B7(E)

3D Imaging of Magnetically Labelled Cells

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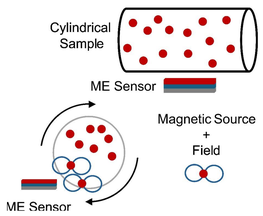
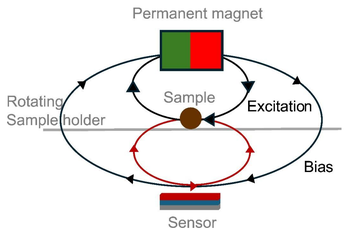
biomagnetic sensing SFB 1261

Objectives and Original Planning

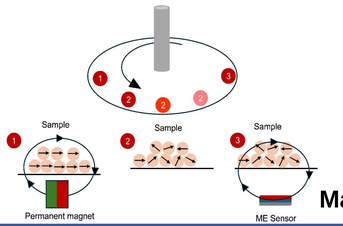
To investigate magnetoelectric sensors, developed in the CRC 1261, for the detection of living cells which are tagged with magnetic micro- or nanoparticles



Magnetic Particle Mapping (MPM)



Magnetic Susceptibility Particle Mapping (MSPM)



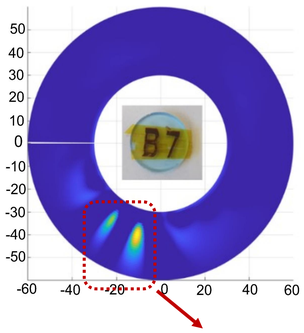
Magnetorelaxometry

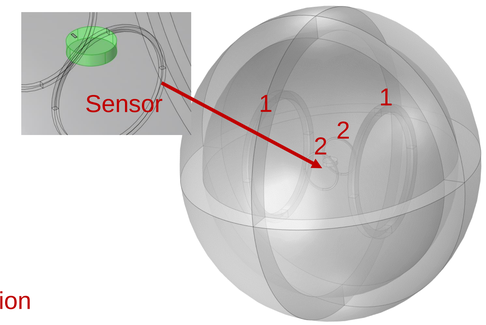
- AC field and higher harmonics
- Motion-Modulated DC field
- Magnetic particles inside cells vs freely moving particles

Research Plan Changes

From the concepts of motion modulation and field free line to device design

1: Selection field coils (DC field)
2: Driving field coils (AC/DC field)

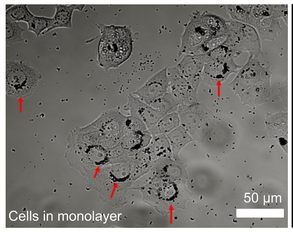


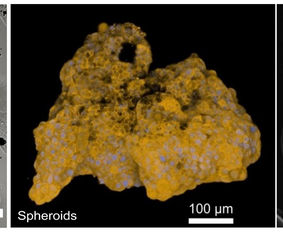


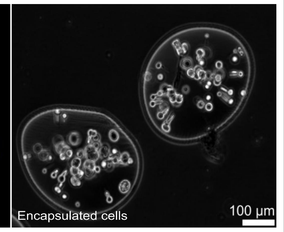
- Local excitation of the magnetic nanoparticles (MNPs) by using field free line (FFL)
- Static FFL vs Dynamic FFL
- Performing backprojection algorithm to reconstruct the images
- Tune the active area in the sample holder by controlling the current ratio
- Sensor response modulation performed via linear periodic motion

Artificial tumors like phantoms

- The magnetic properties of the magnetic particles change when they are exposed to more viscous environments such as extracellular matrix
- For evaluating the application of our magnetoelectric sensors, 3D biological models were developed: spheroids and capsules



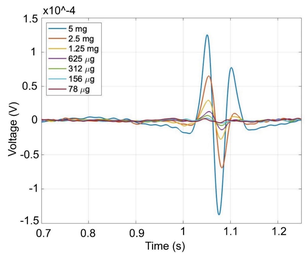




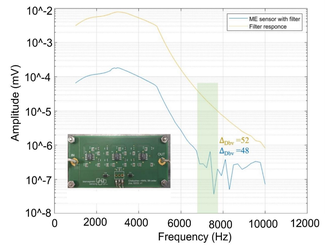
- The method to generate tumors like capsules was patented by Ruprecht-Karls-Universität Heidelberg
- A higher density of magnetically labeled cells can be confined in smaller volumes to reach the L.O.D. of our magneto-electric sensors

Results

- Thorough theoretical understanding of MPM and MSPM
- Colored MPM demonstrated for color bio-imaging
- Adaptive Model for MPM eliminating uncertainties in orientation of sensor sensitive axis
- Characterization and understanding of ME sensor nonlinearities
- New MSPM setup with field free line technique and back-projection algorithm
- Thorough understanding of magnetically labeled cells and cell scaffolds including effect of magnetic field gradient



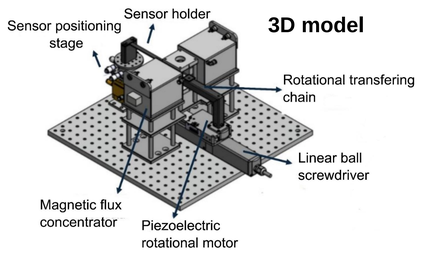
Magnetic particles signal MSPM

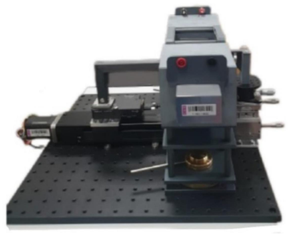


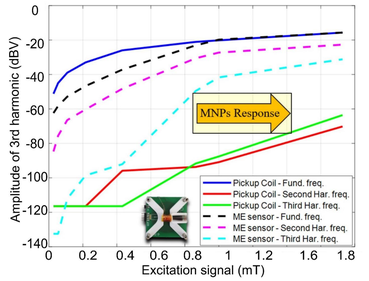
Pre-filtering of the signal source with 9th order low pass filter

- Detection of magnetic particles in a non-shielding environment
- Source nonlinearity covers third harmonic response of particles
- Quality factor of the sensor amplifies the harmonic response
- System faces challenges in accurately detecting 2D shapes at the voxel level

New MSPM apparatus using FFL approach



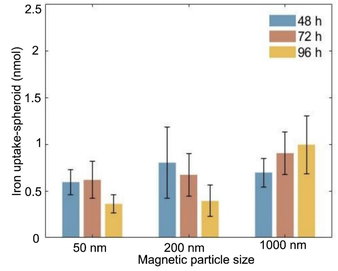




Sensor and pick up coil response without nanoparticles

- New device aims to focus excitation field onto a target area, mitigating point spread function issues
- Iterative filtered back projection via inverse optimization algorithm improves resolution of reconstructed image
- The cut-off iron uptake concentration for most of the magnetic spheroids is 1 nmol

Backprojection



Quantification of Magnetic particles in spheroids

Collaborations

B1: Design and fabrication of electronics for signal processing
Z2: Characterization of ME sensors and signal processing
Z1: Contributed to the fabrication of the used ME sensors
Participation in focus group F6 Biomedical Applications

Staff Funded During Second Funding Period

1 Doctoral researcher,1 Post-doctoral researcher

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