Fabricating a Flexible Biocompatible Microelectrode Array for 3-D Applications

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Motivation

- Biocompatible microelectrode arrays enable new ways to study brain function
- Creating a 3D rather than 2D electrode array allows for study of neurons in more natural environment
- Goals:
  - Fabricate ultra-thin, flexible, biocompatible microelectrodes using lithographic procedures
  - Layer electrodes into a 3D structure and electrically monitor and promote cell growth

Electrode Design

Design considerations:
- Substrate (spin-cast polyimide):
  - Biocompatible, stable
  - Low Young’s modulus
  - Thin, permeable to growth media and cells
- Metal electrodes (Titanium/Platinum):
  - Nonreactive, robust through processing steps
  - Adheres strongly to substrate
  - Sensing material
- Encapsulation (spin-cast polyimide):
  - Protects and electrically isolates material
  - Same as substrate requirements
- Release layer (gold):
  - Weak adhesion to silicon carrier wafer
  - Strong enough to last through lithographic steps

Electrode Features

- Pores made in polyimide and metal allow for cell growth
- Minimum spacing between pores dictated by structural stability
- Vias made through encapsulation layer for measurements
- Varied measurement via size from 20 μm to 500 μm so optimum can be determined later

Fabrication Procedure

Sample fabricated on silicon carrier wafer to allow for several lithographic steps on ultra-thin material

- 100 nm Au release layer sputtered onto a silicon carrier wafer
- 3.5 μm of polyimide is spin-coated onto the sample, cured at 350°C
  - Titanium/platinum electrodes are sputtered, then patterned
  - 3.5 μm of protective, encapsulating polyimide is spin-coated, cured at 350°C
  - To etch the polyimide, we used a metal mask to protect the polyimide from oxygen plasma:
    - 50 nm Cr etch mask is sputtered and patterned
    - Polyimide is etched using oxygen plasma
    - Cr mask is removed using Cr etchant

Results

-Nearly 2-D ultra-thin electrode array successfully fabricated
-Robust fabrication process created that is easily repeated

Challenges Encountered

- Premature delamination of gold and polyimide from the carrier wafer
- Removal of finished microelectrode array from wafer

Future Steps

- Use the finished microelectrode array to take impedance measurements of an electrolytic solution
- Grow a layer of neurons underneath and on top of one of these microelectrode arrays to determine whether the cells will grow and integrate fully with the electrodes

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