Microtomography on Biomaterials using the HARWI-2 beamline at DESY

J. Herzen[1], F. Beckmann[1], B. Müller[2], F. Witte[3], T. Donath[1], B. Leukers[4], S. H. Irsen[4], M. Störmer[1], N. Hort[1], A. Schrott-Fischer[5], R. Glueckert[5], and A. Schreyer[1]

[1]GKSS-Research Center, Geesthacht, Germany. [2]Biomaterials Science Center, University of Basel, Switzerland. [3]Laboratory for Biomechanics and Biomaterials, Hannover Medical School, Germany. [4]ceasar research center, Bonn, Germany. [5] ORL University Clinics, Medical University Innsbruck, Austria

INTRODUCTION: The synchrotron radiation beamline HARWI-2 operated by the GKSS-Research Center in cooperation with Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany is designed for materials science experiments using hard X-rays. A fixed-exit monochromator provides a highly intense, monochromatic X-ray beam in the energy range between 15 and 200 keV [1]. This large range of photon energies, the spatial resolution down to 3 µm and the related density resolution are important for microtomographic applications. The advantages of the beamline are demonstrated for absorption contrast tomography on the field of biomaterials.

METHODS & MATERIALS: The homogeneity of the collagen coating of the 3D-printed and collagen-coated scaffolds for bone replacement has been analysed using synchrotron radiation based micro computed tomography (SRµCT) in absorption mode at a photon energy of 30 keV. The collagen coating significantly improves the mechanical stability of the scaffolds [2].

Cortical bone screws were machined from magnesium alloy AZ31 extruded rods. These screws were implanted into hip-bones of sheep and removed from the animals three months later. Afterwards SRµCT was performed at a photon energy of 30 keV to study the corrosion behaviour of the screws.

The cochlear implant consists of 12 electrodes and was inserted into the inner ear of a patient with a sensory neural hearing loss. The electrode stimulates electrically the sensory cells in the cochlea. The implant with surrounding tissue was removed 36 hours after the patient's death and fixated in Karnosky solution. To improve the soft tissue density resolution, the entire specimen was stained with 1% OsO_4. The measurements were performed in absorption contrast mode using the photon energy of 64 keV [4].

RESULTS & CONCLUSIONS: The superior density resolution of the SRµCT at HARWI-2 allows visualizing non-destructively the 3D distribution of collagen coating on bone replacement scaffolds.

The SRµCT enables to describe non-destructively the in-vivo corrosion of engineered cortical magnesium (AZ31) screws in sheep bone and thereby overcomes artefacts associated with the preparation of magnesium materials soluble in water and body fluids [3].

The detailed analysis of the cochlear implant also takes advantage of the microtomography for visualizing non-destructively the temporal bone structures of the inner ear, the position of the electrode array and for characterizing the integration of cochlea implants almost free of any artefacts (Fig.1). In contrast histological techniques that are commonly applied, are accompanied by artefacts caused by the preparation methods, especially for metallic cochlear implants when the electrode array in the embedded tissue specimen block has to be cut.

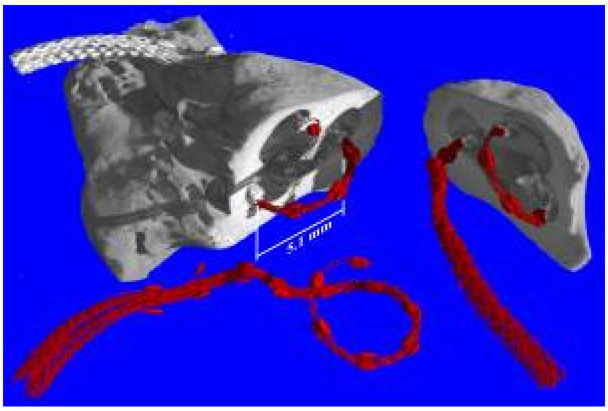

Fig. 1: The metallic cochlea implant consisting of an array of 12 pairs of electrodes and the winding of the human cochlea.

Due to the wide energy range and the superior contrast the SRµCT at HARWI-2 provides non-destructive high quality 3D visualization of a large range of different materials. Even samples with a dimension of several centimetres can be analysed with a very low amount of artefacts.

REFERENCES: [1] F. Beckmann et al. (2006) *SPIE Proceedings* 631810-1-11. [2] S. H. Irsen et al. (2006) *SPIE Proceedings* 631809-1-10. [3] F. Witte et al. (2006) *SPIE Proceedings* 631806-1-9. [4] B. Müller et al. (2006) *DESY Annual Report 2006,* 1291-1292