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Biomaterials with unique properties for implant applications

Equal Channel Angular Pressing (ECAP) is an innovative processing technology for the production of metallic biomaterials with unique properties. It leads to a strong grain refinement of bulk crystalline materials down to the sub-micrometer range by means of very large, multidimensional plastic deformation under enhanced hydrostatic pressure. The modified microstructure of ECAP-processed biomaterials is the reason for high strength combined with good ductility. Such high-performance biomaterials are very promising candidates for applications in high-loaded implants, for longer implant lifespans, for the miniaturization of implants and for completely new implant concepts. The effects of ECAP are presented on the examples of commercially pure (CP)-titanium and special Mg-alloys. CP-Ti is a commonly used implant material especially in dentistry. In this field of application, the Ti-alloy Ti6Al4V-ELI is avoided because of its problematic alloying elements aluminum and vanadium. Nevertheless, for many dental applications a higher strength than that of CP-Ti is requested. Using ECAP and tailored optional post-processing we achieved in CP-Ti ultimate tensile strengths >1000 MPa, which is stronger than the Ti-alloy. A further very important effect of ECAP is that it produces a very homogeneous ultrafine grain structure and consequently very homogeneous mechanical property across the whole work piece. The ideal material for biodegradable implants must combine high biocompatibility, application-oriented degradation rate and excellent mechanical properties especially for load bearing applications. To achieve all these goals, we used a newly developed double-ECAP tool to process a special low alloyed Mg alloy which was developed and produced at AIT. The double-ECAP tool consists of three channels with two intersection angles and offers exceptional high deformation efficiency. By using it, the ultimate tensile strength of a ZX00 Mg alloy could be raised to unprecedented strength values of about 400 MPa.

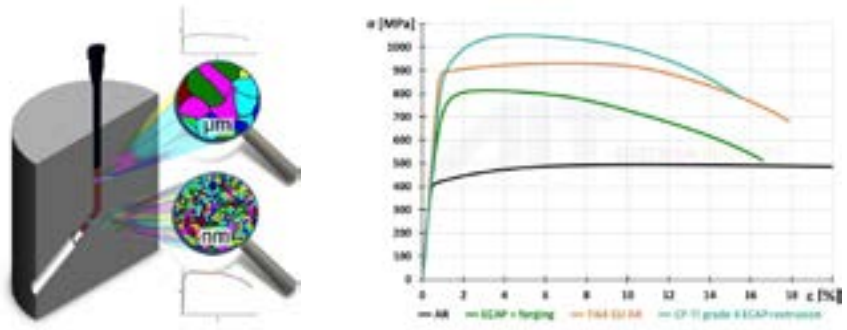

Figure 1: Principle of Equal Channel Angular Pressing ECAP (left); stress strain curves of CP-Ti in different conditions in comparison with Ti6Al4V- ELI. CP-Ti grade 4 after ECAP + extrusion is stronger than the Ti alloy

Recent publications

1. Draxler J, Martinelli E, Weinberg A, Zitek A, Irrgeher J et al. (2017) The potential of isotopically enriched magnesium to study bone implant degradation *in vivo*. Acta Biomaterialia. 51:526-536.
2. Mingler B, Krystian M, Horky J, Bammer M (2016) High-strength biomaterials for implants. Biomed Tech 2016; 61 (s4) © by Walter de Gruyter • Berlin • Boston. DOI 10.1515/bmt-2016-5000 S4.
3. Krystian M, Bryla K, Horky J, Mingler B (2017) Equal Channel Angular Pressing (ECAP) of hollow profiles made of titanium. IOP Conference Series: Materials Science and Engineering 194:1-6.
4. Hofstetter J, Rüedi S, Baumgartner I, Kilian H, Mingler et al. (2015) Processing and microstructure-property relations of high-strength low-alloy (HSLA) Mg-Zn-Ca alloys. Acta Materialia. 98:423-432.
5. Krystian M, Bryla K, Horky J, Mingler B (2016) New developments in Equal Channel Angular Pressing (ECAP) of Mg alloys. eCM Meeting Abstracts 2016, Collection 7; 8th Biometal (page 4).

Biography

B Mingler studied physics at the University of Vienna, where he also worked and taught as Assistant Professor mainly in the field of Materials Science. Since 2009 he works at the Austrian Institute of Technology GmbH in the Center for Health & Bioresources. In his function as Senior Scientist and Thematic Coordinator he has his expertise in design and application of biocompatible and biodegradable metals and alloys, their characterization in respect of microstructure, mechanical, corrosive and biological properties as well as in theory and implementation of severe plastic deformation (ECAP, HPT) and characterization of ultrafine grained and nanocrystalline materials. He was the Project Manager of several contract research projects and funded projects and currently heads Research Studio Austria and the strategic lead project. He is co-inventor of several patents dealing with special Mg alloys and ECAP designs and applications

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