BIOMEDICAL ENGINEERING
Carnegie Mellon University

Tuesday, February 27, 2018
4:30 – 5:30 p.m.
Doherty Hall A302

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Thiol chemistries for flexible electronics additive manufacturing

Abstract: Polymer engineering, specifically tuning monomer chemistries, polymerization kinetics and thin film interfaces, seeks to address grand challenges in neuroscience, semiconductor processing and additive manufacturing.

We demonstrate peripheral and cortical neural stimulators and recording devices using engineered low cure stress softening polymer substrates. Polymers can be implanted at moduli of more than 1 GPa and soften toward the modulus of tissue. Neural interfaces allow for delivery of a large amount of information transfer, but current microstimulators or microrecorders fail chronically or are poorly suited for interfacing with small biological structures, such as sensory peripheral nerves. We discuss chronic device failure through design of both materials and devices to overcome various failure mechanisms. We demonstrate the effects of self-coiling vagus nerve stimulators and self-wrapping cochlear implants. We demonstrate spinal stimulators that reduce inflammation and tissue response and behave in a manner similar to ball electrodes for use in understanding long-term muscle plasticity.

We demonstrate flexible substrates compatible with full photolithographic process with 2 micron features sizes and microfabrication processes at temperatures up to 300°C. Substrates compatible with high mobility semiconductors such as indium-gallium zinc oxide are highlighted. Devices are thermally cycled through thermal transitions and compared to state-of-the-art flexible substrates including biaxially oriented poly (ethylene naphthalate), polydimethylsiloxane, polyimides and others.

We demonstrate methods to 3D print materials that are isotropic, namely deformation perpendicular to the print grain does not lead to poorer thermomechanical properties than deformation in the XY plane along the print grain. This is accomplished using thiol-click chemistries and recently developed stereolithography printing techniques including our patent pending Z-Cup® paradigm. Tough materials across modulus ranges are printed into complex shapes and compared to state-of-the-art 3D printed materials. We take advantage of partial polymerization of oxygen-tolerant resins that can subsequently chemically crosslink into successive layers leading to strong tough materials.