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ASPECTS OF FUNCTIONAL ELECTRO-CHEMICAL BIOCOMPATIBILITY IN MICROSYSTEMS

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Biosystems, such as single living cells, show characteristics that strongly differ from technical systems: a high complexity by function integration into the substrate, dynamic stabilization and adaptivity of structures as well as an encaptic hierarchy of the evolutively differentiated sub-systems. Signal transport as well as signal processing are based on ion fluxes.
Bases of a general understanding of functional electro-chemical biocompatibility aspects in the area of microsystems are introduced, derived from experiences in several research projects. One important project was the utilization of active polymers for miniaturized actuators. With an electro-chemically driven pump, an effective conversion of energy could be shown [1].
Cyto-based regenerative medicine is an ongoing and fast growing worldwide research field. Our research approaches are focused on hybrid microsystems, to cultivate and/or accommodate biologic specimen inside technical structures even for long-term experiments. First theoretical and empirical knowledge as well as engineering experiences were requirements for research of the synthesis of extracellular matrices and the technical housing and fluidic support for a crystalloid P-Protein [2]. This rather large and chemo-active molecule was used to demonstrate a bio-hybrid fluidic switch (valve) based on ion-management (Ca^{2+}/EDTA-chelation).
Cells as well as organisms require a function saving environment (ecosystem) that ensures beneath other components energy and information supply. Thus, microsystems have to provide the capability to handle extremely small amounts of signal carrying substances (ions). In microstructures, both in the cellular dimensions of organisms and technical components, surface-related physical interactions dominate the volume-based effects. This makes the substance and energy transfer on interfaces to be a crucial and dynamic part of all structures and functions. Respecting these propositions, microsystems allow for micro-chemical stimulation of cells as well as signal derivation on cells using ionomeric intermediate layers. We tested this approach in several experiments. One setup is a planar flow-through chamber with two electrodes of the second kind (Ag/AgCl-contacts on glass frit carrier), in which the galvano-tactic behaviour of protozoa could be observed. A double-chamber setup according to USSING utilizes a cation-permeable membrane of Nafion® to separate two fluidic compartments. In these, a concentration gradient is established between isotonic NaCl-solution and distilled water. This gradient generates a reproducible potential on a physiologically relevant level. To avoid disturbance of side effects like polarization and transition impedance, non-electric control of ion flux can be implemented using UV-light

instead of metallic electrodes. This radiation can induce reversible conformation changes in complex-compounds (chelates), which are embedded into polymeric conductors, thus generating local and transient ionic signals. An initial electron transfer reaction is required which was realized in an UV transparent flow chamber. A miniaturized and technology compatible UV-plasma source has been developed in cooperation with the department of Electronic Technology at Technische Universität Ilmenau. All these components and layouts establish preconditions to have an optimized functional electro-chemical biocompatibility in communication with living cells and tissue. Beside the low feedback of the signal derivation of cell membrane potentials, also a new impulse can be set for the elucidation of control mechanisms for cell motility, cell differentiation, and morphogenetic regulation.

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