BioMEMS Photomask Aligner

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Client: Professor John Puccinelli, PhD

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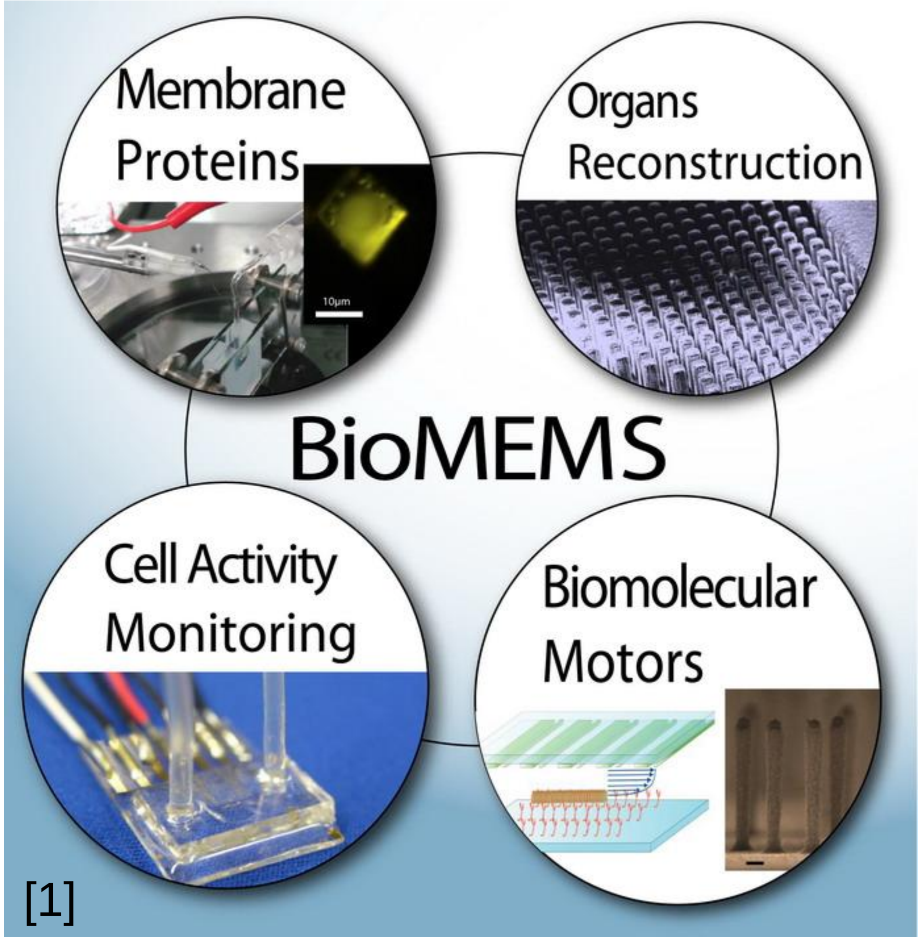
Overview

- BioMEMS
- Photolithography
- Current Alignment Techniques
- Design Alternatives
- Future Work
- Q & A

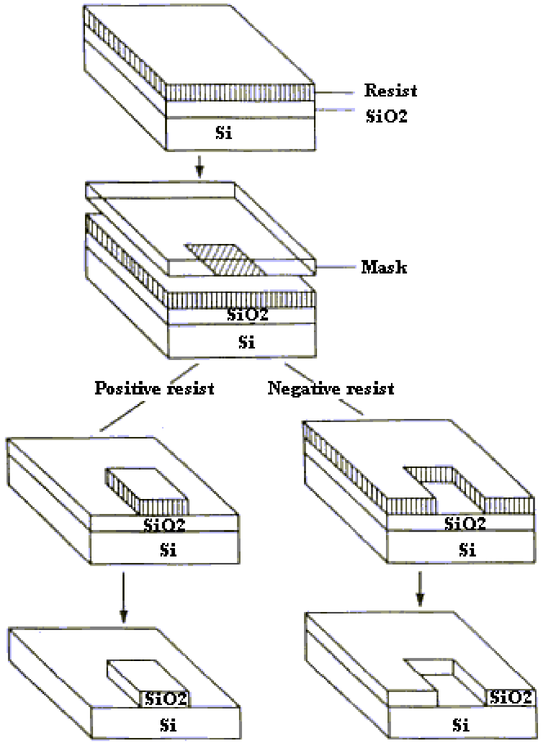
Biological MicroElectroMechanical Systems

- 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]

<u>Basic Steps to the Process</u>

- 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

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Karl Suss MA-6 Mask Aligner

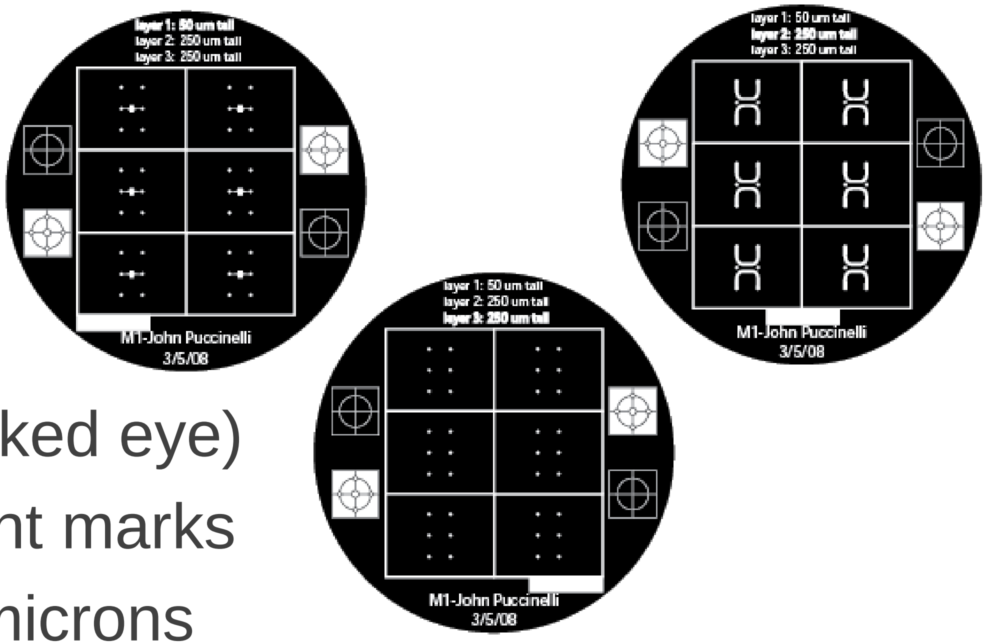
- Electronic
- Multiple wafer sizes
- Accuracy ~ 0.5 microns
- Expensive ($30,000 used)

[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

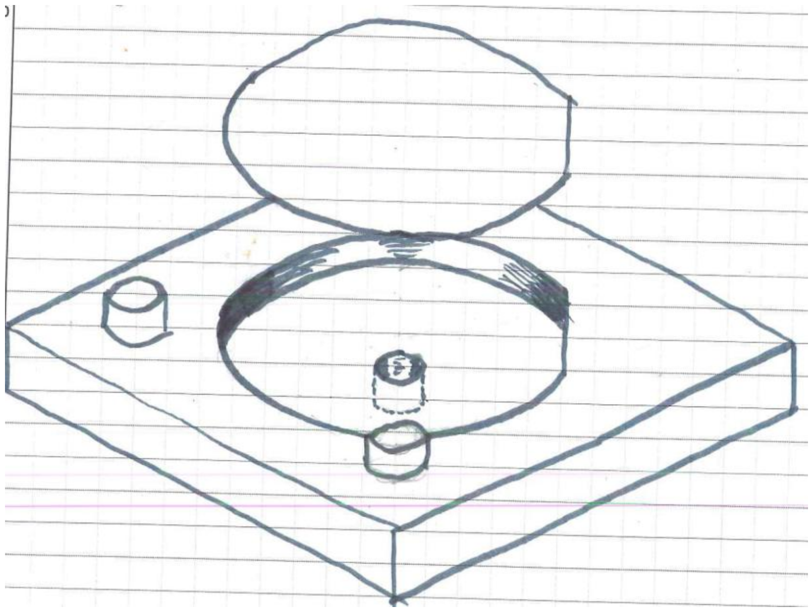
- Create a photomask aligner that is:
  - accurate between 10μm and 100μm
  - less than $200 to fabricate
  - relatively simple to use
  - reproducible by other labs

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 $\pm$300 µm
  - 6” wafer
    - Diameter tolerance $\pm$200 µm

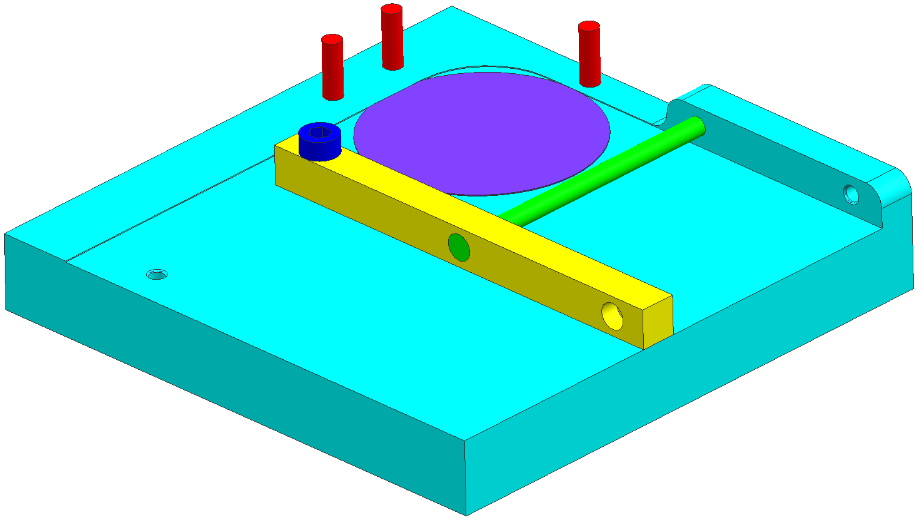
Design #1 – Ejector Well

- Operation
  - Wafer profile cutout
  - 2 rods to align photomask
- Pros
  - Very simple to use
  - Highly repeatable
- Cons
  - Tight machining tolerances
  - Wafer variability
  - Doesn’t work for 3” and 6” wafers



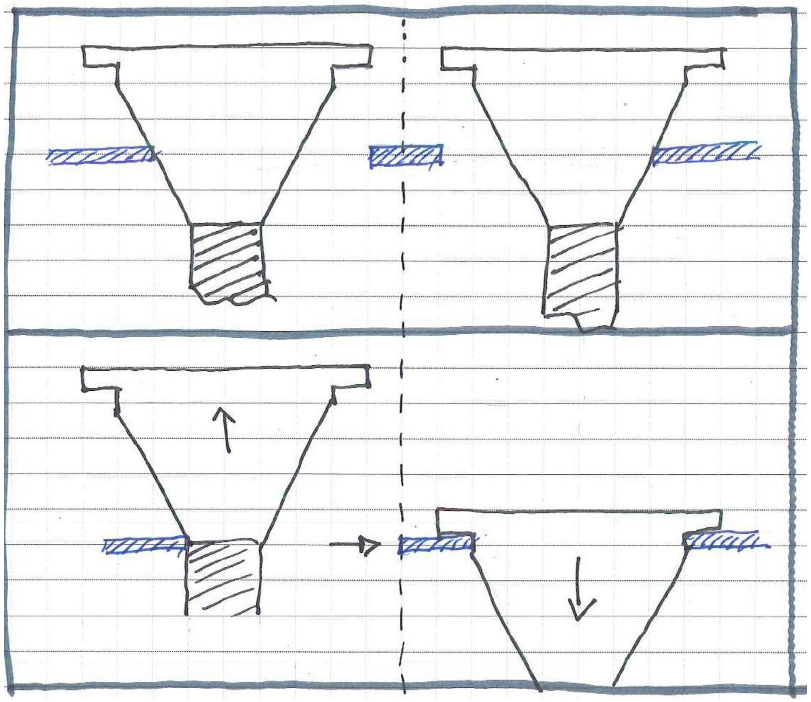
Design # 2 – Wafer Threaded Lock

- Operation
  - Wafer wedged into corner
  - Threaded rod tightened to secure wafer
- Pros
  - Cost and manufacturability
  - Works with 3” and 6” wafers
- Cons
  - Repositioning wafer accuracy
  - Added alignment step



Design #3 – Tapered Screws

- Operation
  - Multiple threaded holes surrounding wafer
  - Tapered screws position mask
- Pros
  - Added ability to position mask
  - Simple concept
- Cons
  - Dynamic adjustment (not linear)
  - Repositioning of wafer



Design Matrix

- All rated on 0-5 scale, then multiplied by weight

Criteria	*Possible Designs*		
Considerations (Weight Multiplier)	**Ejector Well**	**Wafer Threaded Lock**	**Tapered Screws**
Accuracy/Precision (x7)	2	3	4
Cost (x8)	3	5	4
Manufacturability (x2)	2	4	4
Reproduceability (x1)	4	3	3
Ease of Use (x2)	5	4	3
Total	56	80	77

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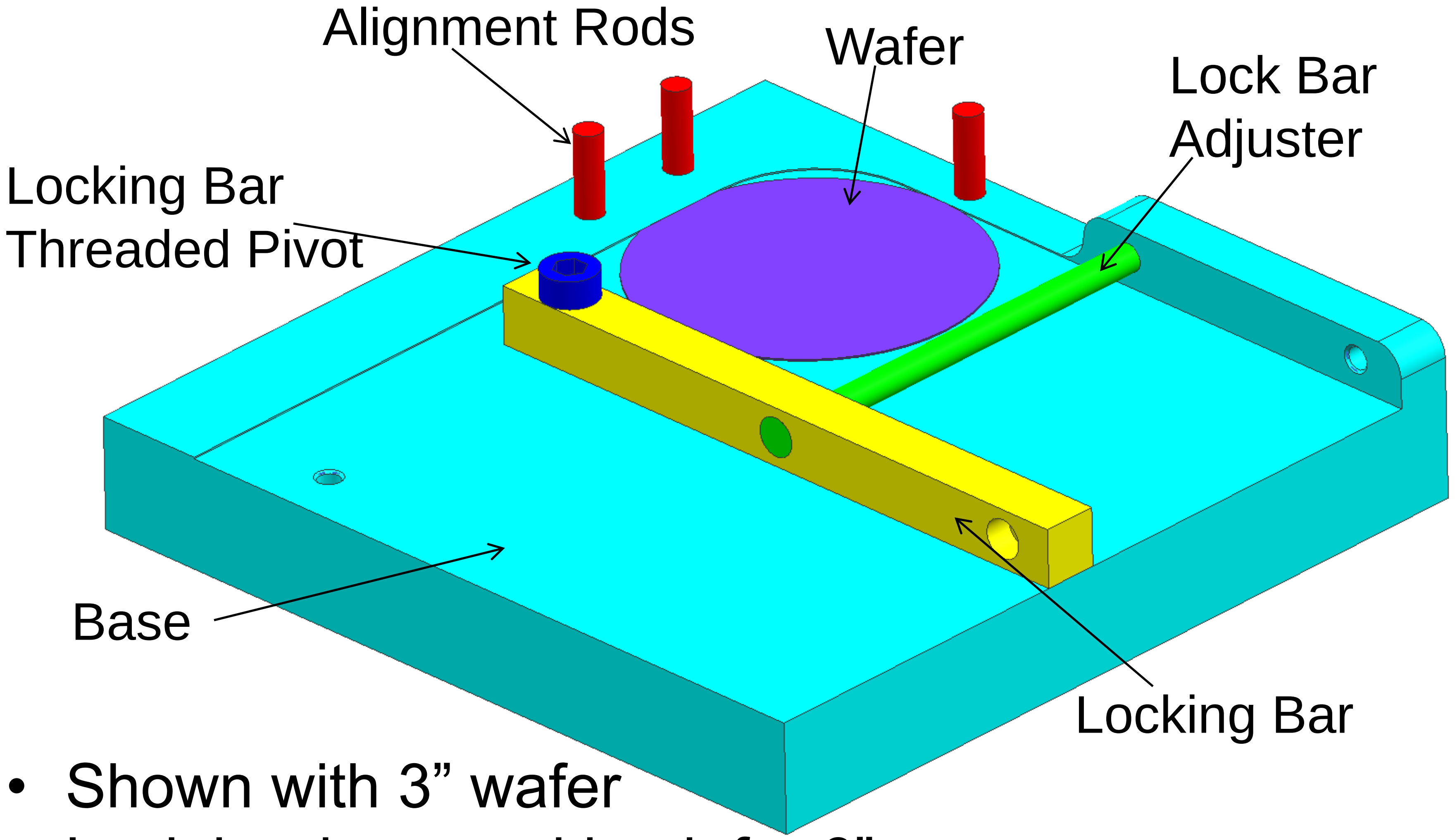
Final Design



- Shown with 3” wafer
- Lock bar is moved back for 6”

Future Work

- 3D CAD Models
  - Prints (toleranced)
- Fabrication
  - COE Student Shop
  - Tosa Tool (Madison)
- Testing
  - Laser printer cutting accuracy
  - Acquired alignment accuracy (testing with 2 and 3 layers)
  - Comparative analysis to current alignment techniques
- Adjustments/Improvements
- Final Report/Presentation
- DIY Report for personal fabrication

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)

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