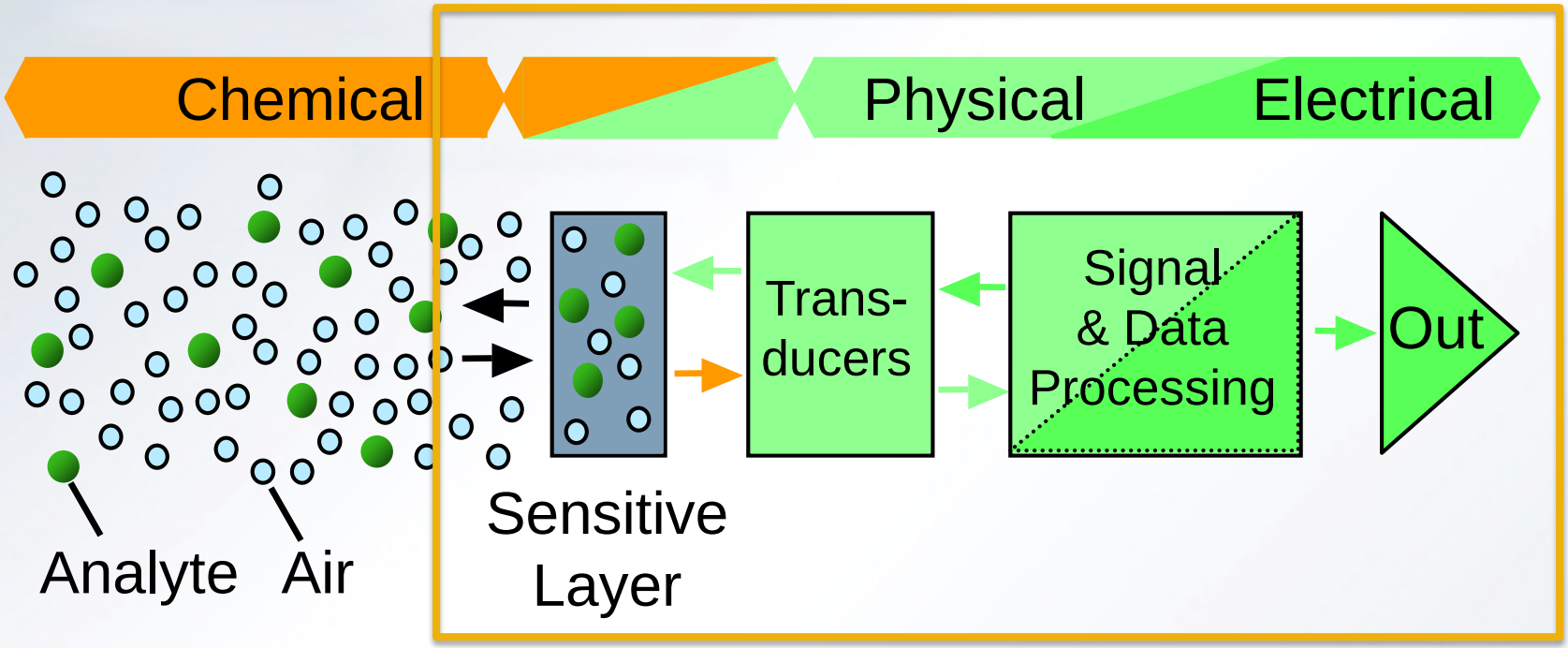
Georgia Tech Institute for Electronics and Nanotechnology

Southeastern Undergraduate Internship in Nanotechnology, NSF EEC-1757579

(Bio)Chemical Sensing System



Sample Prep
- Uptake
- Filter
- Pre-Concentration

System Integration

Courtesy of Prof. A. Hierlemann, ETH Zurich

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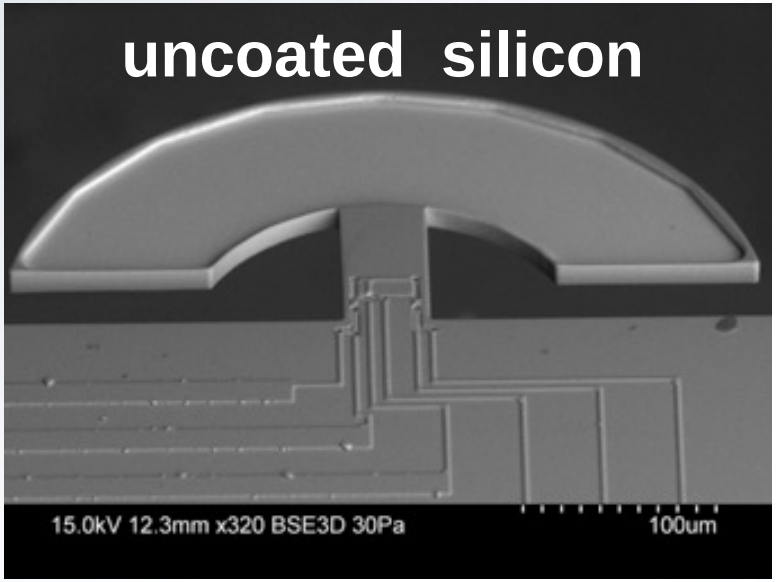
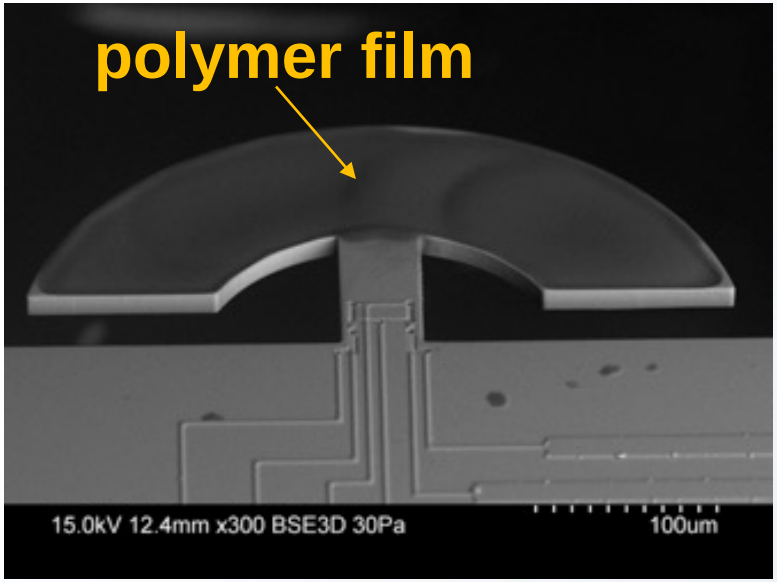
Current Mass-Sensitive Sensor

- ”Hammerhead” resonator with uniformly coated polymer sensing film
- Resonance frequency decreases as analyte is absorbed into the polymer sensing film





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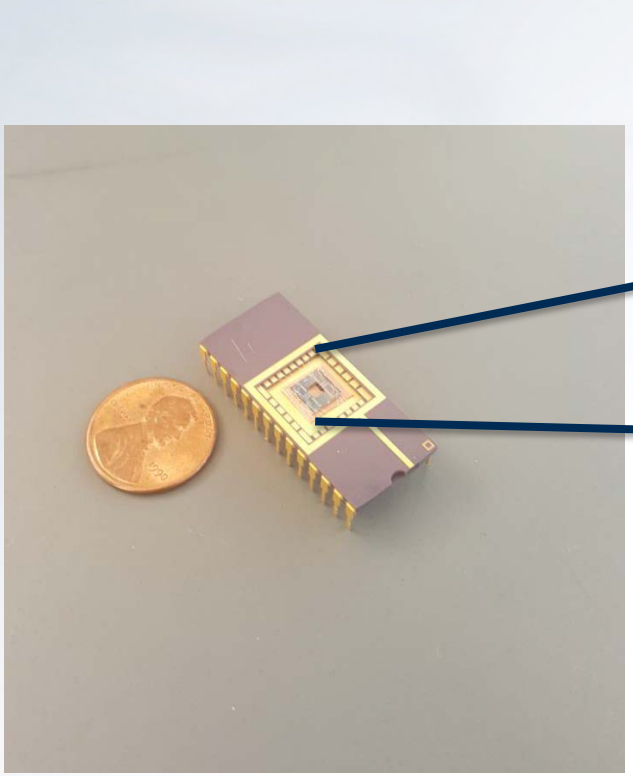
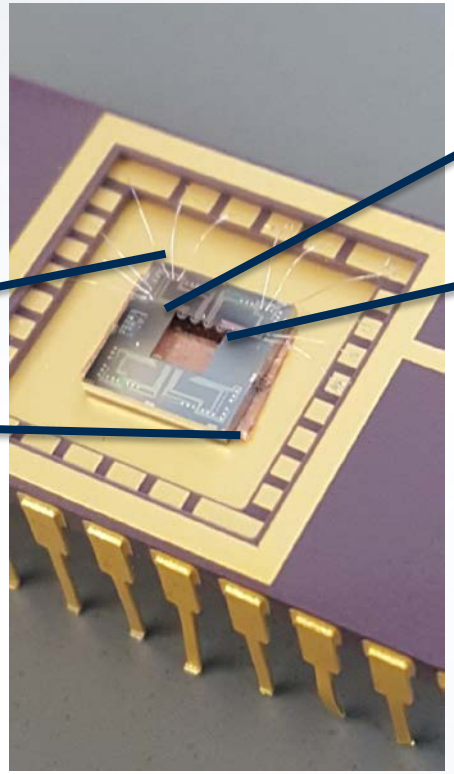
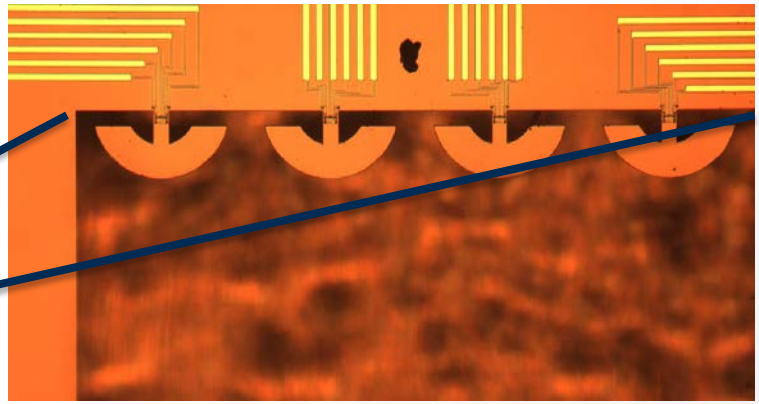
Transducer Design & Packaging







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Sensor Sensitivity vs. Reponse Time

Sensor Sensitivity $\propto$ Volume of Sensing Film

Sensor Response Time $\propto$ (Thickness of Film)^2

Goal: ***High sensitivity*** (large volume) AND
Fast/short response time (thin sensing film)

Approach: ***Nanostructured Sensing Film***
providing large volume
via ***large surface area*** combined with ***thin sensing film***

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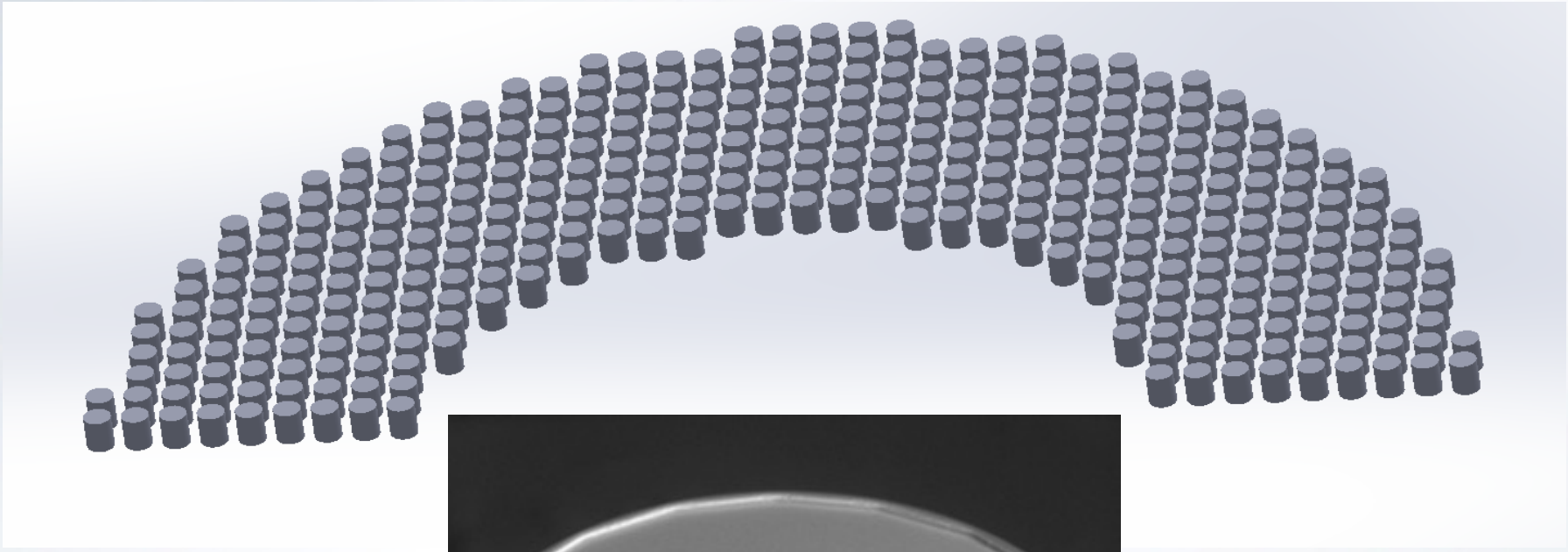
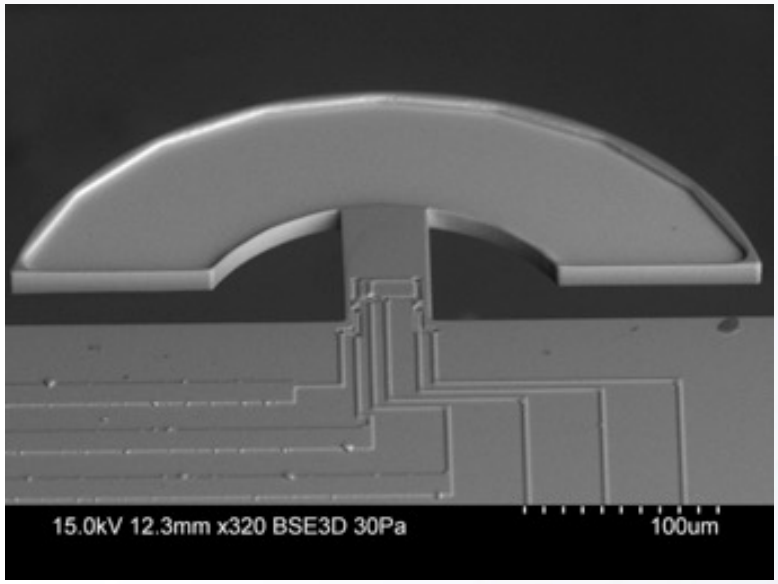
Concept of Cylindrical Pillars Array





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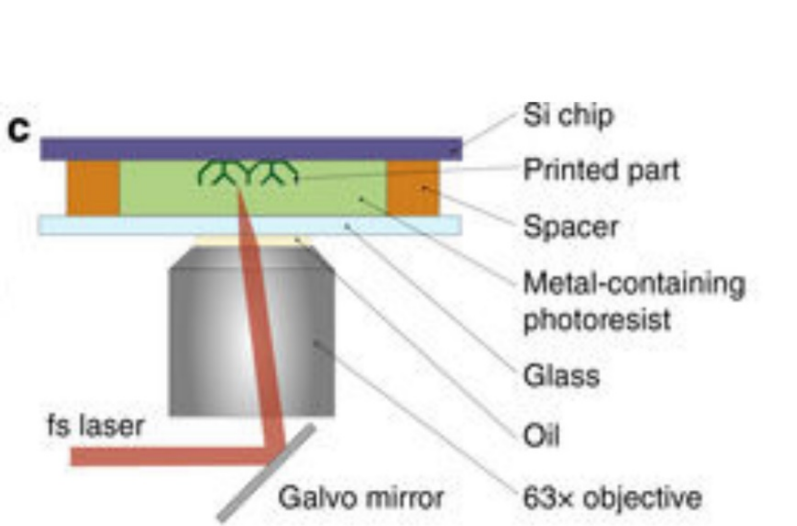
Nanoscribe – 3D Laser Lithography System

- Nanoscribe Photonic Professional GT, a commercial 3D lithography system with sub-micrometer resolution based on 2-photon polymerization.



Designing and Testing Procedures

Variables	Range
Diameter	100 – 5000 nm
Height	800 – 10000 nm
Pitch	1600 – 2500 nm
Power	20% - 100%
Speed	2000 – 10000 um/s

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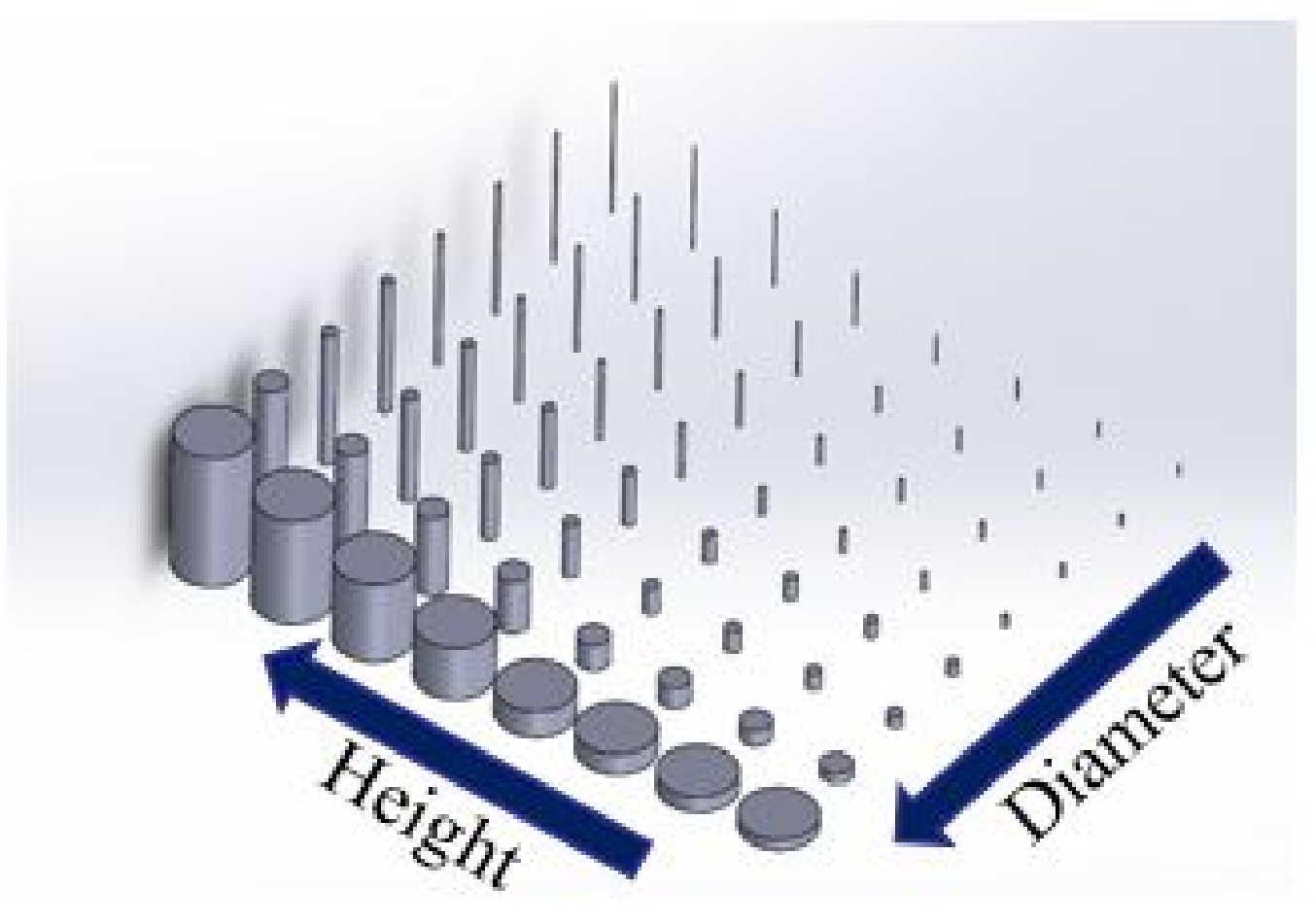
Designing and Testing Procedures



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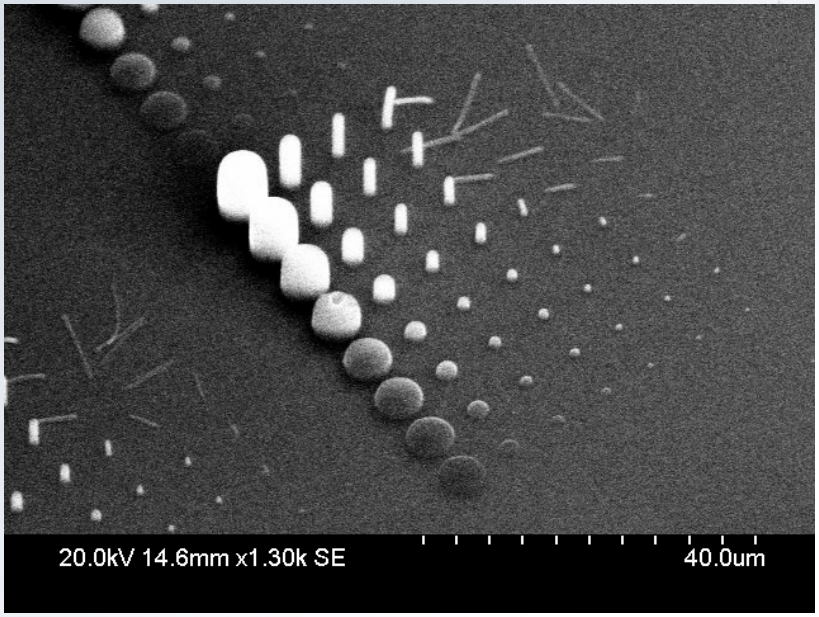
Testing Results & Classification



Height (nm) \ Diameter (nm)	100	200	300	400	800	1000	2000	5000
800	Burnt	Good	Good	Good	Good	Good	Good	Good
1200	Burnt	Good	Good	Good	Good	Good	Good	Good
1600	Not printed	Good	Good	Good	Good	Good	Good	Good
2000	Not printed	Fallen over	Good	Good	Good	Good	Good	Good
4000	Not printed	Fallen over	Fallen over	Deformed	Good	Good	Good	Deformed
6000	Not printed	Fallen over	Fallen over	Fallen over	Good	Good	Good	Good
8000	Not printed	Fallen over	Fallen over	Fallen over	Good	Good	Good	Good
10000	Not printed	Fallen over	Fallen over	Fallen over	Good	Good	Good	Good

- Not printed
- Burnt
- Deformed
- Fallen over
- Good

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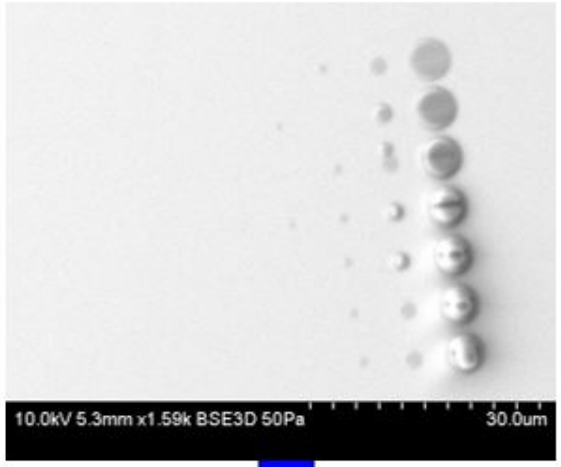
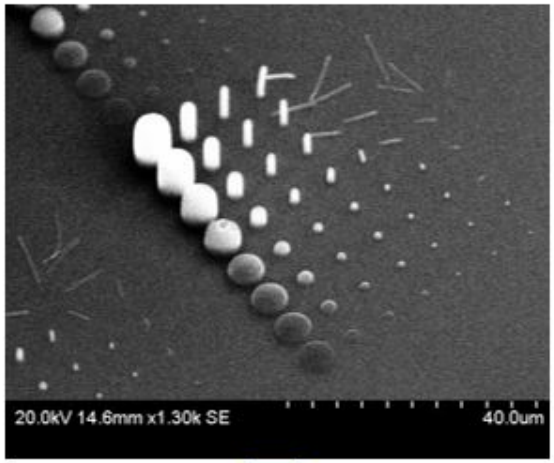
Testing Results - Comparison

Low Dose



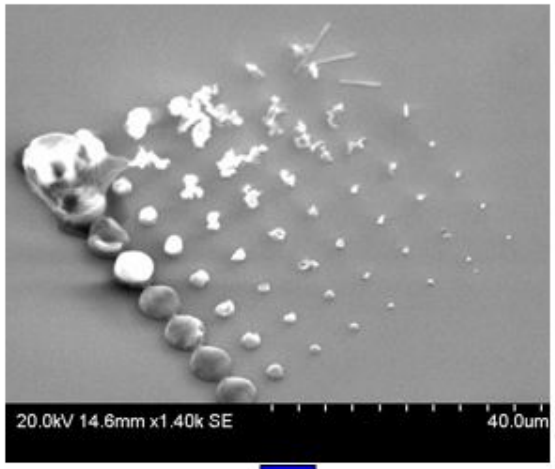
Height (nm) \ Diameter (nm)	100	200	300	400	800	1000	2000	5000
800								
1200								
1600								
2000								
4000								
6000								
8000								
10000								

Optimal Dose



Height (nm) \ Diameter (nm)	100	200	300	400	800	1000	2000	5000
800								
1200								
1600								
2000								
4000								
6000								
8000								
10000								

High Dose



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800								
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8000								
10000								

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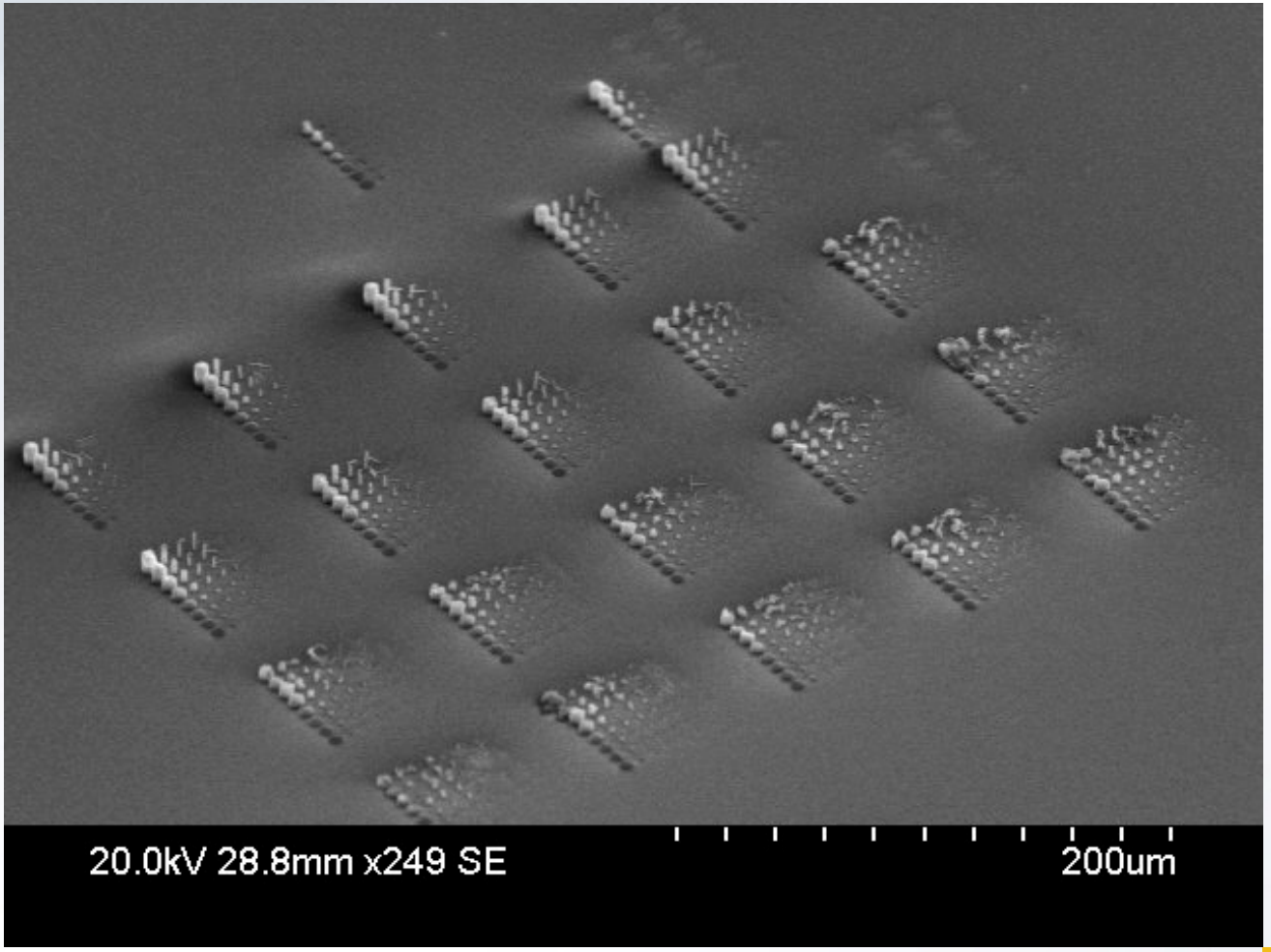
Testing Results



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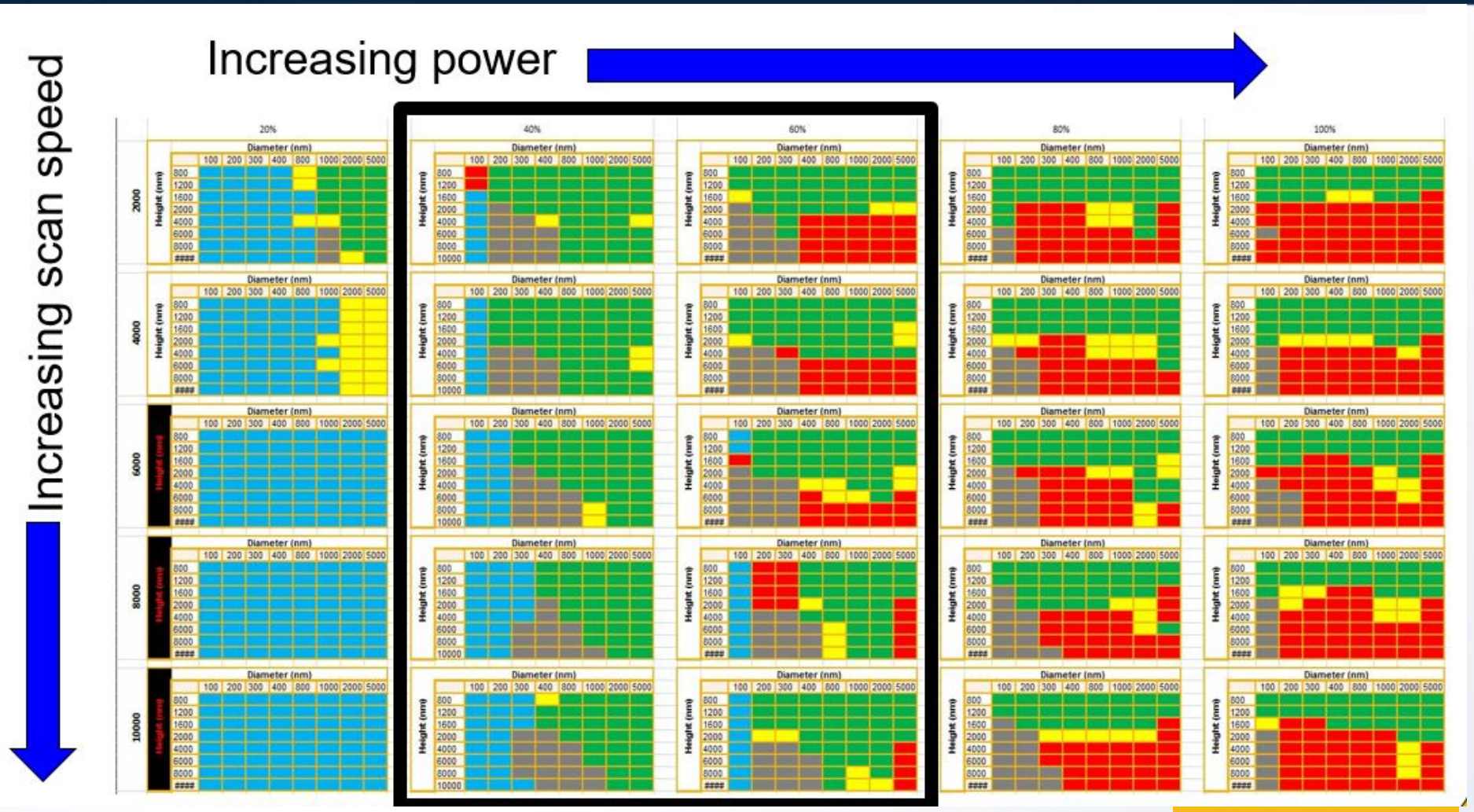
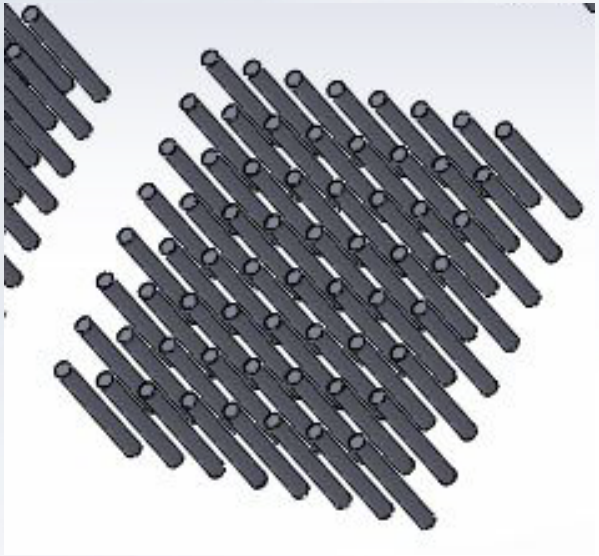
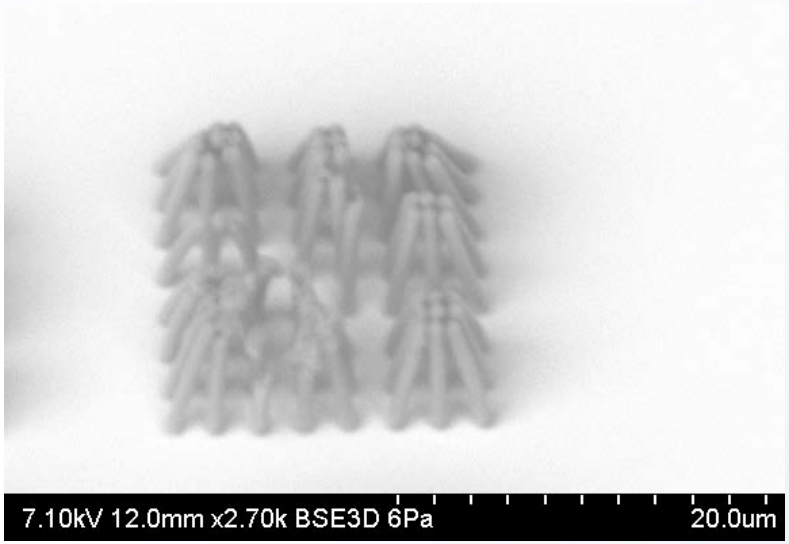
Testing Results – Process Window



Effect of Capillary Forces on Pillar Array





- Pillar arrays suffer from insufficient mechanical stability against capillary forces

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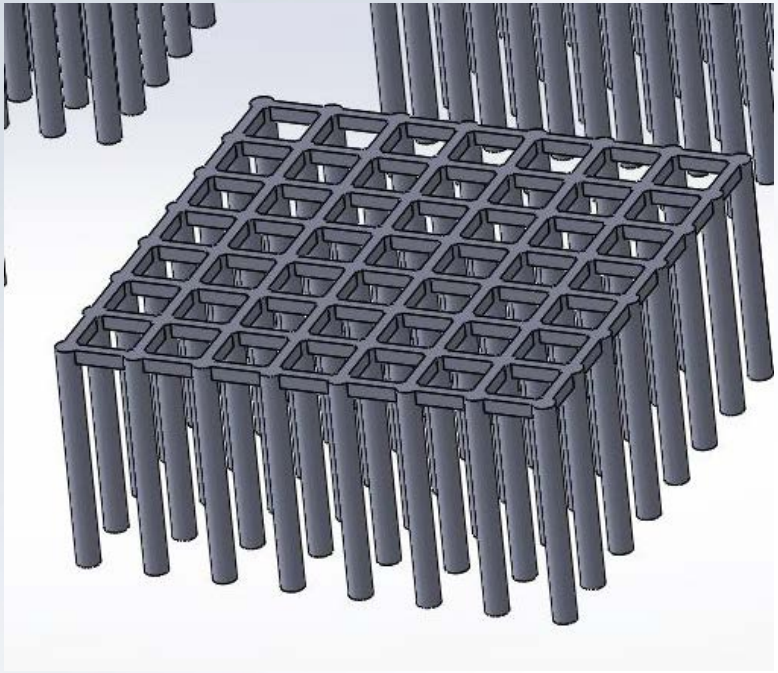
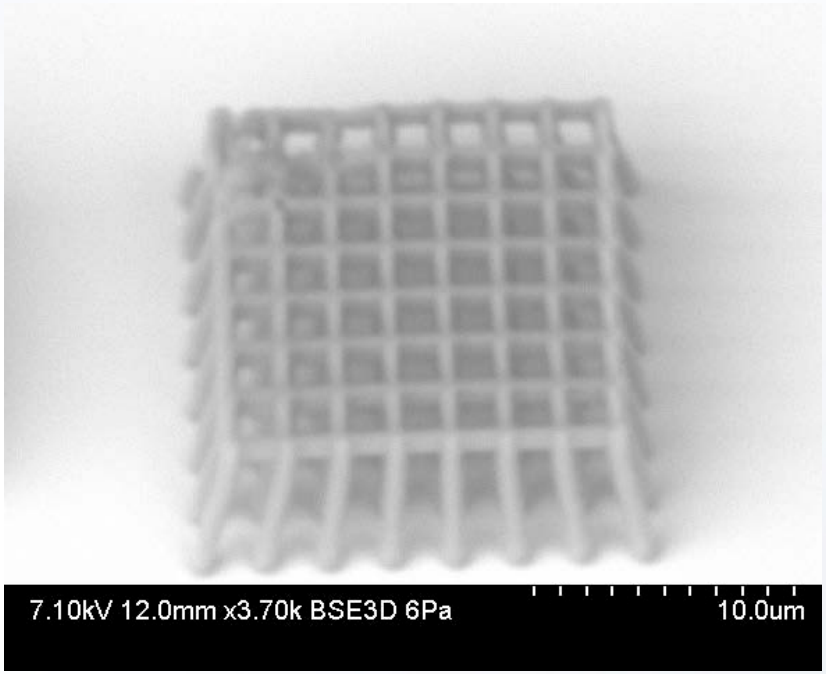
Effect of Capillary Forces on Pillar Array





- Adding stiffening bars across the top of pillar arrays provided additional stabilization

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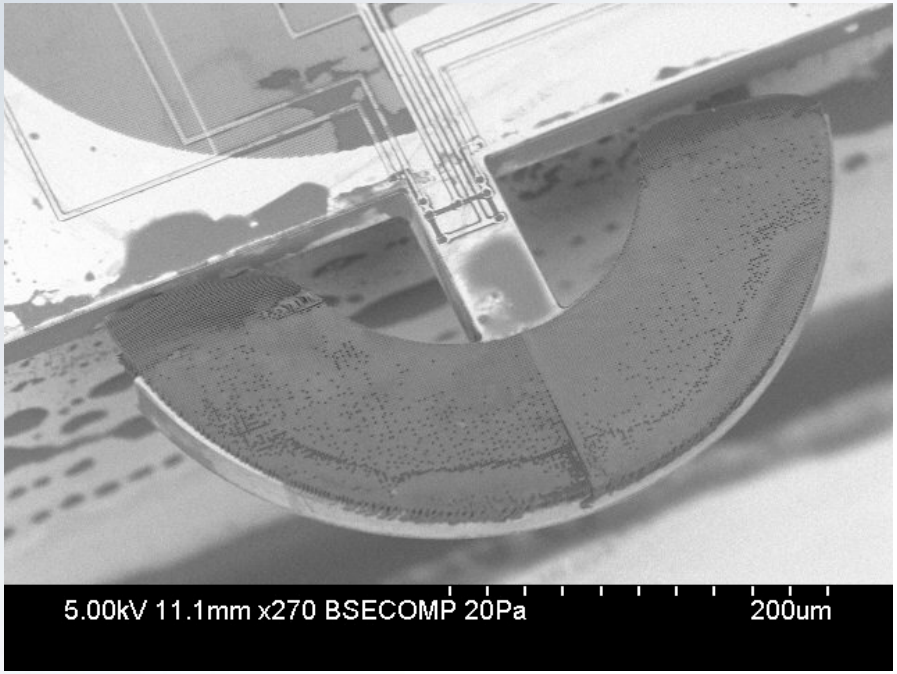
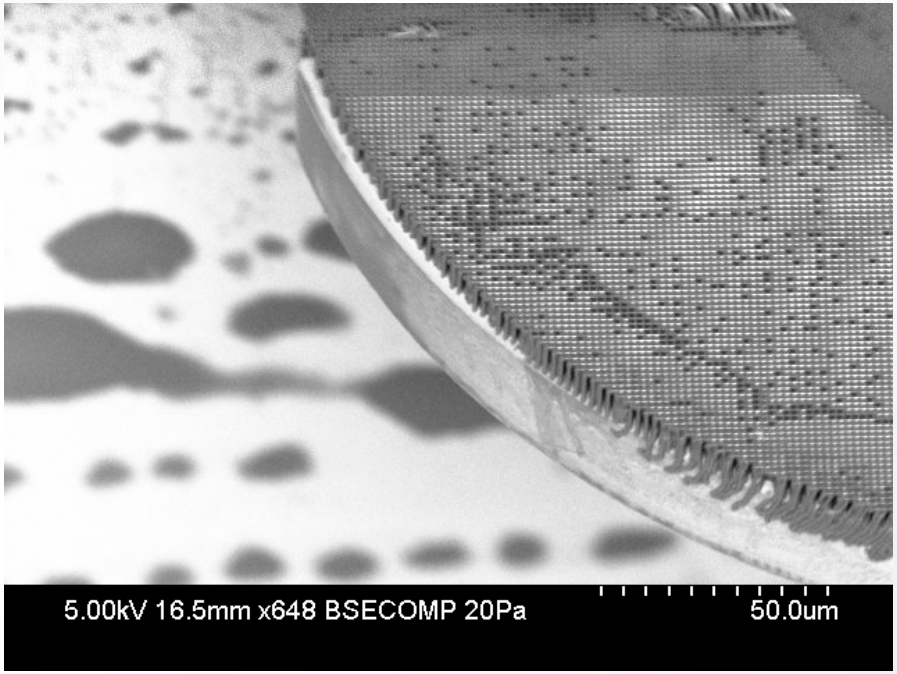
Print Best Structures on Fabricated Hammerhead Resonators





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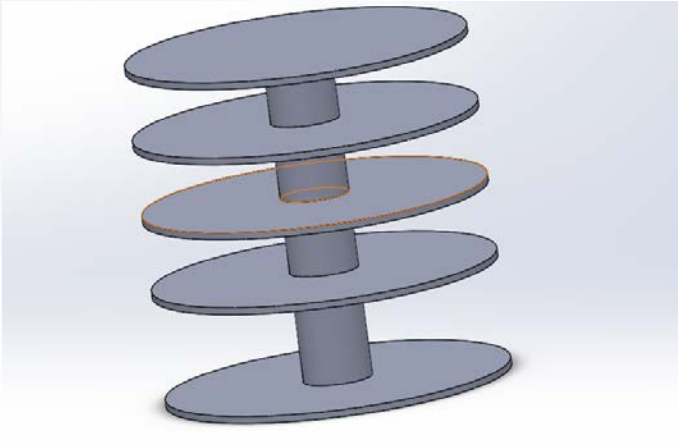
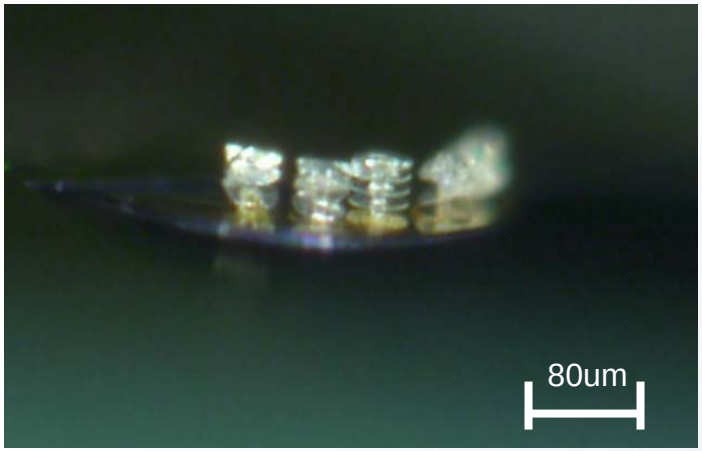
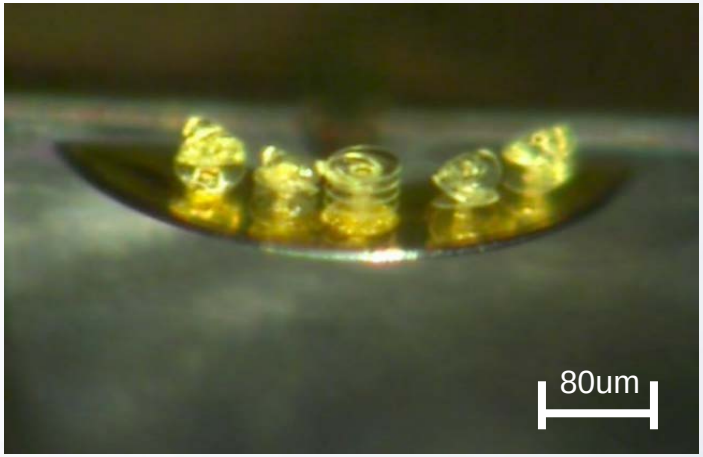
Future Work

- Test the silicon-based hammerhead resonators with 3D sensing films
- Print pillar arrays with different material which can absorb the target gas
- Design different structures with better aspect ratio to increase the sensitivity







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Questions?

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  - Steven A Schwartz,
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Thank You!

http://www.ien.gatech.edu

biya.desalegne@gmail.com