Institute of Light Metals (ILM) Joint Usage/Research Grant Report in FY 2022

2023/04/28

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| Principal investigator | Affiliation | Instituto Tecnológico de Costa Rica |
| Job title | Assistant Professor |
| Name | Jorge M. Cubero-Sesin |
| Collaborated researchers of ILM | Affiliation | MRC, Kumamoto University |
| Job title | Professors |
| Name | Takanori Kiguchi / Zenji Horita |
| Title of the joint research | Hexagonal metallic materials for orthopedic prostheses |
| Joint research Program※check the box | □　Program for Joint Usage / Research Centers (JURC)□　Program for International JURC□　Program for providing samples and materials□　Program for using ILM facilities for sample analysis and characterization | □ Focused themes□ Transportation■ Biomaterials□ Bridge/building materials□ Kink strengthening□　Independent research theme |
| Name of joint usage apparatus | SEM, EBSD, Optical microscope, Hardness tester  |
| Total amount of grant 300 000JPY | Travel expense（　300,000JPY） | Consumable Fee（　　　　　　　　　JPY） |
| **Research Results**　**※Please describe the following three items briefly.**【The major results】 In this research, Mg-based Ca alloys were processed in the form of 10mm discs by High-Pressure Torsion (HPT). In the HPT facility, the disc sample is placed between two anvils (upper and lower) and pressed up to P=6 GPa. An intense torsional strain was introduced by rotating the lower anvil with respect to the upper anvil at 1 rpm for N=1 and N=10 revolutions. The initial conditions of the samples were as-extruded and annealed at 450 oC for 1 hour. The mechanical properties of the alloys processed by HPT were compared with the as-extruded and annealed states. The microstructure evolution was studied by optical microscopy, SEM and EBSD analysis. In addition, the microhardness profile on the surface of the samples was measured using Vickers microhardness and the mechanical properties were evaluated by tensile test. The phase composition of the alloys was analyzed by XRD.XRD profiles showed the presence of a secondary phase of Mg2Ca phase in all samples and the maximum dislocation density in the Mg-5%Ca sample processed by N=1. This condition obtained the lowest tensile strength and presented a more brittle behavior. Fragmentation of the secondary phase occurred in this sample, but it could not be refined as effectively as in the Mg-1%Ca, as observed in the SEM images. EBSD analysis showed that the Mg-1%Ca alloy processed for N=10 had a more homogeneous ultrafine-grained microstructure, which resulted in higher tensile strength and ductility. In general, the ultrafine-grained structures achieved with N=10 increased the microhardness level and uniformity in the sample.【Future Prospects】 It is intended to perform TEM analysis on the samples that presented optimal mechanical properties to determine the grain size of the Mg matrix and other microstructural features about the secondary phase, as well as carry out an electrochemical analysis (polarization curves) to determine the corrosion rate of the alloys under different processing conditions. In this way, the aim is to obtain a complete set of data that allows a more precise understanding of how HPT processing affects the properties of the alloy which is intended for bioabsorbable medical devices. 【Concrete results】(1) This study will be presented at an international conference in 2023.(2) J. Paniagua Rojas, J.E. González-Hernández, J.M. Cubero-Sesin, Z. Horita, D. González-Flores. “Benchmarking of Aluminum Alloys Processed by High-Pressure Torsion: Al-3% Mg Alloy for High-Energy Density Al–Air Batteries”. Energy & Fuels, 37, 6, (2023) 4632–4640. |
| **Notes**・Please use the form and submit to ILM office (mrc@kumamoto-u.ac.jp) by Friday, April 28, 2023.・The joint research report will be published in the ILM joint research report (annual report) and will be available on our website. Therefore, please prepare the contents for public release accordingly.・Please add pages, if needed. |