Additive manufacturing of electrically stimulating implants for bone regeneration using piezoactive materials

Prof. Dr. Hermann Seitz, Chair of Microfluidics, Faculty of Mechanical Engineering and Marine Technology, University of Rostock, Germany

Abstract:
European populations are ageing rapidly. For this reason, the social and socio-economic relevance of regenerative therapies is clearly increasing. This holds particularly true for implants: the older the population grows, the more medical implants for various indication areas are required and the more often they have to be replaced during the course of therapy. The research vision pursued by the Collaborative Research Centre ELAINE (ELectrically Active ImplaNts) focuses on novel electrically active implants. Piezoactive materials play a key role in this context. One focus of ELAINE is on the usage of piezoelectric transducers as energy harvesting elements for the conversion of mechanical energy from load-bearing implants into electrical energy for electrostimulation applications. Another focus is on piezoactive materials that can be processed by additive manufacturing technologies in order to fabricate implants. The piezoactive materials are beneficial for cell growth due to their ability to be used for electrically stimulating implants. Ceramic materials with piezoelectric properties such as barium titanate are investigated by which a proliferation of osteoblasts can be induced via the piezoeffect. The osseointegration of ceramic scaffolds can be improved by functionalisation with bioactive glasses. Ongoing studies deal with scaffolds that are 3D-printed with a powder-based additive manufacturing technique using $BaTiO_3$ powder and powder blends consisting of $BaTiO_3$ and bioactive glass. The 3D-printed scaffolds will further be infiltrated with bioactive glass in order to improve osteoinductivity/osteoconductivity and mechanical properties. The aim is to create scaffolds that can be exposed to mechanical stimulation in order to use the direct piezoelectric effect to generate an electrical field for cell stimulation. Subsequently, it is also planned to investigate the inverse piezoelectric effect in $BaTiO_3$. By applying an electric field to a piezoelectric ceramic, a mechano-transduction for advanced cell stimulation can be achieved which can lead to further enhancements in bone regeneration. The development of an appropriate stimulation chamber which integrates the possibility of applying either electrical or mechanical stimulation on scaffolds is also within the scope of the Collaborative Research Centre ELAINE.