IMEC's CMORE platform

Neuroelectronics @ IMEC

Technology description

The merger of life sciences and electronic engineering offers new, exciting and practical methodologies for the development of bio-electronic hybrid systems. Although still in their infancy, neuro-electronic interfacing technologies are already present in retinal and cochlear implants and are used to explain and eventually treat, brain disorders or their symptoms, such as the Parkinson and Alzheimer diseases.

IMEC is developing neuro-electronic hybrid systems based on the concept of an artificial synapse between a neuron (pre-synaptic element) and a microelectronic device (post-synaptic element). The hardware part of such a system integrates different transducers, able to pick up and/or trigger both electrical and chemical neuronal signals, with readout and data processing electronics. Moreover, IMEC combines top-down and bottom up micro- and nanofabrication techniques in order to create a cellular micro-environment on chip. The role of this bio-environment is to ensure long-term cell survival, strong adhesion between the cell membrane and the chip surface as well as reliable anchoring of receptor molecules.

Applications

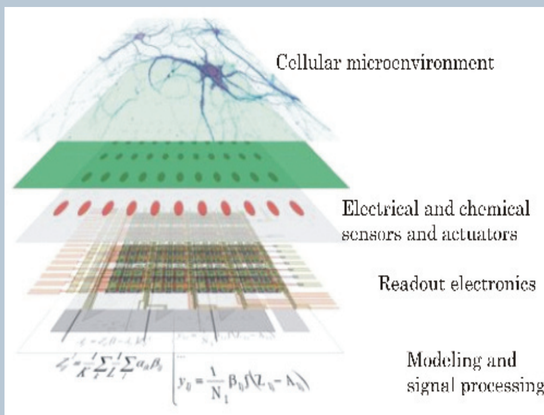
The enormous importance of neuro-electronic hybrid systems for medical use is quite obvious. Brain diseases represent 35% of the total disease burden in Europe. If all the related sequelae and complications are included, this percentage is even higher. The burden of brain diseases is expected to increase in the future by the ageing European population.. Age is the major risk factor for neurodegenerative diseases such as Alzheimer's and Parkinson's diseases, exacting a terrible human toll. Novel technologies are therefore needed to better understand the early stages of the disease process in vitro as they occur in patients in vivo. These technologies will lead to better screening assays helping to identify small compounds that can be used in clinical trials. For instance, IMEC's platform could be customized to serve as a model system for Alzheimer's disease research, helping to understand how the amyloid burden in the brain of Alzheimer's patients causes the neurodegenerative process. Functional interfaces enabling bi-directional communication between nerve cells and electronic devices could be used in order to simulate the early steps of the disease process in vitro as they occur in patients in vivo. This could lead to better screening assays helping to identify small compounds that can be used in clinical trials.

Neuro-electronic hybrid systems would also be applicable in deep brain stimulation and micro-recording, for example in surgical therapy of Parkinson's disease or of some obsessive compulsive disorders, by amelioration of or by additional functionality to current implant technology.

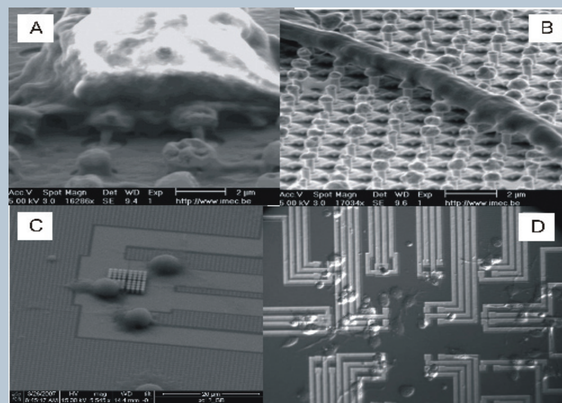
Technology advantages

IMEC develops and integrates in a multidisciplinary environment a couple of selected base technologies enabling the construction of neuro-electronic junctions. A novel neuro-ICT hybrid platform, relying on direct interactions between the IC technology and living cells, could constitute a significant improvement to both state-of-the-art in vitro systems and implants.

Immediate applications for these technologies are high-throughput, automated pharmacological studies on primary cell cultures and cell lines. Compared to classical electrophysiology tools (i.e. patch clamp), the neuron-electronic systems offer the advantages of minimal invasiveness (extra-cellular recording and stimulation), high-throughput and automation.



Neuro-electronics deals with a complex interfacing problem: integration of cells and electronics at micro- and nano-scales requires development and integration of several key technologies (i.e. cellular environment on chip, electronic sensors and actuators, readout electronics, modeling and signal processing).



Cells on chips: (A) and (B) neuron-blastoma cells on sub-micron nails (SEM micrographs); (C) and (D) PC12 cells on nail-decorated electrodes.

Benchmarking

The neuro-IT field is extremely broad and involves a large variety of technologies and application domains and sub-domains. Consequently, worldwide many research groups investigate different relevant technologies and/or applications including development of hardware and software for recording neuronal signals (spikes), bio-mimetic surfaces and patterned neuronal networks, tissue engineering, prosthetic devices (e.g. cohlear and retinal implants, cortical prostheses etc.), brain plasticity, biocompatibility, bio-computation, robotics etc.

Consisting of a set of multidisciplinary explorations combining new and alternative approaches of future and emerging ICT-related technologies with biotechnologies, IMEC's research brings vital know-how for the development of brain-computer interfaces (i.e. the "base technologies"). In the future, these technologies will be heterogeneously integrated following the system-in-a-package approach.

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