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Influencing Cell Growth and Adhesion on Microelectronic Sensor Surfaces

H. D. Wanzenboeck[1], C. Almeder[1], K. Dominizi[1], P. Hagl[1], E. Bertagnolli[1]
E. Bogner[2], M. Wirth[2], F. Gabor[2]

[1] Vienna University of Technology
Institute for Solid State Electronics
Floragasse 7/1
A-1040 Vienna, AUSTRIA

[2] University of Vienna
Institute for Pharamceutical Technology and Biopharmaceutics
Althanstrasse
A-1090 Vienna, AUSTRIA

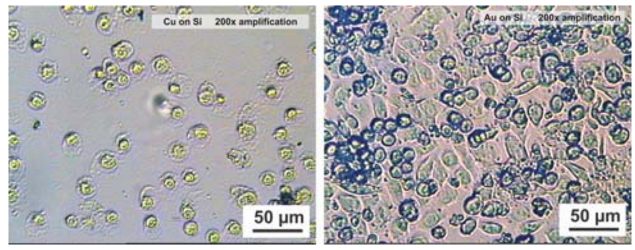
Future microelectronic biodevices and biosystems will heavily rely on noninvasive biological cell identification and cell interrogation devices. Cell-based biosensors will allow analytical applications to couple the exquisite selectivity of living systems with the processing power of modern microelectronics. for monitoring pharmacological processes such biosensor are demanded to be robust and reliable. However, this interdisciplinary technology faces fundamental technological challenges. The crucial point for all applications is the adhesion and growth rate of biological cells on the inorganic materials typically used in microelectronic device fabrication. In this study the effect of the substrate material and of the surface roughness on the cell growth was investigated.

To clarify the influence of the material a cell culture of colon carcinoma cells (CaCo-2) was grown directly on microelectronic material samples. The CaCo-2 cells are well acknowledged for being an excellent model for studying human intestinal ephithel cells. A comprehensive investigation on the biocompatibility of microelectronic materials was performed. Either pure semiconductor wafers or wafers were coated with a metall or a dielectric layer were used. The viability of cell cultures was tested on several metals, dielectrics and semiconductors. Gold was identified to be a highly suitable metal to serve as electrode. Silicon nitride showed to be the most appropriate insulator enabling unconstrained cell growth. For mixed substrates with gold and silicon nitride the cell tissue was observed to equally cover metal and insulator areas.

Also the effect of surface topography of the sample on the cell growth or adhesion was studied. Grid arrays of an ordered sequence of uniform mesas and trenches was fabricated with a periodicity ranging from 2 µm up to 100 µm. CaCo-2 cells have a diameter of 10 up to 40 µm so that the surface roughness in this range is relevant for the cell growth on the surface. Topographic steps of 200 nm height were no obstruction for cell growth. Preliminary results indicate that on rougher surfaces even a better cell adhesion was observed.

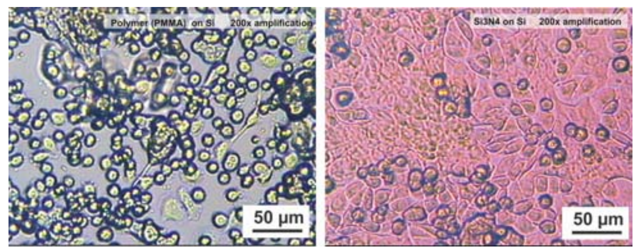
With a functional electrode array the cells may be manipulated depending on the electrode configuration . When integrated with a signal processor this renders a sensor array that may simultaneously read out several signals or generate arbitrary electric field shapes.

Bioelectronic devices offer powerful new analytical tools with major applications in medicine, pharmaceutical research, environmental diagnostics and the food and processing industries.



(a) (b)

Fig. 1. CaCo-2 cells grown on Cu (a) and on Au (b) for the same period. Cu appears to inhibit cell growth.



(a) (b)

Fig. 2. CaCo-2 cells grown on PMMA photoresist (a) and on silicon nitride (b) for the same period. On silicon nitride the growth is faster and cells adher on the surface.