Engineering Research in Undergraduate Studies:
Neural Engineering

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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”

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

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

*10x magnification, 20 um features*
**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

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

*10x magnification, 15 um features
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

*10x magnification, 20 um features
Conclusions: Inking Stamps

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

*10x magnification, 15 um features
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
References

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