

Formation mechanism of an α_2 phase-rich layer on the surface of Ti-22Al-25Nb alloy



Bin Shao, Shengxiang Wan, Wenchen Xu, Debin Shan, Bin Guo, Yingying Zong*

State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China

ARTICLE INFO

Keywords:
Titanium aluminides
Oxidation
 α_2 phase
Surfaces

ABSTRACT

In order to investigate the formation mechanism of the α_2 -rich layer in the surface of the Ti-22Al-25Nb alloy, systematic analyses are carried out on the surface of the alloy by using SEM, XRD and EBSD. The results reveal that this α_2 -rich layer is formed by oxidation of the surface layer. In this surface oxidation layer, there are abundant Ti_2O_3 particles similar with the α_2 phase in structure. These Ti_2O_3 particles serve as nucleation points and lower the nucleation energy of the α_2 phase, promoting the precipitation and growth of α_2 phase on the surface layer of the alloy. This surface layer has a hardness of 684 HV, significantly exceeding the value of 312 HV for the interior of the alloy and thus considerably improves the surface properties of the alloy, serving as a high-performance, self-generated surface strengthening layer.

1. Introduction

The Ti-22Al-25Nb alloy is a new generation high-temperature alloy with improved room-temperature ductility, formed by the addition of Nb to Ti_3Al and $TiAl$ alloys [1,2]. Owing to its reduced room-temperature brittleness [3,4], this alloy is a more practical choice for making mechanical parts [5,6]. The Ti-22Al-25Nb alloy consists of three phases, namely the O phase, α_2 phase, and B2 phase [7,8], and possesses characteristics such as low density, high strength, high specific strength, thermostability, and creep resistance. Alloy sheets are mainly used in aerospace engineering as the supporting frame for thermal insulating materials, propeller blades, and other parts made from stamped sheet metal for high-temperature operations [9–11], which makes their surface quality and properties particularly important [12]. The alloy can only be processed at temperatures above 900 °C owing to its excellent machinability at high temperature [13]. Because most of the processing steps are carried out in air, the alloy surface is prone to some degree of oxidation. The main oxides of the Ti-22Al-25Nb alloy include TiO_2 , Ti_2O_3 , Al_2O_3 , NbO, and Nb_2O_5 [14–19]. Ti_2O_3 and Al_2O_3 have rhombohedral unit cells [20] and are commonly known as “corundum” and possess high strength and wear resistance. However, the oxides mainly comprise loose particles, which makes the surface of the oxidized alloy rough. Formation of these oxides degrades the integrity of the alloy surface instead of enhancing it. Therefore, in general, mechanical polishing, surface modification, and coating must be carried out on the surface of the alloy components after fabrication

to facilitate their use. The surface of parts used in specific applications requires improvement in terms of strength, wear resistance, and corrosion resistance [21], and therefore surface-processing is required prior to use. The thickness of the surface coating is usually greater than 50 μm [22]. As the thickness increases, problems such as poor interfacial bonding and peeling of the coating become more prominent, affecting the service life of the surface coating [23]. In addition to the oxide layer, we report herein the formation of a layer rich in the strong α_2 phase on the alloy surface after high-temperature oxidation and analyze its formation mechanism.

2. Materials and Experimental Procedures

Ti-22Al-25Nb alloy sheets with a thickness of 1 mm, a length of 8 mm and a width of 6 mm were used for the experiments. The original microstructures were O + B2 microstructures. The samples were thermally processed between 850 and 1200 °C in air, at increments of 50 °C, with a holding time of 15 min, after which they were water-quenched. Different samples were held at 1050 °C for 5, 15, 30, and 60 min and water-quenched. Heat treatment was performed in the high-temperature chamber of an SX-2-10-13 resistance furnace. For anaerobic heat treatment, the samples were sealed in the vacuum glass tubes before placing them into the SX-2-10-13 resistance furnace. Scanning electron microscopy (SEM) and back scattered electron microscopy (BSEM), compositional analysis, and electron backscatter diffraction (EBSD) were all performed on a Supra 55 Sapphire instrument. The

* Corresponding author.

E-mail address: hagongda@hit.edu.cn (Y. Zong).

<https://doi.org/10.1016/j.matchar.2018.08.030>

Received 12 April 2018; Received in revised form 7 July 2018; Accepted 17 August 2018

Available online 18 August 2018

1044-5803/ © 2018 Elsevier Inc. All rights reserved.

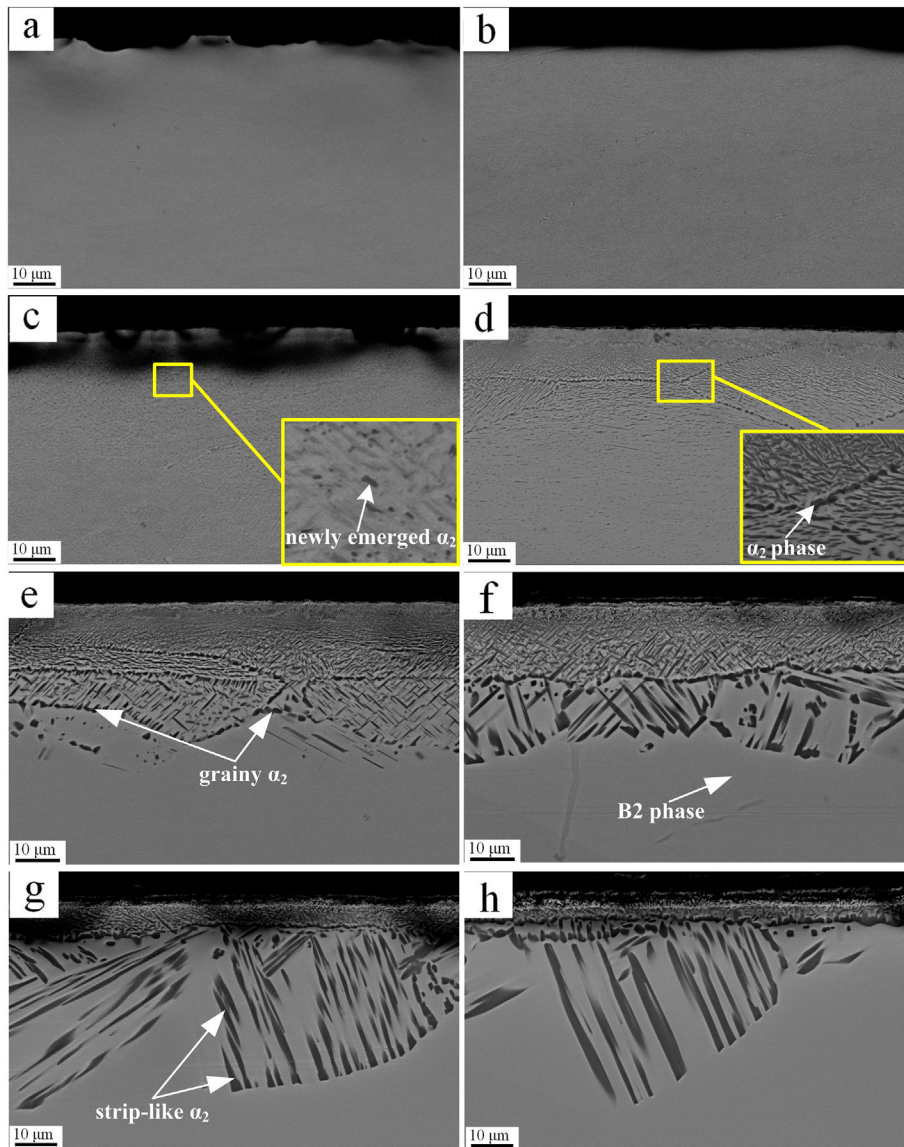


Fig. 1. BSEM image showing the morphology of the α_2 -rich layer after 15 min of holding at different temperatures: (a) 850 °C; (b) 900 °C; (c) 950 °C; (d) 1000 °C; (e) 1050 °C; (f) 1100 °C; (g) 1150 °C; (h) 1200 °C.

accelerating voltage during EBSD scanning was kept at 20 kV and the scanning step was 0.35 μm . The software Channel 5 was used to analyze the data. The XRD was performed on the Empyrean digital X-ray diffractometer. The hardness was measured on a HVS-1000Z Digital Micro-Vickers Hardness Tester.

3. Results and Discussion

Fig. 1 shows the morphology of the α_2 -rich layer formed after holding the samples at different temperatures. At temperatures 850 °C and 900 °C, no layer rich in the α_2 phase is formed, as shown in Fig. 1(a), (b). At 950 °C, the α_2 -rich layer begins to form on the surface of the alloy; the layer consists of newly formed fine α_2 phase particles, as shown in Fig. 1(c). When the temperature reaches 1000 °C, an α_2 -rich layer forms clearly on the alloy surface and the granular α_2 phase distributes densely, as shown in Fig. 1(d). The alloy enters its α_2 + B2 phase region at 1050 °C. This temperature facilitates the existence and growth of the α_2 phase. At this moment, the α_2 -rich layer becomes much clearer and the α_2 phase particles start to grow remaining a quite dense distribution, as shown in Fig. 1(e). When the temperature increases to 1100 °C and 1150 °C, the α_2 phase in the layer appears as

long strips and is therefore sparsely distributed. At this point, the size of the α_2 phase increases significantly, as shown in Fig. 1(f) and (g). At 1200 °C, the alloy is in the single-phase B2 region; the strip-like α_2 phase becomes unstable and then decomposes, and a significantly less amount of this phase is detected than at 1150 °C, as shown in Fig. 1(h). The morphology of the α_2 phase in the α_2 -rich layer of the alloy changes in coincidence with the law of phase transformation. However, the concentration of the α_2 phase at surface layer is not completely induced by phase transformation and its detailed cause needs further study.

Fig. 2 shows the BSEM image illustrating the morphology of the α_2 -rich layer after holding at 1050 °C for different times. As shown in Fig. 2(a), the α_2 -rich layer starts to emerge after a holding time of only 5 min, with the phase appearing fine-grained. As the holding time increases, the grainy α_2 phase gradually grows in size, and the layer rich in this phase increases in thickness, as shown in Fig. 2(b) and (c). At 60 min of holding, the thickness of the layer increases significantly, while the α_2 phase remains granular, as shown in Fig. 2(d). This implies an effect of the holding temperature, but not the holding time, on the morphology of the phase. The thickness of the α_2 -rich layer increases with increasing holding time. At this holding time, the particle density

Download English Version:

<https://daneshyari.com/en/article/10128594>

Download Persian Version:

<https://daneshyari.com/article/10128594>

[Daneshyari.com](https://daneshyari.com)