PROGRESS REPORT FOR AINGRA07046

PROJECT TITLE: Thermomechanical behaviour of multi-functional titanium alloys

INVESTIGATOR(S):
- Chief Investigator: A/Professor Michael Ferry, Materials Science and Engineering, The University of New South Wales
- Other Investigators:
  - Students: Mr Wei (Gregory) Guo
  - ANSTO Investigators: Sam Moricca
  - Specialist Committee: M

SCIENTIFIC OBJECTIVES

The aim is to investigate a new route for producing Multi-Functional Titanium Alloys (MFTA) involving hot isostatic pressing (HIP) followed by equal channel angular pressing (ECAP) and to examine the optimal conditions for producing these alloys. ECAP will allow large components to be consolidated without the need for forging and hot rolling, as used by the Japanese pioneers of these alloys. Through the modification of composition or manufacturing parameters, we aim to further reduce the elastic modulus and increase the strength of MFTA for applications in the medical and aerospace industries.

PROGRESS REPORT and RESEARCH OUTCOMES

We did one HIP run of MFTA in 2006, but the vacuum level was unsatisfactory which resulted in pores in the samples. Although correct composition, correct phase were obtained, the microstructure of the sample after forging was inappropriate. In 2007, we did two sintering runs of MFTA and got the correct composition, correct phase and correct microstructure after forging. The samples are still in the process of swaging which took a long time than expected because we need to make and test about 20 sets of dies (we have made three sets of dies). The vacuum level of sintering was relatively high, but still a little short of our requirement and we will try to solve the problem of vacuum this year.

DATA

1. Composition:

The designed composition is Ti-36Nb-3Zr-2Ta-O, we got Ti-36.8Nb-2.7Zr-1.99Ta-0.48O, we converted it into atomic percentage and calculate the three magic figures: valence electronic number ratio (e/c) is 4.24, the bond order of the alloy is 2.87 and the Md value is 2.45, which meets the requirement of composition of MFTAs.

Table 1: The composition of the alloy

<table>
<thead>
<tr>
<th>Element</th>
<th>Nb</th>
<th>Zr</th>
<th>Ta</th>
<th>Ti</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Ni</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage (Wt %)</td>
<td>36.8</td>
<td>2.7</td>
<td>1.99</td>
<td>Balance</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Percentage (mole %)</td>
<td>23.6</td>
<td>1.76</td>
<td>0.66</td>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Phase:
XRD Analysis by Siemens D5000 shows that the phase of the sample after solution treatment is composed only of β phase. No α phase is found, as shown in the fig. 1.

![X-ray Diffraction Profile](image1.png)

Fig. 1: X-ray Diffraction Profile of sample after solution treatment which shows only β phase

3. Microstructures
The bright field image and the dark field image of optical microscopy (shown in Fig 2, 3) of Sintering sample shows a lot of pores with the size up to 20 µm. Based the calculation of porosity of six dark field images using the Photoshop, the average porosity of the sintered sample is 7.8%.

After forging and solution treatment, the amount of pores was greatly reduced or almost eliminated as shown in Fig 4. and the sample become condensed. Fig 5 shows the microstructure of a sample after swaged by 19% of area reduction rate.

![Microstructures](image2.png)

Fig 2 Bright field image (OM) of MFTA after Sintering process
Fig 3 Dark field image of samples after Sintering process

Fig 4 Bright field image of samples after solution treatment (etched)
Fig 5 Image of samples after swaged by 19% area reduction rate

<table>
<thead>
<tr>
<th>Signature of Investigator preparing the report for</th>
<th>Proj: AINGRA07046</th>
</tr>
</thead>
<tbody>
<tr>
<td>After signing this report please fax this page with your signature for our files</td>
<td>Date:</td>
</tr>
</tbody>
</table>

**PUBLICATIONS / REPORTS arising as a result of your work.**

No publications were generated from this project in 2007.

**PhD STUDENTS**

PhD student, Wei Guo, of University of New South Wales, is expected to graduate in December 2009.