SECTION C -- DESCRIPTION/SPECIFICATION/WORK STATEMENT

ARTICLE C.1. Background

Microelectrode arrays are being developed that are capable of stimulating or recording concurrently from many individual cells in the central nervous system. In acute settings, stimulation or recording can be routinely accomplished. Unfortunately, the techniques that are effective for acute recording and stimulation do not generalize to the chronic recording environment. For dependable chronic recording or stimulation of specific cells, the interface between the microelectrodes and the target cells needs to be made more stable. This research effort will focus on achieving such stability through modification of the surface properties of microelectrode arrays.

The surface of an implanted microelectrode interacts with the neural and other cells around it mechanically and chemically as well as electrically. This interaction is a major determinant of the long-term viability of the microelectrode-cell interface. Two factors that work against a stable interface are differences in mechanical stiffness between the microelectrode and neural tissue; and a surface chemistry on the microelectrode that does not promote specific cell attachment.

With respect to stiffness, silicon microelectrodes have an elastic modulus of around 100 gigaPascals. The stiffness of neural tissue is on the order of 0.1 megapascals. This million fold difference in stiffness can result in significant differential movement in response to an external stress. The mismatch is a greater problem in large brained animals where the greater movements of the brain in the skull can produce greater stress loads. A variety of methods such as a graded interface between the silicon and neural tissue offer the possibility of a significant reduction in the stiffness mismatch.

The surface of an implant should also be chemically recognized by the target neural tissue as a surface that is appropriate for contact. Our current understanding of communication between cells and between a cell and the extracellular matrix provide clues about how to develop microelectrode surfaces to promote neural adhesion. Advances in surface chemistry now provide the techniques to produce microelectrode surfaces with a wide variety of exposed surface functional groups that can include both extracellular matrix factors and trophic factors.

Advances in these critical areas raises the likelihood that a new generation of electrodes for chronic implantation into the CNS can be developed. This research project will develop biomaterials for a chronic microelectrode-neural interface. The goal is to develop a matrix on the surface of a microelectrode that both biomechanically and biochemically supports the growth and adhesion of neurons. These surfaces will then be tested in an animal model to evaluate interface stability.

ARTICLE C.2. STATEMENT OF WORK

Independently, and not as an agent of the Government, the contractor shall develop a biocompatible matrix on the surface of implantable silicon microstructures that will improve the mechanical stability of the microelectrode-tissue interface and will provide a bridge between the microstructure and neurons, glia, and related cells.

Specifically, the contractor shall:

A. Develop or select candidate matrix surfaces that are likely to enhance mechanical stability at the interface of neural tissue and a microelectrode array implanted chronically in the central nervous system.

B. Select or develop candidate organic functional groups that are bound to or diffuse from the matrix surface and that are likely to enhance growth and/or adhesion of neurons or neuronal processes to specific regions of an implanted silicon microelectrode array.

C. Develop or adapt methods to deposit a matrix with selected surface functional groups onto silicon microelectrode arrays. Microelectrode arrays shall be selected from the devices available at the Center for Neural Communication Technology (http://www.engin.umich.edu/center/cnct/) sponsored by the National Center for Research Resources.

    1. The matrix and functional groups shall be stable in saline at 37^{o} C. for at least 3 months.
    2. The matrix shall remain adherent to the microelectrode following implantation through the pia-arachnoid into neural tissue.

D. Select an in-situ animal model(s) of mammalian cortex (excluding chimpanzees) and investigate the growth and adhesion of neurons, glia, micro-glia, and other cells present in the nervous system on chronically implanted microelectrode arrays coated with the selected matrix. Studies shall be done with and without cables attached to the microelectrode arrays.

E. Cooperate with other investigators in the Neural Prosthesis Program by coating microelectrodes (estimate 50 over the contract period) with the most promising materials for in-vivo evaluation. The microelectrodes will be supplied by the NINDS Project Officer.

F. Upon completion of the tasks specified above, prepare and deliver to the government a comprehensive final report that shall summarize what was achieved, what was not achieved and shall include recommendations for future research and development in this research area.