ABSTRACT FOR THE GENERAL PUBLIC

Ageing of the society is nowadays beyond controversy. The world faces several societal challenges and health issues become more and more predominant with the accelerating demographic transition. One of the immediately visible effects of society's ageing is the reported increase in the necessity of orthopaedic implants currently boosting to a huge economical market. Implants are designed to last as long as possible. However, reality shows that current implants are far beyond being perfect. The daily use and thus loading, friction, and wear may cause the generation of wear particles and inflammatory events potentially leading to a subsequent failure of the entire implant, and consequently requiring secondary revisions or removal surgeries. Considering that during the COVID pandemic, 97% of the revision surgeries have been postponed, the lifetime of implants became even more vital for patients. For successful integration of an implant, bone regeneration, osseointegration at the interface bone and implant, as well as mitigating inflammatory events, are crucial aspects.

The aim of this project is the development of a new biocompatible titanium/Hydroxyapatite (Ti/HAp) composite material to increase the biocompatibility and therefore the longevity of surgical implants. Hydroxyapatite as a mineral is of course not new but one of the main constituents of human bone and dental enamel in a slightly modified way. However, the mechanical properties are strongly influenced by the microstructure of this mineral which in turn is a result of the synthesis route. Within this project, a gradient biomaterial composed of cast titanium bulk and a Ti/HAp composite offers completely new possibilities for implant materials. One decisive point is that hydroxyapatite is brittle and that the friction and wear properties are not sufficient for a long lifetime of components. Because of that, the project goes beyond the state of the art and aims to combine with a laser surface treatment and a new two-dimensional, easy shearing material called MXene. There are several advantages of using laser radiation. The laser can create well-defined and long-range ordered tiny pockets in the material´s surface. It can also open the underlying porosity of the Ti/Hap composite and additionally improving the cell transport and cell growth in the laser treated area. Moreover, the laser pockets can serve as small storage sites for lubricants to reduce friction and wear between the involved surfaces. The lubricant of interest in this particular research, MXenes, have a two-dimensional structure like a stack of papers, where single sheets can easily be shifted with respect to each other. The most famous type of MXene is a layered titanium carbide ($Ti_3C_2T_x$), whose main constituent is also titanium with carbon as second element. MXenes have proven superior properties for many technical applications already. This unique scientific approach should result in high-quality and durable implant materials thus reducing the number of removal surgeries in the future.