INDUSTRIAL PILOT PROJECT

HAXPES characterization of biocorrosion of additively manufactured Mg components

THE INDUSTRIAL CHALLENGE

OssDsign produces implants for improved healing of cranial defects (fig 1), consisting of a bioresorbable ceramic and an inert Ti64 mesh produced by additive manufacturing (AM). However, the full regeneration of the bone is hindered by the Ti64, which is remining permanently in the body. By replacing the Ti64 with a Mg alloy, the implant would become fully degradable, and thus lead to a complete healing of the bone. Powder extruded (PE) orthopedic screws of Mg are already clinically used, but the degradation rate of Mg processed by AM is too high. This is a problem as it can lead to premature loss of mechanical strength of the implant. To solve this problem, new routines are needed for the characterization of biological corrosion mechanisms of Mg alloys processed by AM.

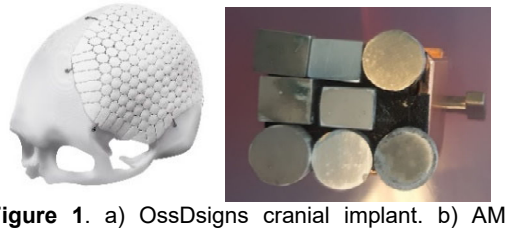


Figure 1. a) OssDsigns cranial implant. b) AM samples (circular) and PE reference samples (square) immersed in DPBS.

WHY USING A LARGE-SCALE FACILITY

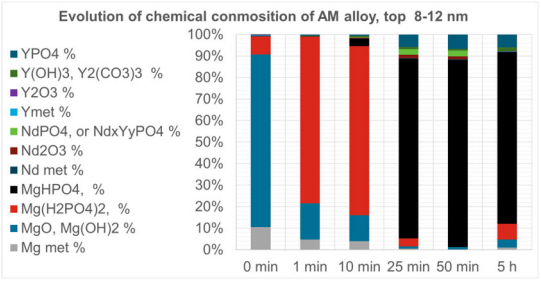
The synchrotron based hard X-ray photoelectron spectroscopy (HAXPES) offers great capability for studying the chemical species forming as a results of corrosion reaction between the alloying elements (Mg, Y, Nd) and the media used. Thanks to the high photon energy corrosion layers up to 30 nm can be analysed. Due to the very high brightness a good signal to noise ratio can be achieved in short time.

HOW THE WORK WAS DONE

The HAXPES measurements were carried out ex-situ at beamline P22 at Petra III (Hamburg, Germany) using two different energies (2.5 keV and 7.5 keV. Orthopedic screws of powder extruded (PE) Mg alloy WE43 are already used clinically and served as reference samples. 16 samples produced by AM and PE were prepared by grinding down to 2500 grit (fig 1) and cleaning with ethanol and acetone. To mimic the salt concentrations of the body they were immersed between 1 min and 24 hours in Dulbecco's Phosphate Buffered Saline (DPBS) solution, with salt concentrations corresponding to the ones found in the body.

THE RESULTS AND EXPECTED IMPACT

Quantitative analysis of the HAXPES spectra clearly show reduction of material in its metallic state on the surface of both the AM and PE samples. Contact with DPBS for less than 10 min leads to the formation of oxides and hydroxides of Mg, Y and, to less extent, also Nd. After 20 min we obtained rapid growth of an inhomogeneous compound layer with thickness of more than 30 nm composed of mainly Mg phosphates and Y phosphates.



The composition of compound layer and dynamics of its formation were slightly different for AM and PE materials. Such observations became possible only thanks to the variable surface and high chemical sensitivity of HAXPES and opens up to study the evolution of the surface of more metallic materials used in implants.

"HAXPES provides an impressive level of detail in the evaluation of surface chemistry. Information that is very important to understand how implant materials will interact with the body."
/Jonas Åberg, Regulatory Affairs Manager, OssDsign

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