doi:10.1017/S1431927621002233
Microsc. Microanal. 27 (Suppl 1), 2021

Development of a porous titanium-base biomaterial with modulus of elasticity close to that of bone structure

Katia Rivera[1], Claudia López[2], Raúl Pérez[3], D. Lardizabal-Gutiérrez[4], José Herrera-Ramirez[5] and C. Carreño-Gallardo[6]

[1]CIMAV, Chihuahua, Mexico, [2]ULSA, Mexico, [3]COMIMSA, Mexico, [4]Departamento de Metalurgia e Integridad Estructural, Centro de Investigación en Materiales Avanzados (CIMAV), Avenida Miguel de Cervantes Saavedra 120, Complejo Industrial Chihuahua, 31136 Chihuahua, Chih., Mexico, United States, [5]Centro de Investigación en Materiales Avanzados (CIMAV), Laboratorio Nacional de Nanotecnología, Miguel de Cervantes 120, 31136 Chihuahua, México, United States, [6]Centro de Investigación en Materiales Avanzados (CIMAV), Chihuahua, Chihuahua, Mexico

The difference in Young's modulus between an implant device and bone is mainly due to a not homogeneous stress transfer; this is defined as stress shielding. Porous titanium (Ti) with entangled structure has been developed and suggested for potential load-bearing biomedical applications because of its favorable mechanical properties (e.g., good toughness and high reliability in service) and the interconnected porous structure that can provide adequate space for ingrowth of the living tissue [1].

Porous Titanium were produced using a mechanical milling process. The porosity was controlled by adjusting the weight ratio of Mg to Ti. Titanium hydride-dehydrate powder (99.5% purity) with particle sizes of around 44 μm and a normally distributed 40–50 μm size range was used as the primary matrix. Spherical magnesium powder (99.8%) with particle size of around 64 μm and normally distributed size range of 55–105 μm was used as the space holder [2].

Titanium and Magnesium powders were mixed in a high energy ball mill without milling media SPEX 8000M for two hours with weight amounts of magnesium of 15% and 30% corresponding to the desired levels of porosity. The powder mixtures were then uniaxially pressed at 530 MPa using a die to obtain cylindrical samples of 6 mm in diameter and 12 mm in height for material characterization. Sintering was carried out in a Lindberg high temperature with an argon atmosphere. Samples were sintered at 1000 and 1300 °C for 2 h. Samples were placed on an Al2O3 ceramic crucible during sintering to prevent contamination. During sintering Mg powders start to evaporate at 400 °C [2] and consequently pores form.

The samples fabricated in this work closely match with human cortical bone, biomimetic titanium fabrication using the mechanical milling process with magnesium powder as the space holder material. This process is simple and guaranteed to obtain controlled porosity, the porosity percentage of the sample with 30% Mg, the porosity percentage was 29.4 and the sample with 15% Mg the porosity was 19%.

Figure 1, the specimens with 15 and 30% Mg is shown, in a sintered condition at 1000 and 1300 ° C. Observing, that at the 1300 ° C condition, a white layer is presented, which is attributed to magnesium oxide.

Figure 2 shows the SEM images of polished cross-sections revealing pore sizes, morphology and distribution. Clearly the magnesium space-holding particles have been removed.

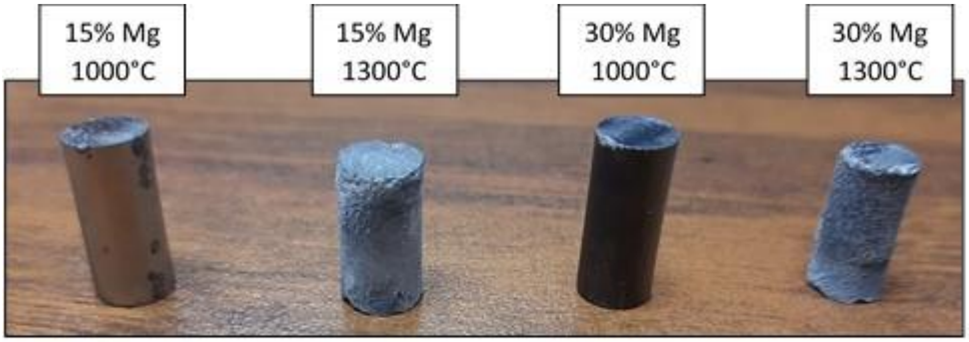

Figure 1. Figure 1. Samples at different sintering temperatures

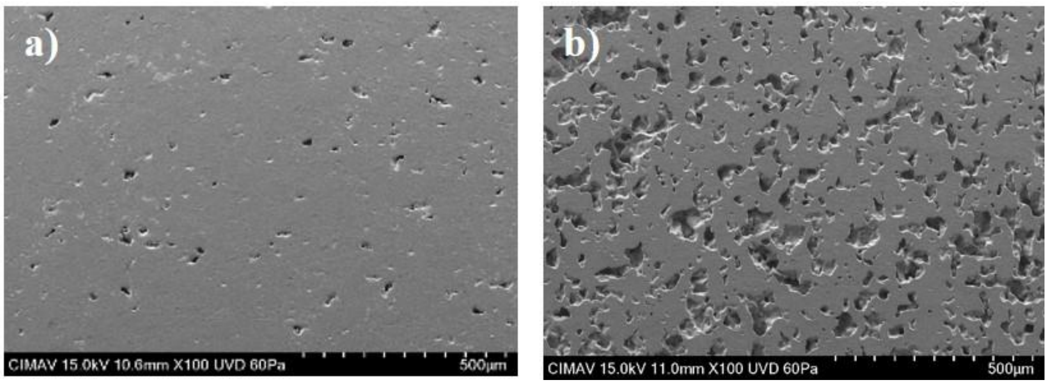

Figure 2. Figure 2. Pore sizes and distribution of the samples 15%Mg (a) and 30%Mg (b).

References
[1] Niinomi, Mitsuo & Nakai, M. (2011). Titanium-Based Biomaterials for Preventing Stress Shielding between Implant Devices and Bone. International journal of biomaterials. 2011. 836587. 10.1155/2011/836587.
[2] Yunhui Chen, Jessica Ellen Frith, Ali Dehghan-Manshadi, Hooyar Attar, Damon Kent, Nicolas Dominique Mathieu Soro, Michael J. Bermingham, Matthew S. Dargusch, Mechanical properties and biocompatibility of porous titanium scaffolds for bone tissue engineering, Journal of the Mechanical Behavior of Biomedical Materials, Volume 75, 2017, Pages 169-174, ISSN 1751-6161, https://doi.org/10.1016/j.jmbbm.2017.07.015.
[3] Skowrouski, S., 1944. By EARL A. GULBRANSEN$, 534. 589–99.

https://doi.org/10.1017/S1431927621002233 Published online by Cambridge University Press