# Defense Announcement

## DEVELOPMENT OF PROTOTYPE MANUFACTURING PROCESS FOR RELIABLE OPTICAL-FIBER BASED NEURAL PROBES

**Apeksha Awale**

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Committee Chair: Dr. Jack Wolfe

Committee Members: Dr. Wei-chuan Shih
Dr. Wanda Zagozdzon-Wos
Dr. John Miller (Physics)
Dr. Valentin Dragoi (UT)

The function of a neuron depends on its microcircuitry - the inputs it receives from local and long-range connections and the outputs it sends to other neurons. Mapping these connections is typically done by stimulating a population of neurons chemically, electrically, or optically, and recording the induced extracellular action potentials with implanted metallic probes. The probes may be cylindrical needles or thin planar blades. The needles have an advantage for deep structures since their circular cross-section minimizes friction, hence insertion force, while planar probes provide much greater design flexibility at low cost by leveraging semiconductor manufacturing technology. In this thesis, we explore the possibility of manufacturing cylindrical probes with dense thin film electrode patterns on fine optical fibers, thus, providing the design flexibility of planar probes in the cylindrical format required for deep brain applications.

Our group reported the fabrication of cylindrical probes with 4-integrated electrodes on 60 µm optical fibers at EIPBN-2013. These proof-of-concept *optrodes* were used to detect photo-simulated electrical activity of neurons in the primary visual cortex of *Olemur garnettii*, a non-prosimian primate. However, processing times were unacceptably long, about 1 month for a batch of 4 probes, and all experienced short-term electrode failure in cerebro-spinal fluid through insulator delamination, which remains a major obstacle to long-term viability of many state-of-the-art probe technologies.

In this thesis we report optimized processes that reduce the time and increase batch size for fabricating 4-channel optrodes that result in a projected processing time of 80 minutes for a batch of 16 probes-about 5 minutes/probe. Our most important achievement was the development of a rugged, pin-hole free dielectric coating with stable impedance in phosphate-buffered saline over a period of 10 days under moderate ($6mA/cm^2$) electrical stimulation at frequencies from 200-10,000 Hz. Electrode impedance on a 60 µm fiber was unchanged after 6 repeated insertions to a depth of 3.8 cm in agar gel (Landor Trading Company), which simulat