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Flexible neural interfaces for multimodal recording and stimulation

Abstract

Neural implants need to establish stable and reliable interfaces to the biological target structures for chronic applications in neurosciences as well as in clinical applications. They have to record electrical neural signals and excite neural cells or fibers by means of electrical stimulation. In optogenetic experiments, optical stimulation by integrated light sources or waveguides must be integrated on implants. Metabolic monitoring and detection of neurotransmitters is also part of the research agenda but not yet mature enough for translation in chronic clinical applications. Proper selection of materials is of utmost importance to bring the interface in close contact with the neural target structures, minimize foreign body reaction and maintain functionality over the complete implantation period, and allow MR imaging in the best case. Our work has focused on polymer substrates like polyimide with integrated thin-film metallization and silicone rubber with metal sheets. Micromachining and laser structuring are the main technologies for electrode array manufacturing. Designing applications for implants in the peripheral and central nervous system needs integration of components, the connection of cables and connectors to both, electrode arrays and hermetic packages containing electronic circuitry for recording, stimulation and signal processing. Failure of one of the components or connections stops the function of the whole system. Thin-film substrates and hybrid combinations with silicone rubber substrates serve as neural interfaces. Adhesion layers have been integrated to obtain long term stability of polyimide-platinum sandwiches. If electrode arrays with hundreds of channels are desired, hermetic packages with the same number of electrical feed-throughs are needed and require novel assembling approaches. Examples of sensory feedback after amputation trauma, vagal nerve stimulation to treat hypertension and chronic recordings from the brain surface display opportunities and challenges of these miniaturized implants. System assembly and interfacing microsystems to robust cables and connectors still is a major challenge in transition of research results into medical products. If they meet the target specifications of longevity and robustness, they open a door for more complex applications to restore functions in neural rehabilitation and to open new treatment paradigms in neural disorders and bioelectronics medicine.

IIT@UNIFE seminar – February, 20th, 2019 at 15:30 @F10 room - Chiostro S.M. delle Grazie at University of Ferrara
(Videoconference available)

Invited by: Prof. Luciano Fadiga