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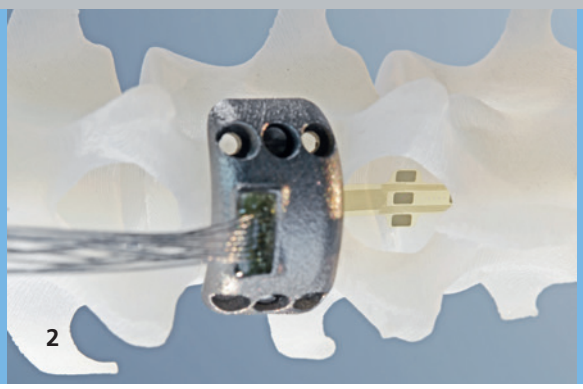
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1 *Rigid 32-channel electrode probe with model of the human brain*
2 *Spinal array with titanium attachment mounted on a 3D-model of a monkey's spine*

MULTISITE MICROELECTRODES FOR NEUROENGINEERING APPLICATIONS

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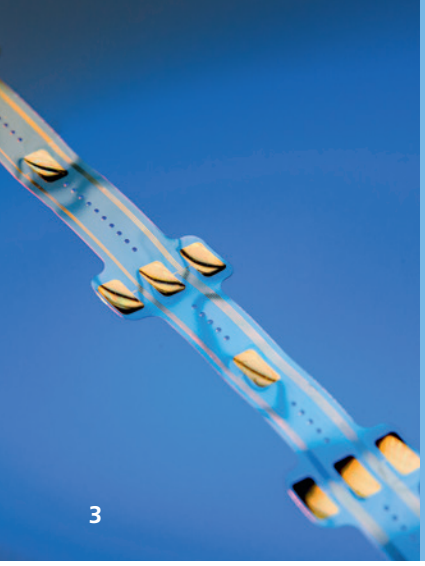
Neuroengineering is a rapidly emerging, multidisciplinary field combining micro- and nanotechnology, microelectronics and computational science with neuroscience. Ultimate goal is to increase the basic knowledge of how the central nervous system works and to realize smart, neuroprosthetic systems capable to restore abilities that might have been damaged as a result of an injury or a neurological disease.

Prominent examples already established in clinical application are e.g. cochlea implants providing sound function to profoundly deaf or the so-called deep brain stimulation employed to alleviate the symptoms e.g. of Parkinson's disease and other neurological disorders. Presently developed retinal implants promise to restore vision after blindness due to retinal diseases. Novel concepts based on electrical stimulation of the spinal cord impressively demonstrated the capacity to restore lost motor functions after severe injury of the spinal cord.

Core component of many neuroprosthetic devices are implantable electrodes. These provide the interaction with the nervous system either through evocation of neural responses via injection of charge puls es or by recording the action potentials related to neural activity.

Custom microelectrode arrays

Due to a number of co-operations with leading partners from neuroscience research, neurosurgery and medical companies IMM has gathered particular expertise in custom development and manufacturing



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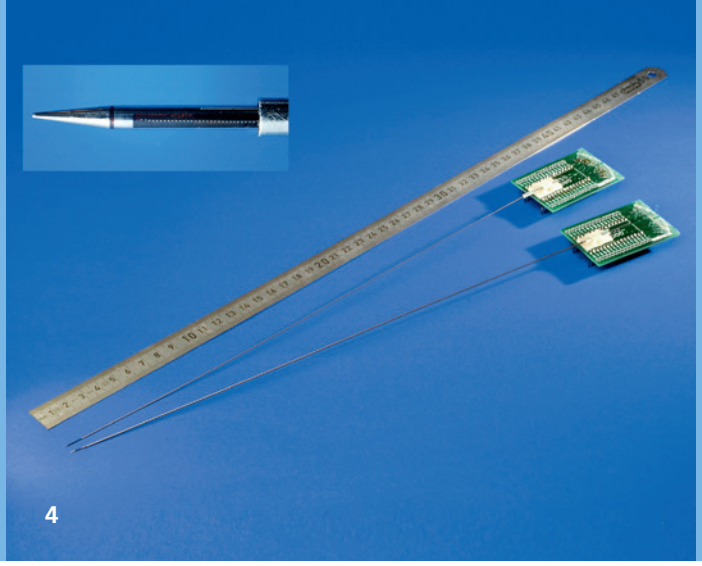

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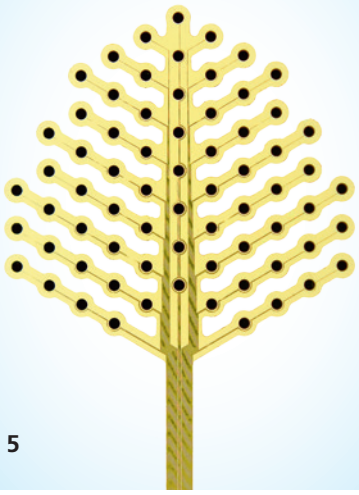

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of rigid as well as flexible multisite microelectrode arrays for neural signal recording and neural stimulation applications. Medical background of these activities are e.g.

- faster, more reliable identification of target areas in the brain by locally resolved multisite recording,
- in vivo identification of residua of malign brain tumors,
- demand-controlled closed loop deep brain stimulation for improved treatment of e.g. the symptoms of, Parkinson's disease
- restoration of motor functions in paralyzed individuals by spatiotemporal stimulation of the spinal cord.

Summary rigid probes

- Custom length 1.5 to 34 cm
- Linear array with up to 32 gold electrodes
- Electrode diameter 50 µm
- Center electrode
- Small probe diameter 300 to 600 µm, depending on number of electrodes
- Made from medical grade materials
- Fully sterilizable e.g. by autoclavation
- Unbreakable under typical conditions of use
- Electrically shielded for high S/N ratio
- Multiple use

Summary flexible arrays

- High flexibility
- Almost any electrode arrangement can be realized
- Minimal thickness 10 µm
- Electrode diameter down to 5 µm
- Electrode material gold, platinum and others
- Low resistance due to reinforcement by electroplating
- Dedicated interfacing technologies e.g. to connect surgical leads
- Integration of electronic components feasible

Rigid multi-site electrode probes

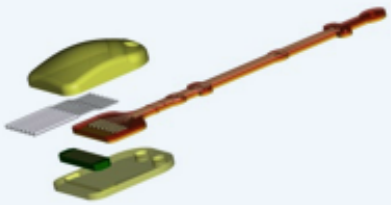
These probes can be equipped with a linear array of up to 31 microelectrodes allowing spatially resolved recording of the neural signals in the target area and thus help to increase speed, efficiency and precision in neurosurgical interventions. A central tip electrode can be used for recording as well as for stimulation. Fabricable in custom-defined lengths ranging from 15 up to 340 mm the probes can be combined with standard stereotaxic frames. All materials in contact to tissues comply with medical product regulations. The outer sheath is formed by a stainless steel capillary providing high mechanical robustness, rupture strength and good electrical shielding as well. In animal studies the probes are suited for multiple use. The connector interface at the distal end can be realized according to the customer's needs.

Flexible electrode arrays

Manufacturing of flexible electrode arrays is based on UV-lithographic structuring of photosensitive Polyimide (PI) formulations. Polyimide is known to be a mechanically and chemically extremely robust polymer of proven high biocompatibility. The process offers vast design freedom regarding the overall size and the arrangement of the electrodes to realize custom-made devices. Reinforcement of the gold leads and electrodes by electroplating provides low ohmic resistance making such devices well suited for electrical stimulation of neuronal structures. Coating of the gold electrodes with other materials such as e.g. platinum is also feasible.

For the interfacing of the arrays with surgical leads, encapsulation of the connecting zone and secure fixation of the array, e.g. on the vertebra, dedicated techniques have been developed.

Epidural stimulaton of the spinal cord of rats



Design layout and interfacing of electrode implant

3 *Flexible electrode array designed for implantation in the spinal canal of primate animals*

4 *Rigid, 34 cm long probe with linear 32-fold electrode array for stereotaxic neuronavigation*

5 *Flexible array for epidural cortical multisite recordings*