STRUCTURAL INVESTIGATION OF A TI-25TA-25NB ALLOY USING ADVANCED ANALYSIS TEHNIQUES

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Lucrarea prezintă investigațiile structurale ale unui aliaj Ti-25Ta-25Nb procesat prin deformare plastică severă (SPD) - laminare acumulativă (ARB), realizate prin tehnici avansate ca: microscopia electronică prin baleiaj (SEM) pentru analiza structurii şi difracția de raze X (XRD) pentru analiza texturii prin figuri de poli. Prin folosirea acestor tehnici avansate, cercetarea experimentală a urmărit punerea în evidență a structurilor ultrafine (UFG) în aliajul Ti-25Ta-25Nb procesat prin laminare acumulativă (ARB).

The paper presents the structural investigations of a Ti-25Ta-25Nb alloy processed by severe plastic deformation (SPD) - accumulative roll-bonding (ARB), conducted by advanced techniques, like scanning electronic microscopy (SEM) for structure analysis and X-ray diffraction (XRD) for texture analysis through pole figures. Using these advanced techniques, the experimental research had the purpose of highlighting ultra fine structures (UFG) in a Ti-25Ta-25Nb alloy processed by accumulative roll-bonding (ARB).

Keywords: titanium alloys, severe plastic deformation, accumulative roll-bonding, scanning electron microscopy, X-ray diffraction pole figure analysis

1. Introduction

Titanium alloys are used in a large variety of engineering applications, due to their good mechanical properties and excellent corrosion resistance. In the last decade the field of nanotechnology has been increasingly studied. Nanotechnologies involve techniques for controlling and manufacturing materials at nano-scales. Therefore, many processing techniques for ultra-fine grained

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(UFG) materials or nano-structured (NC) materials have been developed lately. In our study one of these techniques has been applied: the severe plastic deformation (SPD) by accumulative roll-bonding (ARB)[1-3].

The ARB process consists in stacking and rolling of two almost equal metal strips (fig.1), ultimately resulting a consolidated finite material. After rolling the material is cleaned, cut into two halves and rolled again. The sequences of the ARB process can be repeated endlessly, so that high deformation degrees can be obtained.

The alloy analyzed in this paper and processed by ARB was Ti-25Ta-25Nb.

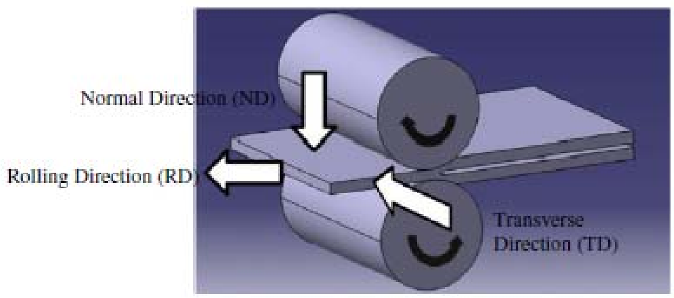


Fig. 1. ARB processing scheme

2. Materials and experimental procedures

The melting process of Ti-25Ta-25Nb alloy

The Ti-25Ta-25Nb alloy has been melted in a vacuum induction levitation melting furnace type FIVE CELES, starting from elementary components.

Table 1 shows the resulted composition.

Table 1

Chemical composition of Ti-25Ta-25Nb alloy

Element	Nb [%]	Ta[%]	O_2[%]	N_2[%]	H_2[%]	Ti
TiNbTa alloy	26,06	25,14	0,0510	0,0100	0,0260	rest

Cold-rolling processing

The cold rolling process was carried out using a laboratory rolling mill type MARIO di MAIO LQR120AS. The rolling speed was 2.4 m/min and the total accumulated strain after rolling was about 82%.

The samples were then cleaned in an ultrasonic bath at 60ºC in ethylic alcohol and processed by ARB.

ARB processing

The cold-rolled Ti-25Ta-25Nb alloy was subjected to severe plastic deformation (SPD) by accumulative roll-bonding (ARB) in the same rolling mill, with the aim of obtaining ultra-fine and nano-structure materials.[4]. In order to get a good adhesion between the layers during ARB processing, the sample surfaces were first cleaned. At the end of ARB cycles have been obtained samples with 4, 8 and 16 layers. Table 2 presents values for the thickness of the samples before and after ARB processing[5].

Table 2

Thickness of samples before and after ARB processing

Nr. of layes	Initial thickness [mm]	Final tickness [mm]	Layer thickness [mm]
4	0.28	0.12	~0.03
8	0.18	0.09	~0.01
16	0.16	0.08	~0.005

The maximum number of layers achieved for the studied alloy was 16, with a layer thickness of 5 µm. This data classify this alloy into UFG alloys.

Structural investigation by SEM analysis and texture analysis

The main goal of the research work was to study the structural characteristics of the Ti-25Ta-25Nb alloy processed by ARB, using advanced techniques like scanning electron microscopy (SEM) for structural analysis and X-ray diffraction (XRD) pole figures for texture analysis. Hence, the ARB processed samples were subjected to further experimental procedures.

SEM analysis has been realized using a scanning electron microscopy type TESCAN VEGA II – XMU. The most precise method for texture analysis is X-ray diffraction (XRD). Pole figures were determined on a X-ray diffraction equipment type Philips PW3710.

3. Results and discussion

Structural investigation by scanning electron microscopy (SEM)

SEM analysis provided images - presented in fig. 2, 3 and 4 - that show the microscopic aspects of the cold-rolled samples with maximum 16 layers. A good adhesion between the layers can be observed from these images. The smallest thickness obtained per layer was 5 µm.

SEM images also show microscopic aspects about the evolution of material consolidation. Between the layers can be seen delimitation areas, due to the presence of fine films of titanium oxides of layer detachment.

From the SEM analysis we can conclude that ARB processing can produced quite uniform ultra fine structures surrounded by mainly high-angle boundaries throughout the thickness.

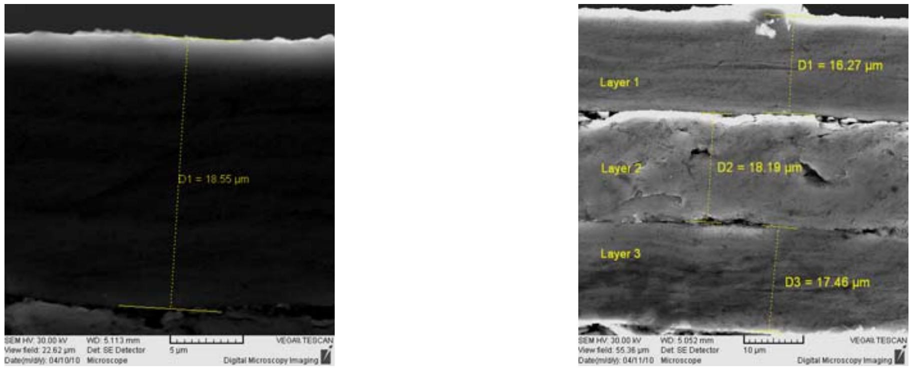


Fig.2. SEM image of Ti-25Ta-25Nb alloy processed by ARB processing – 4 layers

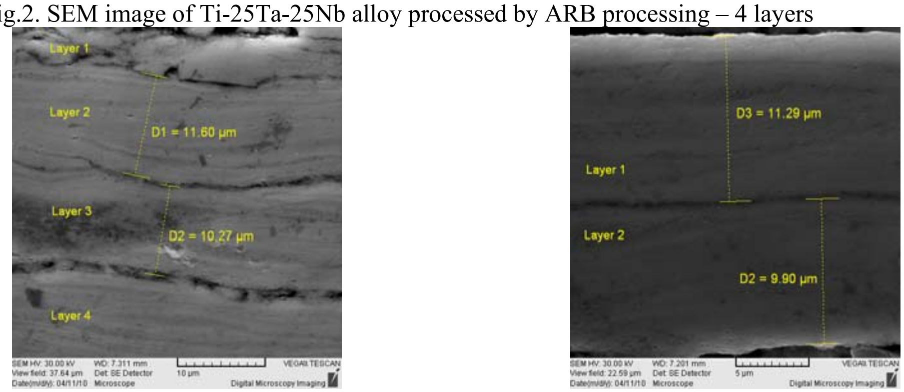


Fig.3. SEM image of Ti-25Ta-25Nb alloy processed by ARB processing – 8 layers

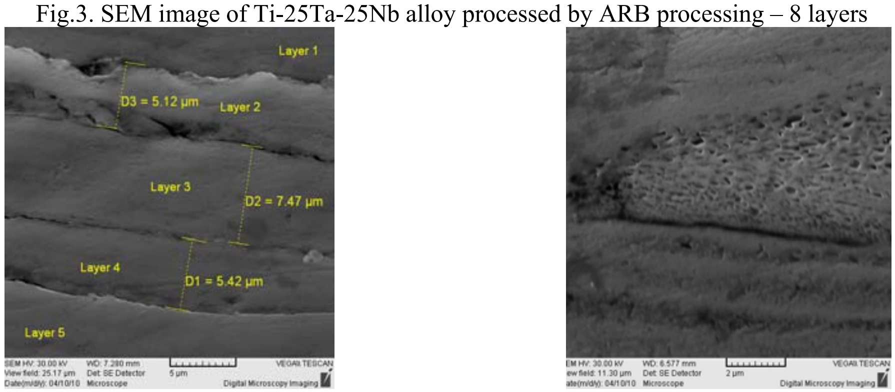
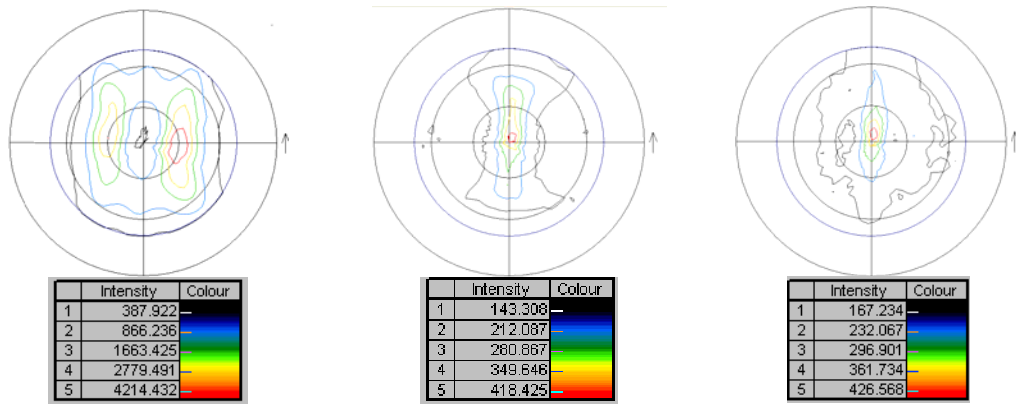


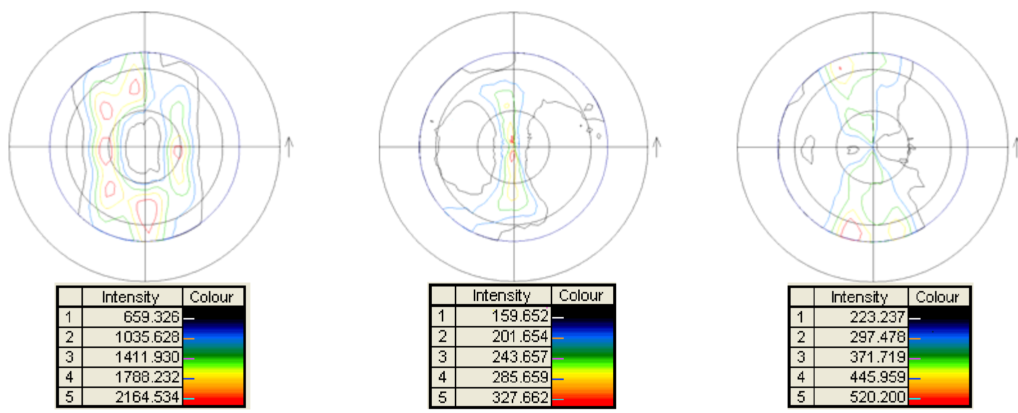
Fig.4. SEM image of Ti-25Ta-25Nb alloy processed by ARB processing – 16 layers

Texture investigation by X-ray diffraction pole figure analysis



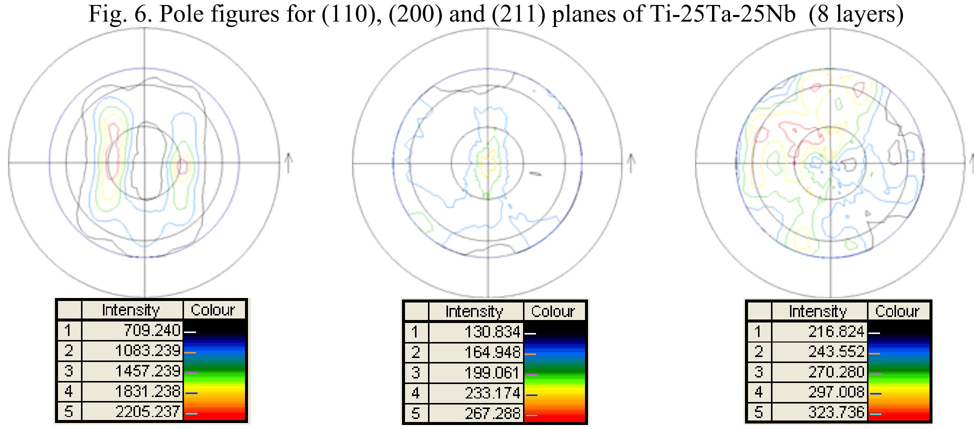
(110) **(200)** **(211)**

Fig. 5. Pole figures for (110), (200) and (211) planes of Ti-25Ta-25Nb – 4 layers



(110) **(200)** **(211)**

Fig. 6. Pole figures for (110), (200) and (211) planes of Ti-25Ta-25Nb (8 layers)



(110) **(200)** **(211)**

Fig. 7. Pole figures for (110), (200) and (211) planes of Ti-25Ta-25Nb (16 layers)

The crystalline texture of the Ti-25Ta-25Nb processed by ARB was investigated on samples with 4, 8 and 16 layers. The peaks with an unusual high intensity indicate the presence of a crystallographic texture.

The pole figures show that the peak intensity varies with the crystalline plane. The highest intensity was recorded for the (110) plane (fig.5) in all investigated samples. A comparison between all peaks intensities of the same plane for samples having different number of layers shows a decreasing, but not necessarily monotone trend. For the same sample the peak intensity decreases - not always monotone - for all crystalline planes (110), (200) and (211), in this order (fig.5, 6 and 7).

4. Conclusions

In order to get ultra-fine grained (UFG) structures in a Ti-25Ta-25Nb alloy, severe plastic deformation (SPD) by accumulative roll bonding (ARB) has been used. The smallest layer thickness obtained for this alloy processed by ARB was 5 μm.

The structure of the alloy processed by SPD-ARB was then investigated by SEM and XRD pole figure analysis.

SEM images showed the existence of very well delimited layers. Consolidation between layers was possible due to fine films of titanium alloys.

Texture analysis by XRD pole figure technique showed that the peak intensity can vary with the crystalline plane. The highest intensity was registered for the (110) crystalline plane, for all samples.

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