CMC MICROSYSTEMS
IMPACT

Microelectronics are the Basis of a Medical Collaboration Providing New Capabilities in Treating Neurological Diseases

Through guided neuron growth, enabled by microelectronic technologies, a team of collaborators in Alberta aim to provide new capabilities to doctors that will improve a patient's brain function or increase the mobility of patients who have suffered an injury to the nervous system.

Dr. Colin Dalton at the University of Calgary is using silicon circuitry to provide medical researchers with intelligent tools to gain a better understanding of brain and other neurological diseases.

Silicon circuitry is providing medical researchers with intelligent tools for studying the cells of the human nervous system. This improved capability helps neuroscientists gain a better understanding of brain and other neurological diseases. Traditionally, the study of cells is facilitated through the use of laboratory tools known as patch clamps. The main shortfall of this technique is the limited number of neurons that can be studied at once—typical commercial clamps allow for up to ten isolated cells at a time. Silicon devices, on the other hand, provide the capability to study entire networks of cells and how they react to one another.

This is the basis for the multi-disciplinary collaboration that brings together medical researchers and engineers from the Universities of Alberta, Calgary, and Saskatchewan, and Foothills Hospital in Calgary, Alberta. The group is supported by a Canadian Institute of Health Research collaborative grant. Pivotal to their research is a biomedical microsystem that relies on silicon circuitry and advanced material processing. The technical advice for the device is provided by Dr. Colin Dalton, leading expert in micro-nano research with the Advanced Microsystems Integration Facility (AMIF) at the University of Calgary.

Severed or damaged neurons often don't re-grow on their own. And when they do, it can take a long time—after a nerve injury to the human arm, for example, it may take months for feeling to return to hands and fingers. The team has developed a multi-electrode array or MEA that provides electrical stimulation to neurons on the device and allows the team to study a network of 60 neurons. This technique allows them to examine the process to regrow nerve tissue, with the future potential to coax nerve growth around scar tissue. The MEA is designed using the CMC-supported software L-Edit from Tanner Research, and manufactured using a microfabrication process at the AMIF cleanroom facility. Currently, off-chip measurement equipment is used to characterize the connection.

While Dr. Dalton develops the specialised chips for this project, medical researchers are growing neurons in their lab—to be later characterized by the MEA—and conducting animal testing. There is continuous feedback from medical to engineering faculties that helps to iterate the design. Coupled with access to advanced micro-nano technologies, the multi-disciplinary nature of the team is the essential ingredient to the success of this project. Explains Dr. Dalton, "No one person can know all this anymore. To be successful you need different people with different backgrounds working together."

Research and development efforts are next being focused on Dr. Dalton's ultimate goal—designing a silicon chip with an array of open transistor contacts that would allow the team to stimulate potentially hundreds of neurons and directly record their activity. The planned design would also provide the inherent advantages of complementary metal oxide semiconductor (CMOS) technology—sensing, manipulation, signal processing, data storage, wired or wireless communication, greater integration, and cost-effective mass production. They have developed an early proof-of-concept prototype to move this research forward, fabricated through CMC's services in the 0.18-micron CMOS technology, provided in partnership with MOSIS and TSMC.

Dr. Dalton and his colleagues believe that much of biomedicine in the 21st Century will be technology driven and its success will depend on how well new technological development—including in silicon circuitry and advanced material processing—is effectively meshed with medical care. This team of collaborators is taking steps together to help make it happen. *cmc*