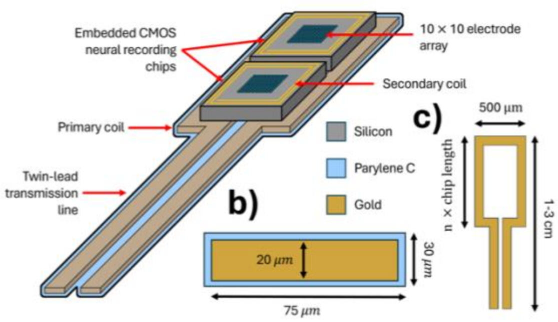
Project Description

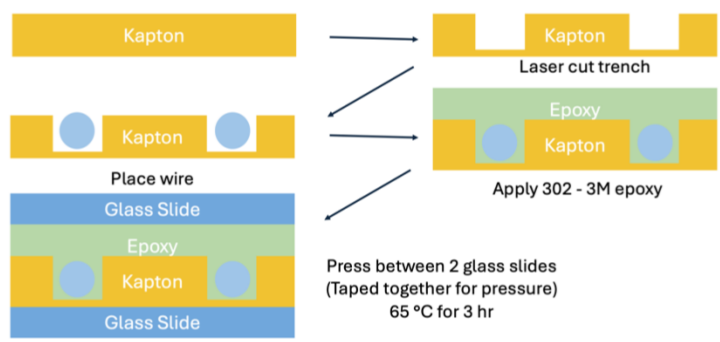
High-Density Flexible Neural Recording Probe

The goal of this project is to design, fabricate, and characterize a high-density, flexible neural recording probe that combines the flexibility of polymer-based neural interfaces with the high electrode density of silicon-based technologies. This hybrid approach aims to enforce high spatial resolution neural recordings while maintaining flexible mechanical properties and biocompatibility required for neural implants.



Neural Recording Probe Diagram

The neural probe is composed of a flexible shank with 1-3 application-specific integrated circuits (ASICs) on the coil. Digitized neural recordings are transmitted via inductive coupling between the ASIC coils and the probe coil. To create this hybrid neural probe, I have assisted my lab in developing and testing the fabrication procedure for the flexible shank. Such methods that I have performed include patterning titanium sheets through femtosecond laser ablation, designing coil molds on CAD software to be 3D printed, designing 2D coil patterns in KLayout to be engraved on silicon wafers, and depositing and etching parylene. I assisted in device packaging, which entails the soldering and molding of the coil to SMA connectors for measurements. This fabrication process involves extensive ideation and testing to maximize inductive coupling strength while also maintaining proper insulation and probe durability.



Coil fabrication technique: parylene engraving + epoxy

I have measured different variations of the coil and conducted data analytics on such measurements. To simulate the neural probe's performance, I conducted COMSOL simulations, studying the magnetic field and inductance of the coil across various frequencies and calculating the coil's Q factor.

I am currently selecting and simulating an appropriate high-speed analog-to-digital converter (ADC) that will contribute to the printed circuit board (PCB) that both drives and reads the neural probe. This PCB generates a 960 MHz carrier signal with a 1 MHz amplitude modulation. The ADC receives and digitizes the probe's analog signal, preparing the neural data for demodulation. I am working on studying the key specifications of the ADC, such as sampling rate and resolution, and simulating its functionality in LTspice

Looking ahead, I will continue to explore strategies for coil fabrication to optimize for signal integrity and biocompatibility and will continue to characterize and simulate the coil designs. In the near future, I will begin developing methods to securely bond the ASIC onto the coil for stable operation and reliability.

By integrating a flexible polymer shank with high-density silicon-based electronics, this project highlights a novel approach to creating high-density, flexible neural recording devices. This research holds great promise for advancing the field of neural interfaces, encouraging the development for more effective and durable tools for neural recording technology and neurological research.