Engineering Research in Undergraduate Studies: Neural Engineering

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Acknowledgements

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  - Dr. Takoudis, Dr. Linninger; REU Program Directors

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Presentation Overview

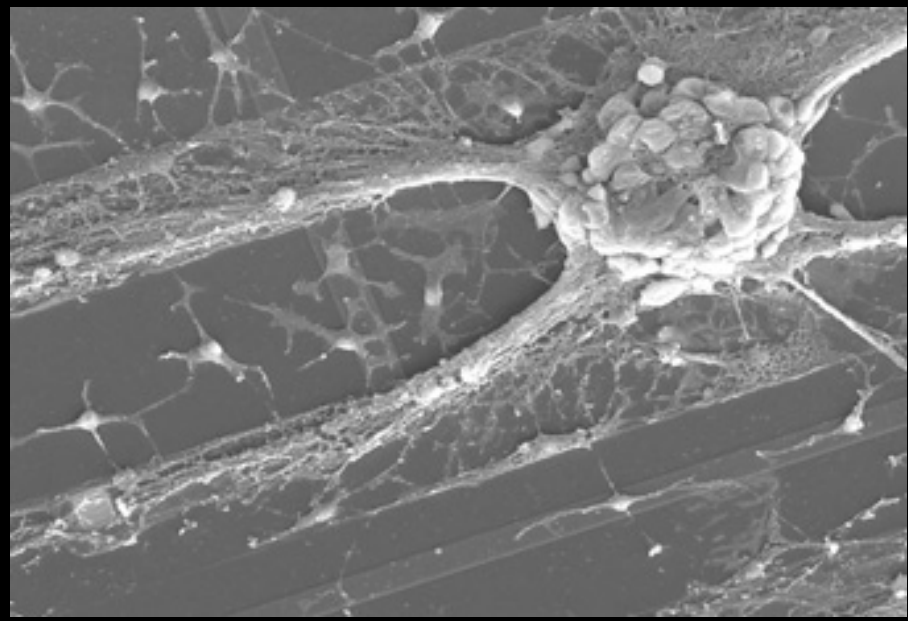
- Overview of 10 week research
- Results with Images
- Final Conclusions
- Remaining Issues

Original Project Goals: Micropatterning

- Silicon Molds
- Rubber-like PDMS stamps with micro-sized features
- Stamps “inked” with protein
- Patterns of protein on glass slides

Motivation for Research

- Develop substrate with micropatterned proteins
- Surface induces living neurons, cells to grow into and interact with substrate
- Optimizing “interface”



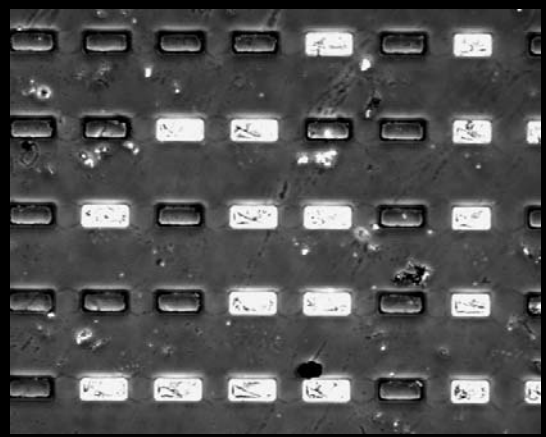
B. Wheeler. http://soma.npa.uiuc.edu/labs/wheeler/home.html, 2005.

Obstacles Encountered

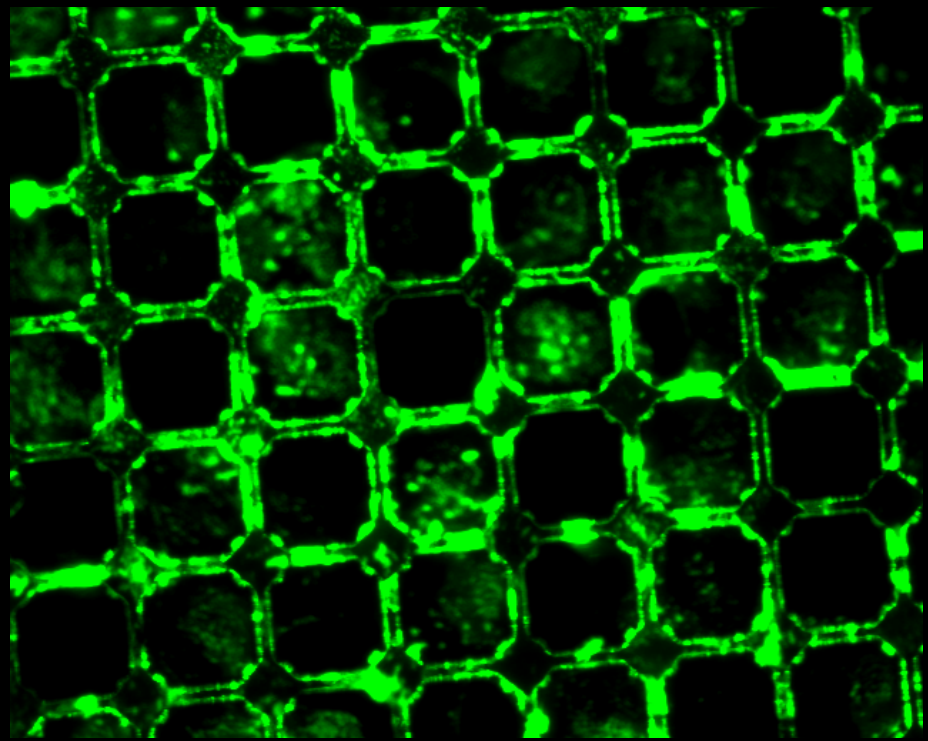
- Set out to find “optimal protocol” for
  - Making Stamps
  - Inking Stamps with Protein
  - Transferring protein to glass substrates
- Experienced difficulties at every step of the process

Obstacle: Making Stamps

- Air bubbles
  - Trapped at relief surface
  - Trapped within stamp body
- Missing Features
  - Pattern not complete
- Stamp surface unclean
  - Too much contamination



Obstacle: Inking Stamps



*10x magnification, 20 um features

- Surface too hydrophobic to adsorb protein
- Protein adsorbs in inconsistent patches, uneven thickness

Obstacle: Stamping Substrates

- Protein does not transfer to substrate in any visible quantity
  - No results can be shown

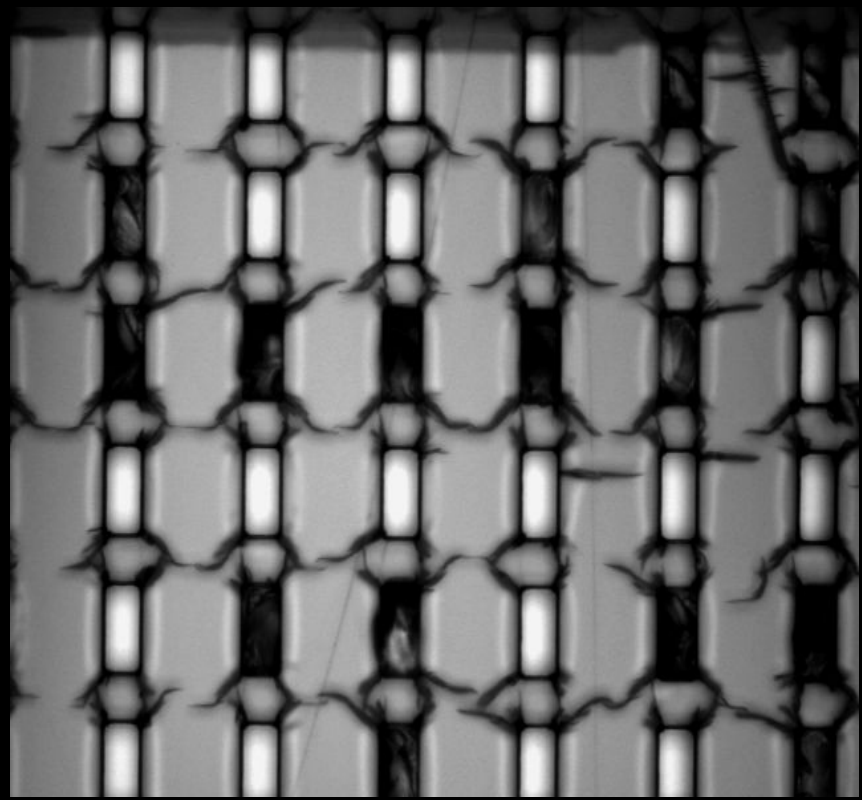
*Note: Have only limited trials with stamping

Obstacle: Most Problematic

- Stamp quality continued to decline, though were “improving” process
- Molds themselves were degraded with use
  - Unable to make new molds, hindered progress

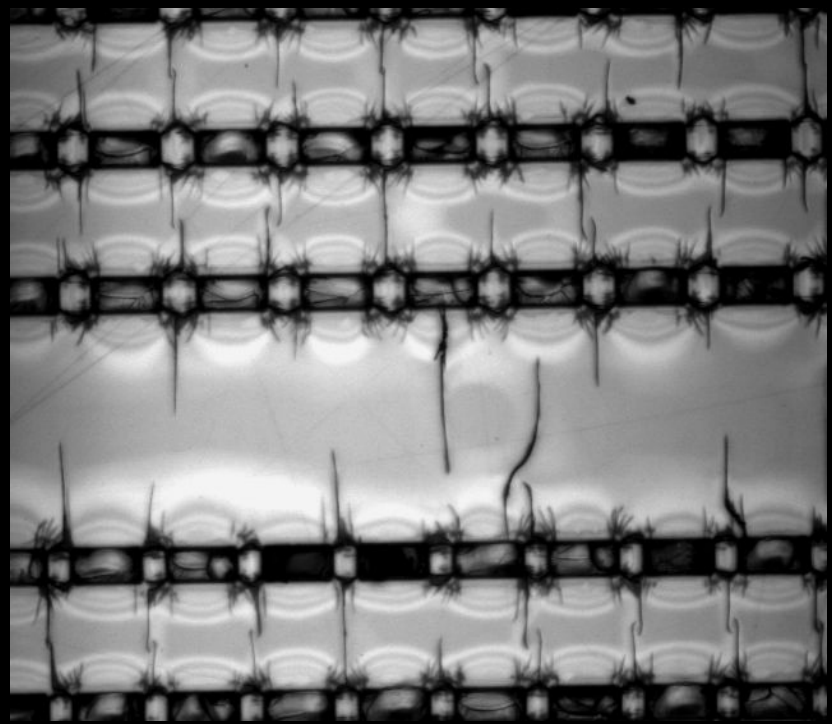
Obstacle: Mold Degradation

- Molds became "dirty" over time
  - Pattern depressions filled with unknown material
  - Could not be cleaned successfully



*10x magnification, 15 um features

Obstacle: Mold Degradation



*10x magnification, 15 um features

- Features started “breaking”
  - Surface showed cracks, missing pieces

Conclusions: Making Stamps

Air Bubbles:

- Re-pressurize vacuum to eliminate surface air bubbles

- Heating stamps reduces curing time
  - Must make stamps thinner to prevent trapping bubbles

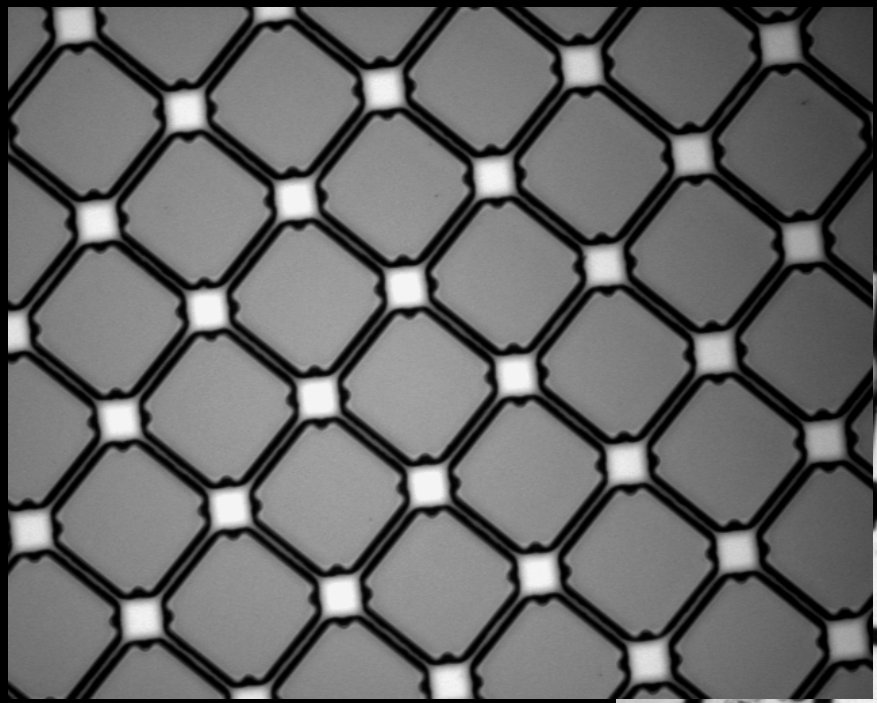
Conclusions: Making Stamps Con't

Missing Features:

- Best *not* to have other material between mold and PDMS
  - No Detergent: plain stamps have best quality
  - No silanization procedure

- Perfect mold required to make perfect stamps

Differing Stamp Quality



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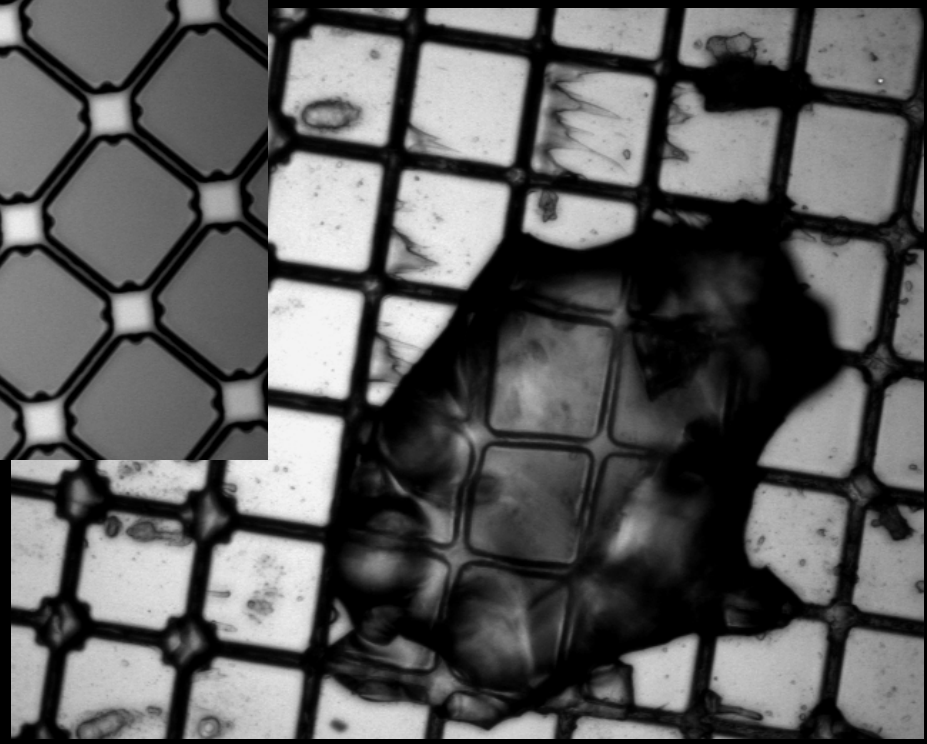
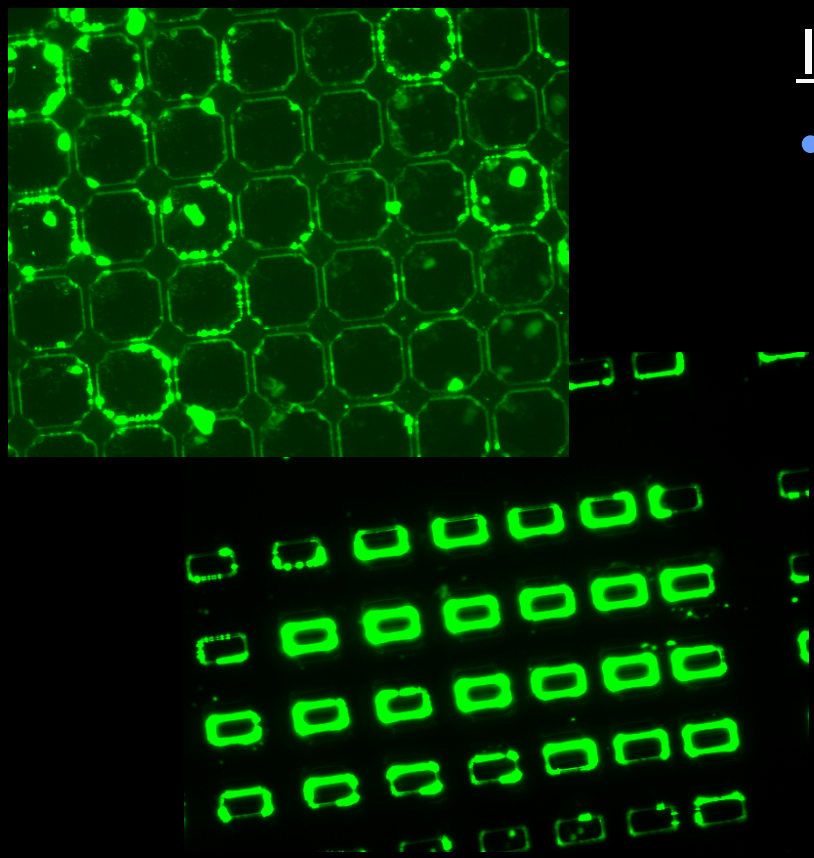


Conclusions: Inking Stamps



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Inking time:

- Let protein sit on stamp at least 30 min
  - More time= no difference
  - Less time= less protein

*Note: Storing PDMS in deionized water for 4+ days before inking helped adsorb protein

Conclusions: Stamping the Substrate

- Cannot produce good substrate printings without thick, even layer protein adsorbed on stamp
- Important to keep time between drying stamp and stamping substrate minimized

Proposed Future Work

- Questions still to address:
  - Understand why molds degrade
  - How to perfect stamp modification
  - Determine best stamping method
  - Culture cells onto protein-stamped substrates

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Thank You!

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