Institute of Light Metals (ILM) Joint Usage/Research Grant Report in FY 2024

2025/05/23

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Collaborated researcher of ILM	Affiliation	MRC, Kumamoto University
	Job title	Professor
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Title of the joint research	Aging behavior of Ti-25at%Nb alloy after using high-pressure torsion	
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	・High-Pressure Torsion (HPT) Machine. ・Furnace for heat treatments. ・Vickers Microhardness. ・Optical Microscope (OM). ・Tensile test machine. ・Scanning Electron Microscope (SEM). ・Electron Backscatter Diffraction (EBSD). ・Electrical discharge machining (EDM) ・Rigaku X-ray Diffractometer. ・Polishing Equipment	
Total amount of grant	Travel expense (300 000 JPY)	Consumable Fee (--- JPY)

Research Results ※Please describe following three items briefly.

【The major results】

The research explored thermal stability and aging treatments on Ti-25at%Nb processed by High-Pressure Torsion (HPT) at 6 GPa for N=100 revolutions at the facility in Kyushu Institute of Technology. The processed samples were subjected to heat treatments at 350 and 400° C for 6, 8, 12, 24, and 48 hours. Vickers microhardness measurements, uniaxial tensile tests, and scanning electron microscopy (SEM) of fracture surfaces were performed to evaluate the mechanical behavior and failure mechanisms. The sample after HPT showed high microhardness of ~400 HV, tensile strength of 1300 MPa, but almost no ductility. After aging for 6 h microhardness decreased to ~300 HV and remained stable for up to 48 h of aging. The results of tensile tests after aging showed an increase in ductility to 5%, with only a slight decrease in tensile strength, in the range of 1100-1200 MPa. These properties can be associated with microstructural changes induced by the aging treatment, which are the topic of ongoing research.

In addition, the Ti phase transformation form α to ω was investigated by HPT processing of Grade 2 Ti at - 196° C (liquid nitrogen). The influence of applied pressure on the stability of the ω-phase and its mechanical properties was examined using HPT under 2, 3, 4, 5, 5.5, and 6 GPa. The processed samples characterization included Vickers microhardness testing, tensile testing, X-ray diffraction (XRD), and electron backscatter diffraction (EBSD). The results indicated an improved distribution of the ω-phase which enhanced the mechanical properties of the material, including a better balance between ductility and strength, with respect to samples processed at room temperature.

【Future Prospects】

- Optimization of the thermomechanical process to produce the optimal microstructure condition: HPT conducted at −196 ° C and HPT complemented by post-processing aging treatments. Future studies will focus on the saturation of ω-phase formation during HPT at −196 ° C using liquid nitrogen and increasing number of revolutions, which could provide valuable insights for determining the optimal combination of high strength and adequate ductility in pure titanium.
- Transmission Electron Microscopy (TEM) observation of the UFG structures, deformation phenomena, grain boundaries conditions and grain size of pure titanium.
- Fabrication of ultra-fine grained (UFG) implant prototype.

【Concrete results】

(1) A scientific article based on this research is currently under development for publication.

Notes

・Please use the form and submit to the URL provided in the email by Friday, May 16, 2025.
・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.