

# INFLUENCE OF DEFORMATION DEGREE ON THE MICROSTRUCTURE OF TITANIUM MATRIX COMPOSITES

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**Abstract:** Microstructure of titanium matrix composites with different deformation degrees were studied by OM. The results show that with the increase of deformation degree, prior  $\beta$  grain size and  $\alpha$  colony size of titanium matrix composites both decreases, which can be attributed to the deformation and thereafter heat treatment process.

## 1 Introduction

As a result of increasing demand in the aerospace area for excellent performance structural materials, titanium matrix composites have been intensively studied due to their super stiffness, toughness, elevated temperature resistance and high specific strength [1-3]. The traditional hot working technology, such as forging, extrusion and rolling, can be applied to process the titanium matrix composites.

However, few researches have been carried out on the deformation of titanium matrix composites, and the influence of deformation degree on the microstructure of titanium matrix composites is not clear. In the present research, microstructure evolution of titanium matrix composites with the increase of deformation degree is discussed.

## 2 Experimental

Stoichiometric amounts of sponge titanium, LaB<sub>6</sub> and alloying elements for synthesizing matrix Ti–Al–Sn–Zr–Nb–Mo–

Si alloy were blended and melted in a vacuum consumable arc-melting furnace. The reinforcements of titanium matrix composites are in situ synthesized according to the reaction:  $2\text{LaB}_6 + 12\text{Ti} + 3[\text{O}] = 12\text{TiB} + \text{La}_2\text{O}_3$ . Chemical compositions of the matrix part of the composites were similar to those of the near alpha high temperature titanium alloy IMI834, and the  $\alpha$ - $\beta$  transformation temperature of the composites is 1313K. The titanium matrix composites slabs were cut from the received material and hot-rolled unidirectionally at 1283K with the deformation degrees of 60%, 80%, 90% and 95%. The original thickness of the 60%, 80%, 90% and 95% rolled slabs were 10mm, 20mm, 60mm and 60mm respectively. Theoretical volume fractions of TiB whiskers and La<sub>2</sub>O<sub>3</sub> particles were 1.82% and 0.58% respectively, which were listed in Table 1. The rolled plates were annealed at 1318K for 0.5 h, air-cooled, and then aged at 923K for 1 h, air-cooled. Samples for optical microscopy were directly cut from the rolled plates. Then the samples were prepared via conventional techniques of

grinding, polishing and etching. About 200 measurements were made to obtain prior  $\beta$  grain and  $\alpha$  colony size for each microstructural condition

### 3 Results and discussion

Microstructure of titanium matrix composites with different deformation degrees is shown in figure 1. It can be found that after  $\beta$  heat treatment, titanium matrix composites with different deformation degrees all show a full lamellar structure that a prior  $\beta$  grain contains several  $\alpha$  lath colonies. This is because when the titanium matrix composites were  $\beta$  heat treated, prior  $\beta$  grain grew and the  $\alpha$  colony were formed during the cooling process.

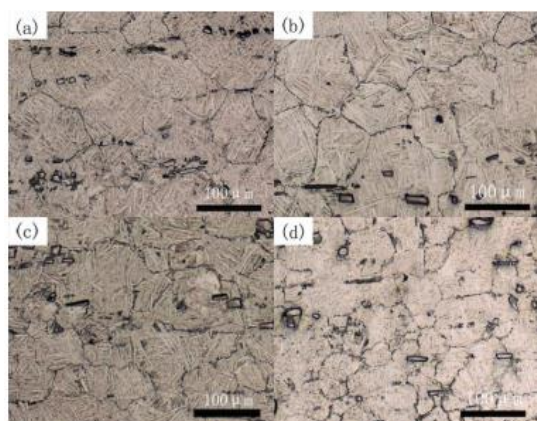


Figure1 Optical micrographs of samples rolled with different deformation degrees(a)60%,(b) 80%, (c)90% and (d)95%[4]

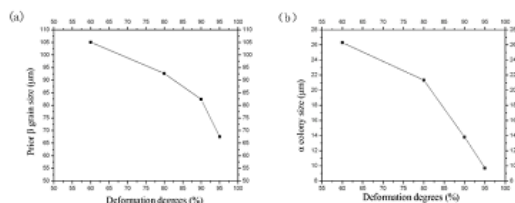


Fig.2 Variation of (a) prior  $\beta$  grain size (b)  $\alpha$  colony size with deformation degrees[4]

In order to discuss the evolution of the matrix microstructure of titanium matrix composites with the increase of deformation

degree, the changing trend of prior  $\beta$  grain size and  $\alpha$  colony size with deformation degree are shown in figure 2. It is clearly found that with the increase of deformation degree, the prior  $\beta$  grain size and  $\alpha$  colony size decreases. The microstructural refinement of the  $(\text{TiB} + \text{La}_2\text{O}_3)/\text{Ti}$  composites can be attributed to the hot rolling and heat treatment processes. When the  $(\text{TiB} + \text{La}_2\text{O}_3)/\text{Ti}$  composites were hot rolled in the  $\alpha$ - $\beta$  region, the existing  $\alpha$  phase in the  $(\text{TiB} + \text{La}_2\text{O}_3)/\text{Ti}$  composites restricted the movement of grain boundaries and hindered dynamic recrystallization, so most of the effects of hot rolling accumulated in this process. In the next step, the titanium matrix composites were heat treated at a temperature above the  $\beta$  transformation temperature, and the newly formed  $\beta$  grain size varies inversely with the extent of prior deformation that carried out in the  $\alpha$ + $\beta$  region [5-6]. The  $\alpha$  colony size is controlled by the cooling rate after the  $\beta$  heat treatment but limited by the prior  $\beta$  grain size [7]. In this research, the titanium matrix composites were all air-cooled after the  $\beta$  homogenization, so there was no difference in cooling rate for the titanium matrix composites. Thus, the  $\alpha$  colony size is greatly controlled by the prior  $\beta$  grain size, and the  $\alpha$  colony size decreases with the decrease of prior  $\beta$  grain size.

### 4 Conclusions

In the present paper, microstructure of titanium matrix composites with different deformation degree is studied. Results show that prior  $\beta$  grain size and  $\alpha$  colony size of titanium matrix composites decreases with the increase of deformation degrees.

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## Reference

- [1] Ranganath S. A review on particulate-reinforced titanium matrix composites. *J Mater Sci*, 32(1), pp:1-16, 1997.
- [2] Lu WJ, Zhang D, Zhang XN, Wu RJ, Sakata T, Mori H. HREM study of TiB/Ti interfaces in a Ti-TiB-TiC in situ composite. *Scripta Mater*, 44(7)pp 1069-1074,2001.
- [3] Sahay SS, Ravichandran KS, Atri R. Evolution of microstructure and phases in in-situ processed Ti-TiB composites containing high volume fraction of TiB whiskers. *J Mater Res*, 14(11):pp 4214-4223,1999.
- [4] Xianglong Guo, Liqiang Wang, Minmin Wang, Jining Qin, Di Zhang, Weijie Lu. Effects of deformation degree on microstructure, mechanical properties and texture of hybrid reinforced titanium matrix composites. *Acta Materialia* ,60 pp 2656–2667,2012
- [5] R. Ding, Z.X. Guo, A. Wilson. Microstructure evolution of a Ti-6Al-4V alloy during thermomechanical processing. *Mater Sci Eng A*, 327, pp 233-245,2002.
- [6] G.W. Kuhlman, F.R. Billman, Selecting processing options for high fracture toughness titanium airframe forgings. *Met. Prog*, 38, pp 3-9, 1979.
- [7] Lutjering G. Influence of processing on microstructure and mechanical properties of ( $\alpha$ + $\beta$ ) titanium alloys, *Mater Sci Eng A*, 243, pp 32-45, 1998.