Synchrotron tomography as a tool for the analysis of magnetic particle distribution in tumor tissue

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Introduction

In biomedical applications of ferrofluids the resulting distribution of the magnetic nanoparticles is a crucial parameter for the effect of the therapeutic approach. The biodistribution is usually determined by histological cuts of the investigated specimen, a technique which provides only a very local information about the overall distribution of the magnetic material e.g. in a tumor As it has been shown recently, X-ray microtomography is a valuable tool for the 3-dimensional analysis of the distribution of magnetic nanoparticles in biological applications [1]. In our presentation we will introduce especially the advantage of synchrotron based tomography to resolve e.g. the structures of the vessel system in the micron range is demonstrated.

Synchrotron tomography: first results

Tumor tissue of a mouse and a rabbit which both have been treated with magnetic nanoparticles have been examined by means of high resolution synchrotron tomography. In order to underline the advantages of this tool in terms of spatial resolution, image quality and the possibility to resolve density differences a direct comparison of the same sample scanned by means of conventional tomography is shown in Figure 1. The left image (a) shows the cross-section through the tomographic dataset of a mouse tumor which has been scanned using the beamline BW2 at HASYSLAB/DESY in Hamburg, whereas in (b) a conventional X-ray tube ased system was used to obtain the dataset.

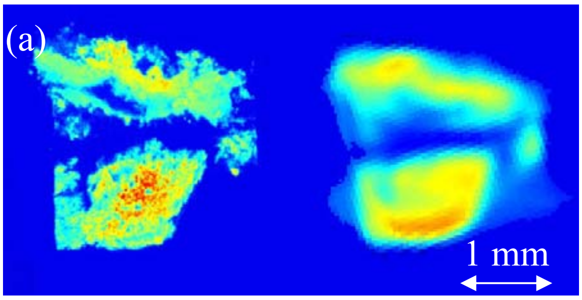

Figure 1.

Due to the much higher spatial resolution of down to 4 µm and the monochromatic character of the synchrotron radiation a quantitative analysis of the density distribution of the samples becomes possible. Thus the relative amount of magnetic particles within the vessels of the tumors can be monitored with much higher accuracy.

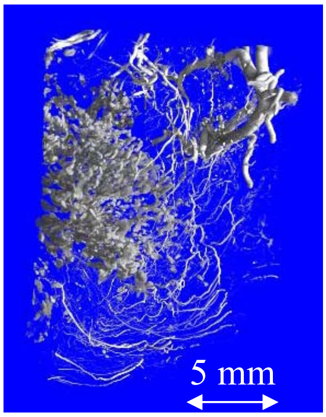

Figure 2.

The rendered image in Figure 2 shows the dataset of a part of a rabbit tumor. During the treatment the vessels system of the tissue was enriched with magnetic nanoparticles which can be observed within the tomographic dataset due to the high absorption coefficient of magnetite. The position and size of the vessels can be analyzed by means of 3D image processing methods as shown in [2].

Development of a new synchrotron-based tomography system

The second part of our presentation will focus on the development status of the tomography system shown in figure 3 which will be installed at the new HARWI-2 beamline at HASYLAB.

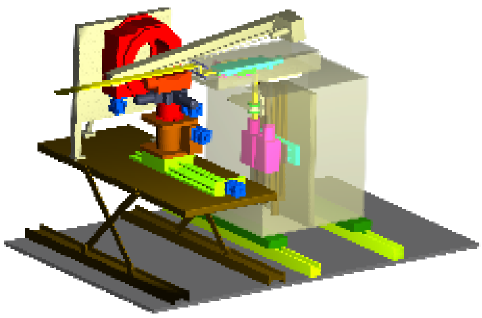

Figure 3.

This beamline features a beam cross-section of up to 80x10 mm2 and a radiation energy range of 20 to 200 keV. This outstanding characteristic of the source gives the opportunity to analyze large samples with high absorption coefficients. The fast read-out rate of the detector will additionally offer the possibility to decrease the scanning time down to a few seconds which in turn will allow serial- as well as in-vivo examinations.

References

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[2] Brunke, O., S. Odenbach, and F. Beckmann,. Eur. Phys. J. of Appl. Phys., 2005. 29:p 73-81.DOI: 10.1051/epjap:2004203