Scanning force microscopy on spatially and temporally varying magnetic substrates for cell cultivation

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The general intention of this work is to analyze spatially and temporally variable nanostructured surfaces generated by functionalized magnetic beads on a biocompatible carrier substrate to induce cell differentiation.

Magnetic thin films show particular domain structures. Especially garnet films show manifold magnetic configurations depending on the magnetic pretreatment. They are metastable (stable without external field) once they are generated. With the application of an additional magnetic field all existing states between the structures mentioned above can be produced and easily varied.

Magnetic nanobeads can be deposited onto domain walls between two magnetic domains. These beads are composed of magnetite (Fe_3O_4) embedded in a biocompatible matrix with NH_2 or COOH reactive groups, which allow covalent binding of growth- and differentiation factors for different cell types. The particles have a diameter of 100nm - 1µm. The particles´ properties have been studied under varying environmental conditions by atomic force microscopy (AFM) (fig.1) and magnetic force microscopy (MFM). They instantaneously follow changes in the domain structure of the magnetic thin film as long as they are kept in liquid environment.

AFM proves the high reproducibility of the surface preparation. The behavior of the particles during or after a reorganisation by external fields can be investigated as well. Furthermore AFM imaging shows that beads remain unaffected by the cell culture and that endocytosis of the beads is prevented. AFM investigations on fibroblasts, grown on garnets with deposited beads, also show the biocompatibility of this set up.

That external magnetic fields allow to change the domain shape at any time and thus continuous variations of the culturing substrate in vivo is one of the mayor advantages of the here presented work. This allows investigating the effects of diverse parameters on cell growth, for example the concentration of growth factors, mechanical forces and topographical short-time variations.

Figure 1:

Magnetic nanobeads of a diameter of 250nm are deposited onto domain walls of a garnet film. The AFM image shows the highly ordered structure and gives information on the behavior of the particles under certain environmental conditions.