

Application of ferrofluids to develop biocompatible micro-structured surfaces and characterization of cell-surface interactions by using SPM methods

J. IBle and U. Hartmann
Institute of Experimental Physics, P.O. Box 151 150, 66041 Saarbrücken, Germany

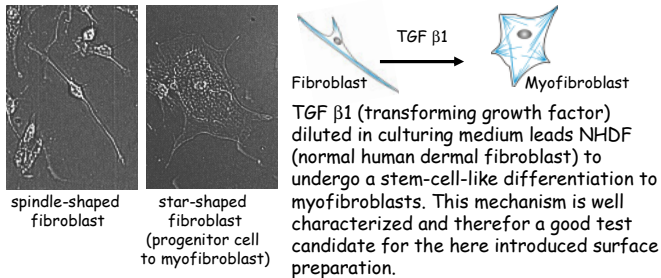
CellIPROM Project

- "reprogramming" individual stem cells by structured and functionalized surfaces (non-invasive) on an industrial scale.
- first steps in "Tissue Engineering"

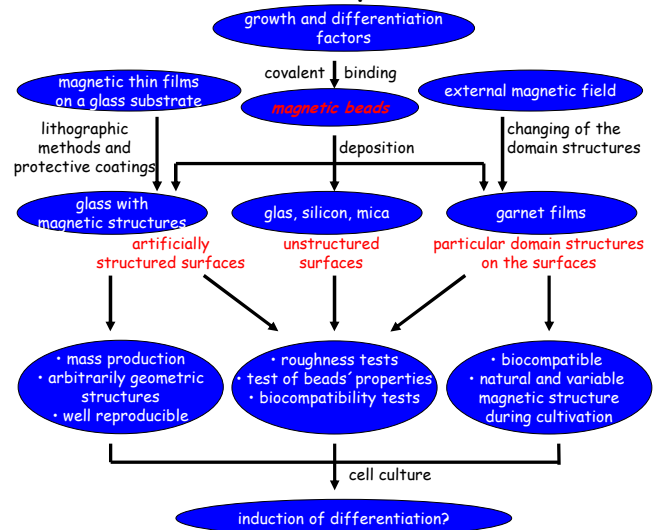
Our part:

- developing a variable system for inducing cell differentiation
- avoiding difficult chemical steps for structuring substrates
- delivering a wide range of different samples for testing cell behavior as a function of surface topography

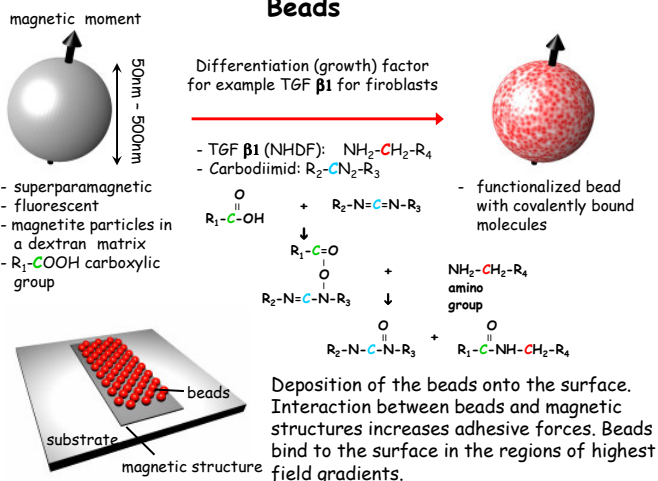
Cell Model: NHDF



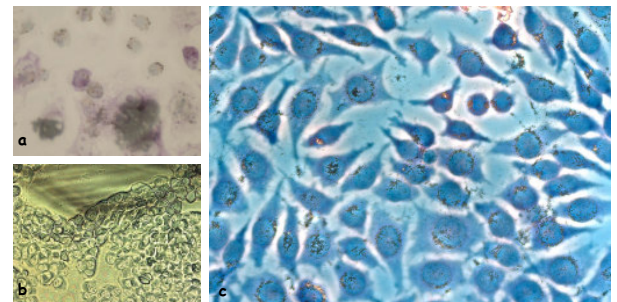
Concept



Beads

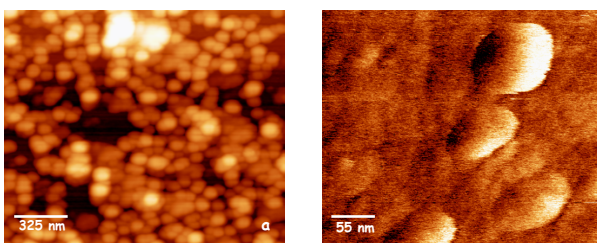


Biocompatibility Tests



- (a) HuTu on Permalloy after three days. The magnetic material peels off under cultivation conditions \Rightarrow protective coating.
 (b) L929 on a garnet film after five days. Cells grow well to confluency.
 (c) L929 with 100nm beads added to culturing media. Endocytosis: Cells collect beads around the core, dependent on size, reactive groups and material of the beads.

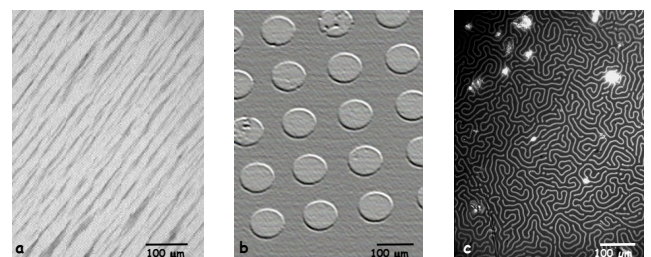
Bead Visualization



Magnetic force and atomic force microscopy are used to visualize single magnetic beads. The MFM technique gives information about the magnetic properties (stray field) of the beads or magnetic surface structures (not shown).

- a) AFM, Tapping Mode, $f_{\text{resonant}} = 70 \text{ kHz}$
 b) MFM, 50 nm mean distance to the surface, same cantilever, coated with 30 nm CoCr

Surface Structuring



- a) Light microscopic images, Beads deposited on glass, structures obtained by using a magnetic stirrer. Turning off the stirrer results in "freezing" of the structure.
 b) Magnetic thin films (here Permalloy FeNi 30 nm thick) structured by e-beam-lithography. Circles $\phi 60 \mu\text{m}$.
 c) Garnetfilm: Y Sm Bi Ga Fe
 • white/dark contrast \Leftrightarrow antiparallel magnetization
 • beads can be deposited between white and dark areas (field gradient)

Summary

A highly variable set up for a straightforward change of the chemical and topographical properties of a substrate for inducing cell differentiation is presented. The usage of functionalized magnetic beads allows to combine topographical with chemical (biomolecules) conditions.

Acknowledgment

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