Seminar of the IPQ

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"Flexible neural implants for applications in fundamental and translational research"
Prof Dr. Thomas Stieglitz

Abstract:

Neural interfaces need to provide stable and reliable functional interfaces to the target structure in chronic implantations both in neuroscience experiments and especially in human clinical applications. Proper selection of substrate, insulation, and electrode materials is of paramount importance as well as the knowledge how process parameters in device manufacturing influence material longevity. Aspects such as size, thickness, and shape contribute significantly to structural biocompatibility and modulate post-implantation foreign body reaction.

Our work focused on polyimide as the substrate and insulating material with integrated thin film metallization as the conductor in our flexible neural interface approach. Platinum, iridium oxide, glassy carbon, and PEDOT serve as interconnect lines and electrode coatings, respectively, depending on the intended electrode size and application. We have investigated different metal-polyimide compounds after in vitro stimulation but also devices after explantation. Optical imaging during electrical stimulation of platinum in vitro showed actuation of thin-films during Implantation as potential origin of adhesion loss. In addition, accelerated aging led to changes in grain structures in these platinum layers. Post explantation analysis of platinum recording arrays from studies up to two years in ferrets proved these initial observations and showed signs of hydrogen embrittlement. In addition, dimpling of arrays into brain tissue, secondary dura and bone growths showed limitations in structural biocompatibility in exemplary cases. Peripheral nerve electrodes from stimulation in human clinical studies over a period of up to six months has demonstrated the stability of iridium oxide sites and the integrity of the metal-polymer multilayer film using silicon carbide as an adhesion promoter. Analysis of explanted fragments, however, showed the necessity to be able to image the device-tissue interface in one stage without separating devices from biological material. The layer composition and tissue contact to the surface might help to better assess the interface compatibility and the influence of surface roughness and coatings on the foreign body reaction and device functionality and longevity.

So far, results are encouraging to continue the translational research path from basic studies to the first human clinical trials, which are necessary to prove that new materials, technologies and devices are applicable in clinical applications and can eventually be translated into an approved medical device.

CV:

Thomas Stieglitz studied electrical engineering in Braunschweig and Karlsruhe. He established the research field of neuroprosthetics at the Fraunhofer Institute for Biomedical Engineering in St. Ingbert/Saar between 1993 and 2004. He received his PhD in 1998 and completed his habilitation in 2002 at Saarland University. Since 2004, he has headed the Chair of Biomedical Microtechnology at the Department of Microsystems Engineering at the University of Freiburg. Stieglitz teaches and conducts research in the field of neurotechnical implants. In 2000, he was awarded the SaarLB Science Prize. Stieglitz is co-founder and advisory board member of the start-up company CorTec.