



Research project:

Micro electrode chambers for the investigation of RF field effects on adherent cells in physiological media

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Duration: June 1997 – June 1999

Objective

- Development and testing of standardized, RF-suitable micro systems for experiments on cells in the Hz, MHz and GHz range
- Investigation of the effects of strong electromagnetic fields on adherent and suspended cells within micro electrode chambers during short time and long time experiments
- Exact calculations of the field strength and temperature within and near to the exposed cells

Results

- Micro structures for the exposure of living cells at 900 MHz and 1,8 GHz were developed and successfully tested
- Cell experiments in the range of 100 Hz to 250 MHz resulted in definite key data where the cells were not damaged, potentially damaged or actually damaged; temperature effects could be clearly differentiated from field effects
- Field parameters near the cells were very good determinable

Investigation parameters

- in cells:
 - increase of cell volume
 - proliferation rate
 - cell migration behavior
 - metabolic activities (e.g. endocytosis)
 - adhesion behavior
 - changes of the cytoskeleton
 - metabolic activities in mitochondria
 - membrane permeability and membrane flow
- at the technical micro structures:
 - local heating
 - electrical goodness
 - rotation rate and levitation (accentuation) of particles for specific field strength calculations



Exposure

Exposure parameters

Signal source / coupling and carrier material for the cells	Micro electrode structure	Slot line resonator
Carrier frequency	100 Hz up to 250 MHz	900 MHz and 1,8 GHz
Field strength	0,1 up to 100 kV/m	up to several 10 kV/m
Duration of exposure	Seconds to several weeks	up to 20 hours
Temperature increase during exposure	max. 2°C at very high field strengths	max. 2°C at very high field strengths

Experimental setup



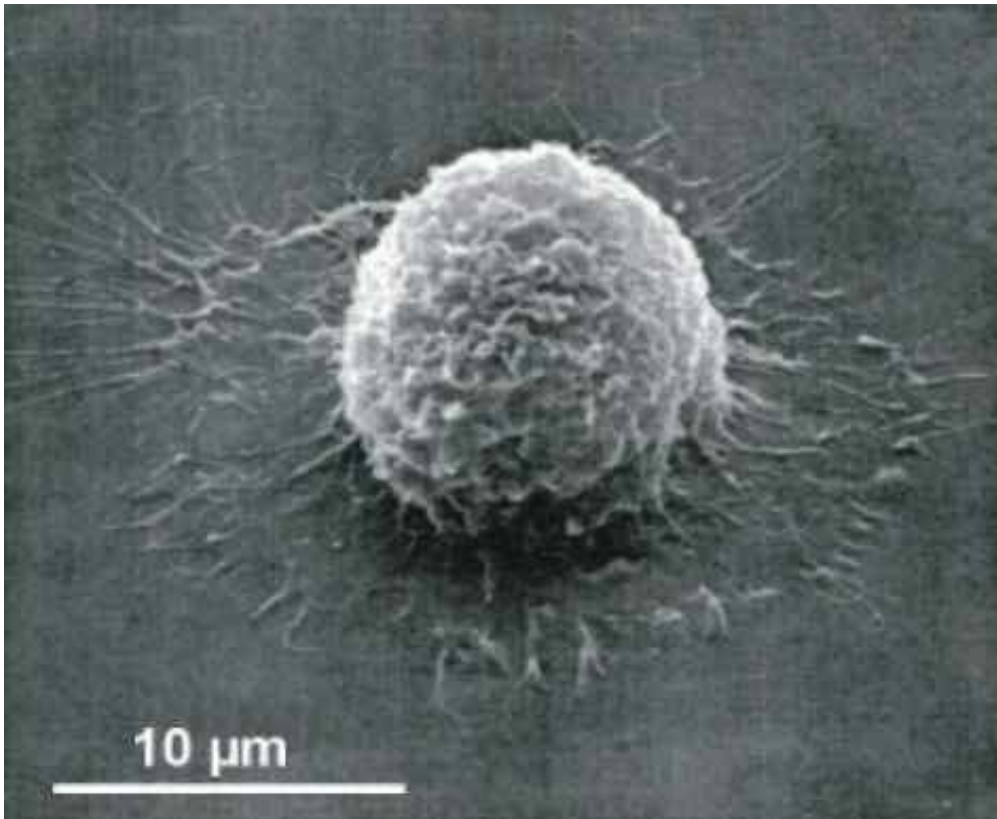
Work station consisting of two completely separated measuring systems:

per system: one microscope, thermostat, measuring chamber with perfusion system and thermo coupler, automatic video system, RF-generator as well as a dual-channel oscilloscope for computerized monitoring and control of the field parameters

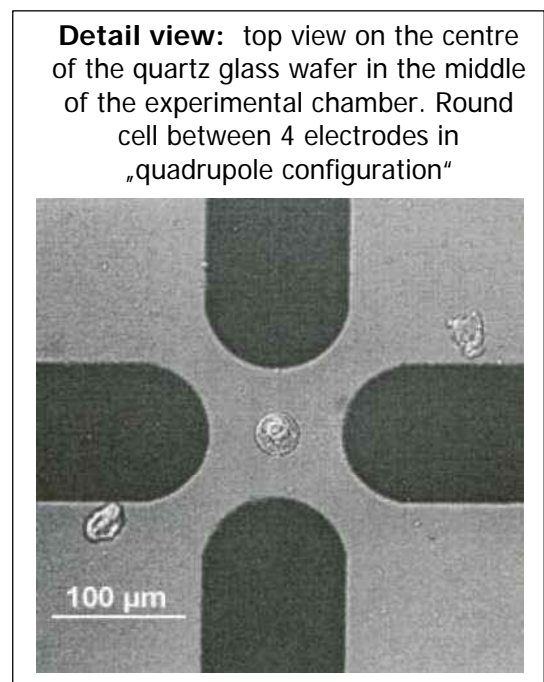
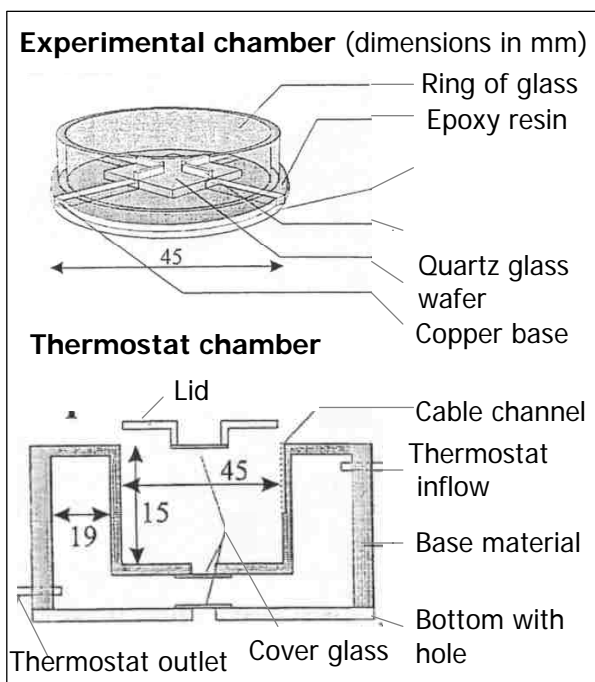


Object

Scanning electron microscopical image of a rounded fibroblast L 929 (cell of the connective tissue of mice) as an example for a typical adherent cell, used in the experiments; the cell begins to adhere to the substratum

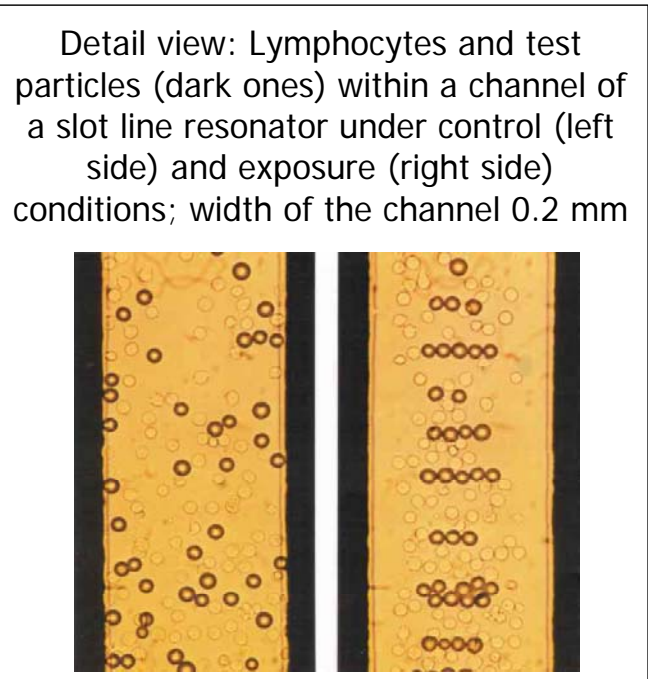
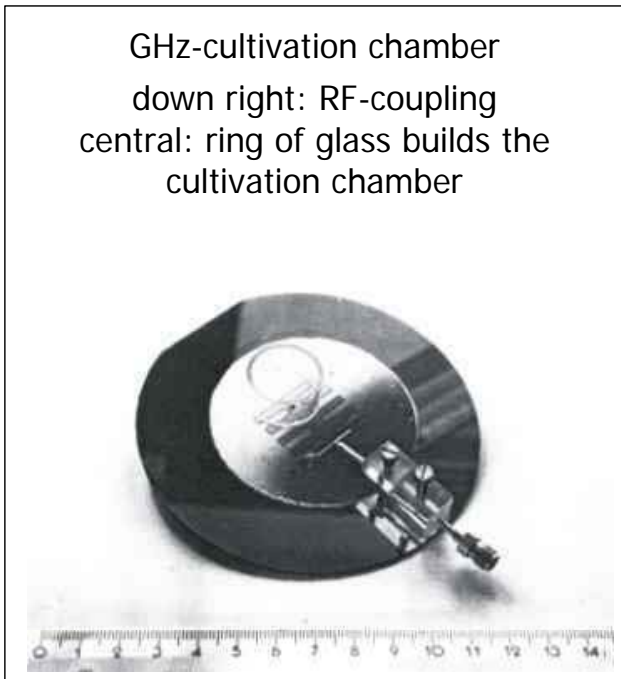


Semiconductor electrode chip





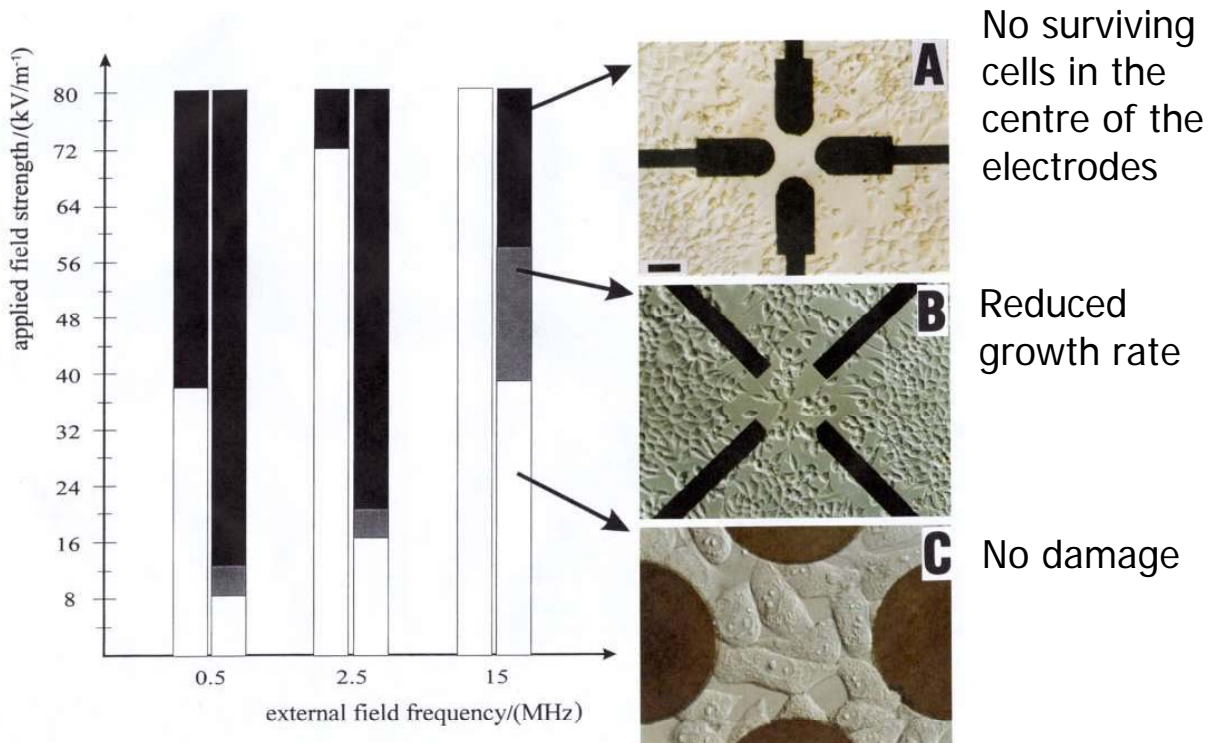
Slot line resonator



Short- and longtime experiments

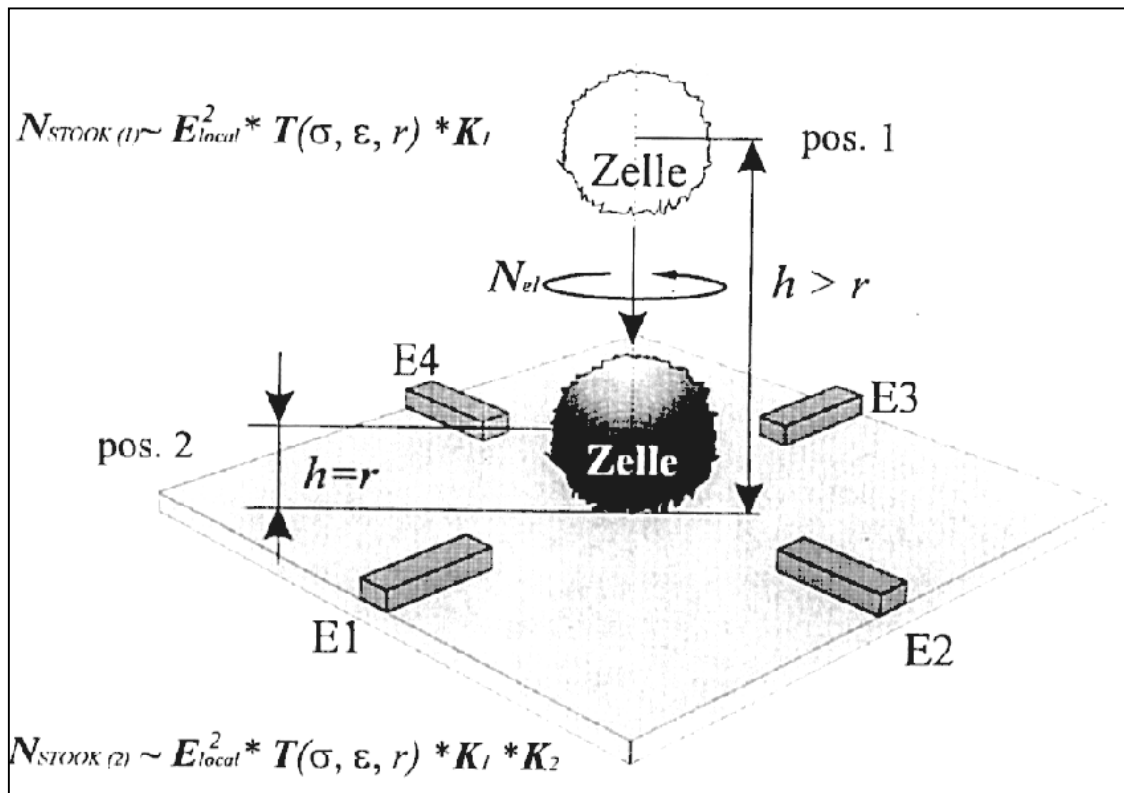
Demonstration of the influence of prolonged field application (500 kHz – 15 MHz, 1 – 80 kV/m) on growing L 929-cells at different frequencies and field strengths

Left hand bars: short time exposure (20 sec)
 Right hand bars: long time exposure (3 days)





Field calibration by rotation measurement



Measurement of the field forces for the calculation of the local field strength within the cell placed in the micro electrode chamber. Here a cell is placed between four cross-like electrodes (E1-E4). The cell is lifted and rotated by the forces of the rotating field. For calibration, the cell is replaced by a latex sphere of the same size.

Publications

„High-frequency electric field trapping of individual human spermatozoa.“

Fuhr, G. et al. 1998:

Hum. Reprod. 13(1), Seite 136-141

„Cultivation of cells under strong ac-electric field – differentiation between heating and trans-membrane potential effects.“

Glasser, H. und Fuhr, G. 1998:

Bioelectrochem. Bioenerget. 47, Seite 301-310

„Electric field calibration in micro-electrode chambers by temperature measurements.“

Glasser, H. et al. 1999:

Thermochim. Acta 333, Seite 183-190