BioMEMS Photomask Aligner

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Client: Professor John Puccinelli, PhD
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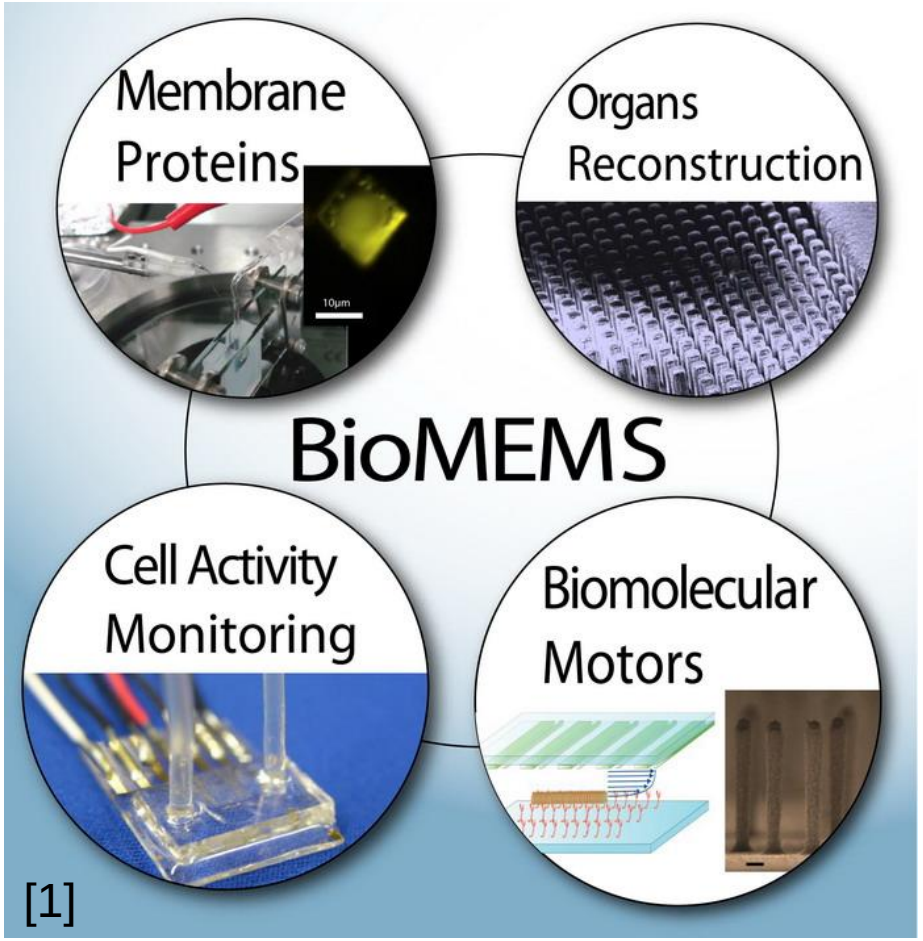
Overview

- BioMEMS
- Photolithography
- Current Alignment Techniques
- Previous Design
- New Design and Fabrication
- Future Testing and Work
- Q & A

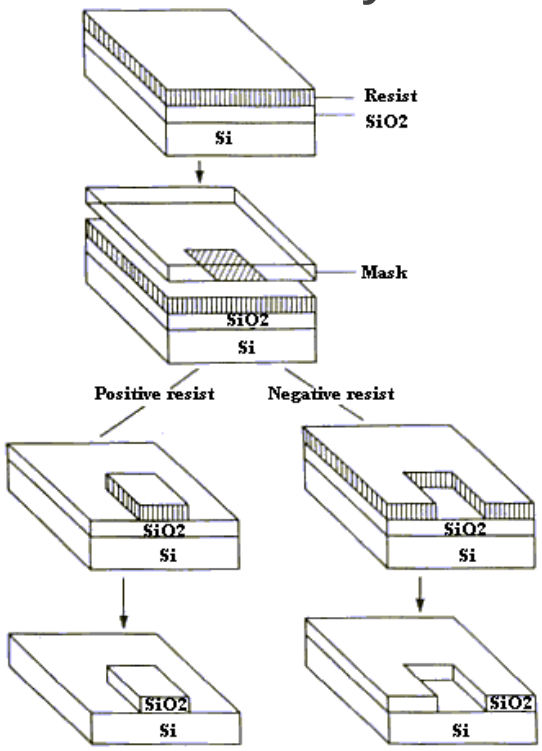
Biological MicroElectroMechanical Systems

- The science of very small biomedical devices
- Subset of MEMS
- At least one dimension from 100nm to 200μm
- New materials that aid our understanding of the microenvironment or biocompatibility



Photolithography

- Optical means for transferring a pattern onto a substrate
- Patterns are first transferred to an imagable photoresist layer



[2] [3]

Basic Steps to the Process

- Clean the wafer
- Form a barrier layer formation
- Spin application of the photoresist
- Soft bake to harden the photoresist
- **Align the Mask**
- UV Exposure and development
- Hard bake to further harden the photoresist and improve adhesion

Karl Suss MA-6 Mask Aligner

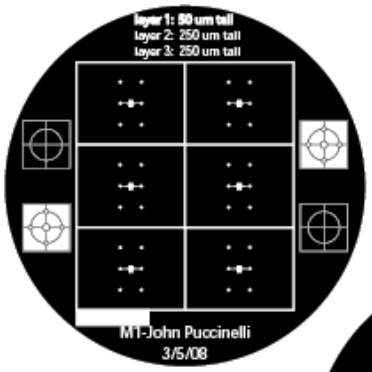
- Electronic
- Multiple wafer sizes
- Accuracy ~ 0.5 microns
- Expensive ($30,000 used)

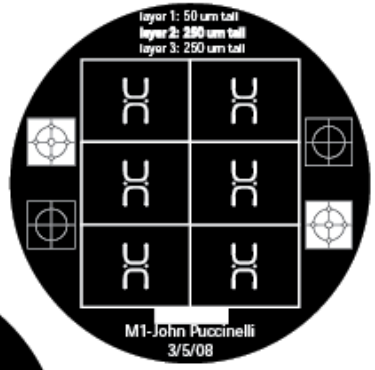
[4]

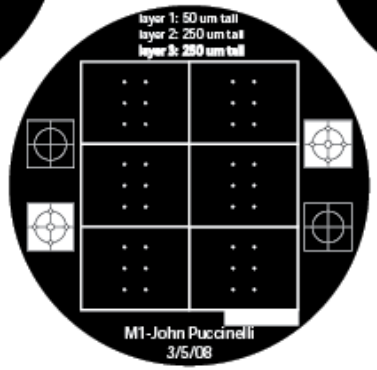
Dr. Justin Williams' Method

- Utilizes former microscope stage
- Manual adjustment
- Glass separating UV light and mask
- Accuracy ~ 50-200 microns

Dr. John Puccinelli's Method







- Aligned manually (naked eye)
- Uses similar alignment marks
- Accuracy ~200-300 microns

[4]

Design Requirements

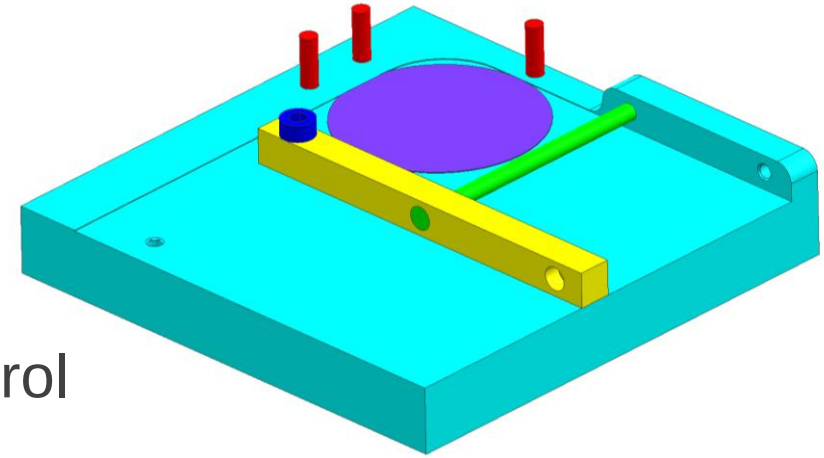
- Create a photomask aligner that is:
  - Accurate between 10μm and 100μm
  - Less than $200 to fabricate
  - Relatively simple to use
  - Reproducible by other labs

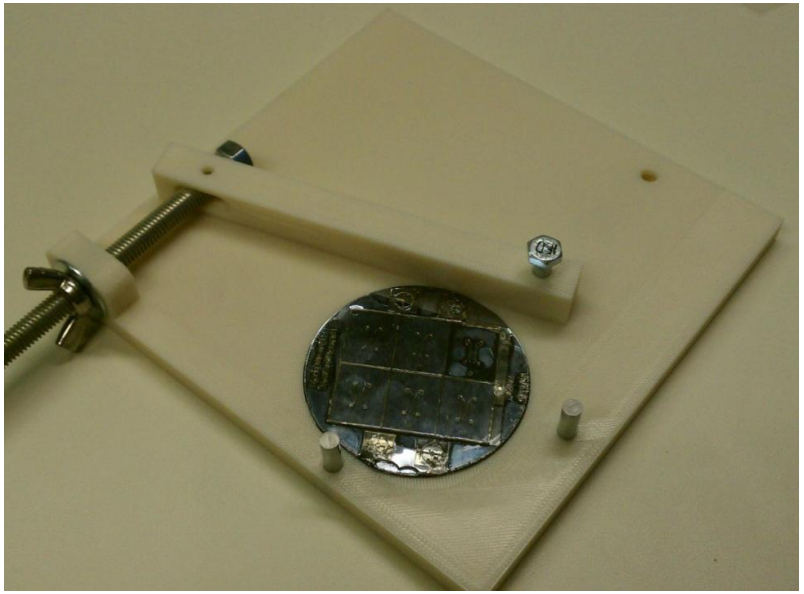
Key Components

- Epilog 40 Watt Laser Cutter
  - Set between 75-1200 dpi (up to ~21 µm resolution)
- Wafers
  - WRS Materials (vendor)
  - Flats
    - 1 or 2 flat edges depending on crystal plane direction
  - 3” wafer
    - Diameter tolerance ±300 µm
  - 6” wafer
    - Diameter tolerance ±200 µm

Previous Prototype

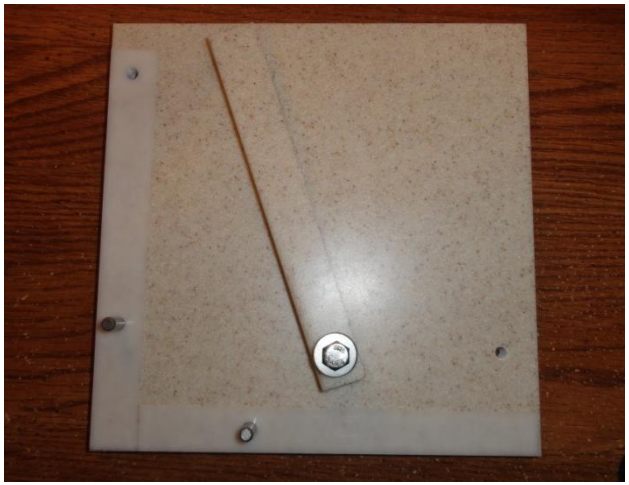
- Largest drawbacks/ shortcomings:
  - Crushed Wafers
    - Threaded rod inhibits user control over wafer compression
  - Inadequate “lip” height
  - No alignment pin taper
    - Difficulty placing masks
  - Rigidity of alignment pins
  - Surface smoothness lacking
    - Layer thickness of 3D printer

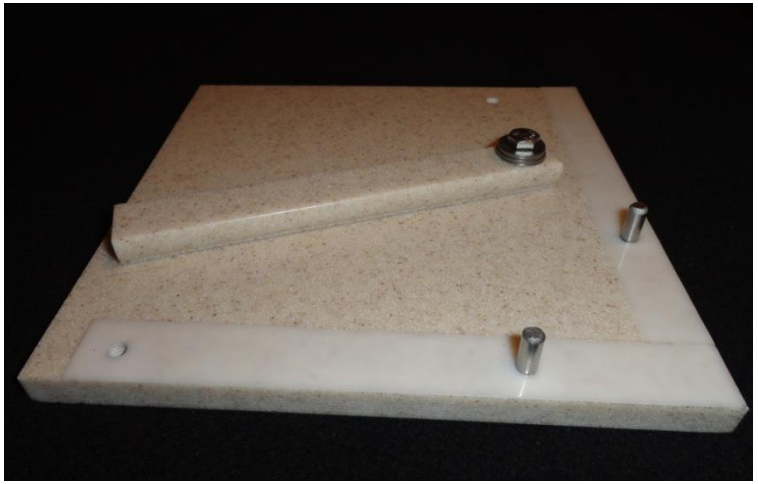




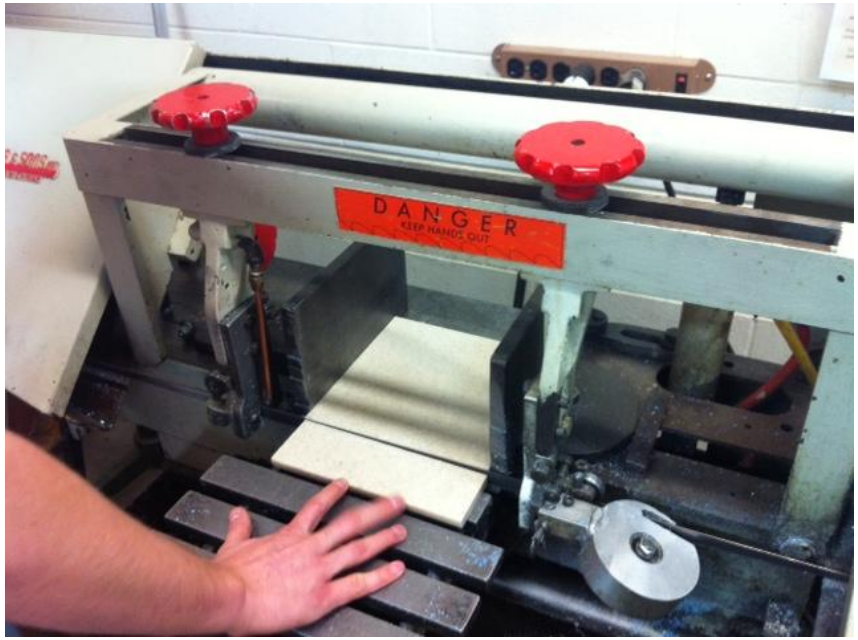
Modified Prototype

- Changes
  - Base Material = 100% Acrylic
  - Separable Layers
    - 0.030” Delrin w/ 3M 300LSE adhesive backing
  - Threads directly into acrylic base
  - Tapered alignment pins
- Future methods
  - Move away from threaded rod
  - Springs
  - Rubber Bands with multiple locations
  - Added vertical tension on lock bar





Fabrication



Comparison

Final Design from Fall 2011

Item	Cost
3D Printing	$152
Hardware	$6.47
TOTAL	**$158.47**

Current Model

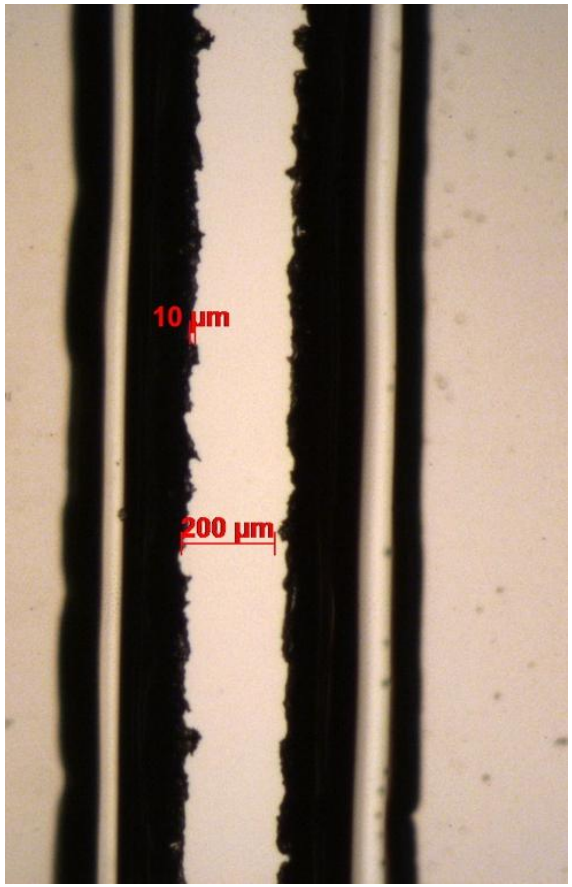
Item	Cost
Acrylic Cutting Board	$9.99
Hardware	~$7.00
Delrin Adhesive Sheet	Sample only (Donated)
TOTAL	**~$17.00**

Test	Accuracy Results	
	Fall 2011	Current Design
2 Layer Photomask	~180 um	?

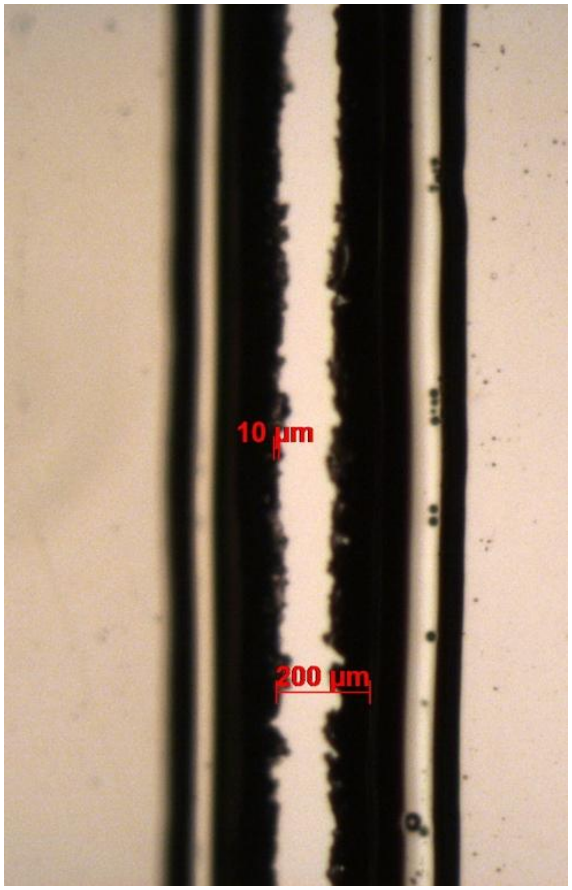
Laser Cut Testing

- Use of 40W Epilog laser to cut holes in mask transparency
- 1200 dpi ≈ 21 μm
- Testing done to determine optimal settings for cut
- Results: 50% speed, 20% power, full frequency

Laser Cutter Testing Results



Speed:50 Power:20



Speed:50 Power:10

Future Testing

- Find ideal hole diameter and spacing for new prototype (Corral Draw)
- “2-layer photomask test”
- Alignment accuracy with 2 and 3 layer photolithography projects
  - Compare to other alignment methods
    - Puccinelli naked-eye method
    - Williams lab method
    - Expensive high-tech method
- Delrin material exposure resistance to UV
- Mask hole abrasion with repeated use over pins

Other Future Work

- 3D CAD models for future fabrication reference
  - Prints and/or fabrication description
- Tension method fabrication (rubber bands or springs)
- DIY Report written in style for *Lab on a Chip: Miniaturization for Chemistry, Physics, Biology, and Bioengineering* in the "Chips and Tips" section. (Published by Royal Society of Chemistry)

Acknowledgements

- John Puccinelli, PhD, Associate Faculty Associate, UW-Madison BME, Client
- Willis Tompkins, PhD, Advisor
- Greg Czaplewski, Graduate Research Student, Williams Lab
- Sarah Brodnick, UW-Madison Engineering Silicon wafer order coordinator
- Justin Williams, PhD, Associate Professor BME (BioMEMS instructor)
- COE Student Shop
- CS Hyde Company, Delrin material supplier

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