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Structural heredity between Al5Ti1B and AlTi, AlB master alloys①

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Abstract: Al5Ti1B master alloy was produced by two-step method. Experimental results show that the structure of Al5Ti1B master alloy depends on that of AlTi and AlB master alloys, the morphologies of $TiAl_3$ depend on AlTi master alloy and the boride phases depend on AlB master alloy. There are remarkable structure heredity between Al5Ti1B master alloy and AlTi, AlB master alloys. Theoretical analyses show that AlTi and Al-B master alloys can change the melt structure of Al5Ti1B master alloy, then affect the solid structure of the master alloy.

Key words: Al5Ti1B master alloy; AlTi and AlB master alloys; grain refinement **Document code:** A

1 INTRODUCTION

Al5Ti1B master alloy is widely used in aluminum industry as a highly effective grain refiner[1~4], it usually contains $TiAl_3$ and TiB_2 particles in an Al matrix[5, 6], among others TiB_2 particles act as nucleants of α(Al), while $TiAl_3$ particles are dissolved in Al melt and promote the formation of TiB_2 nucleants[7,8]. Sometimes, Al5Ti1B master alloy contains certain AlB_2 particles when it is produced by first adding KBF_4 and then K_2TiF_6[9], this will influence its grain refining efficency. The preparing methods of Al5Ti1B master alloy mainly include: double fluoride salts (K_2TiF_6 and KBF_4) method[10, 11], TiO_2 and B_2O_2 method[12, 13]; it is usually finished by one step, but some references reported it needs two steps[13], firstly preparing AlB and AlTi master alloys, then preparing Al5Ti1B master alloy by AlB and AlTi.

The purpose of this experiment is to investigate the structure heredity between the structure of Al5Ti1B master alloy and that of AlTi, AlB master alloys.

2 EXPERIMENTAL

Al-9.5% Ti master alloy was prepared by dissolving 98.0% sponge Ti in 99.7% commercially pure Al in medium-frequency induction furnace under 950 ℃, and poured the melt into a permanent mold(20 mm in diameter and 50 mm in height), the sample is named AlTi-1; then overheated the melt to 1 100 ℃ for 20 min and poured the melt into the permanent mold too, this sample is named AlTi-2.

Al-2.1%B master alloy was prepared by 99.7% commercially pure Al and KBF_4 in resistance furnace at 850 ℃, and poured the melt into the permanent mold too, this sample is named AlB-1. Rapidly quenched ribbon sample(AlB-2) was produced using a melt spinning machine under atmospheric conditions by high frequency induction melting in a quartz crucible, after remelted at 960 ℃ for 20 min (the melt was ejected onto the surface of a rapidly rotating copper wheel).

Two kinds of Al5Ti1B master alloys were produced from above AlTi and AlB master alloys at 850 ℃, as listed in Table 1.

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Table 1 Preparation of Al5Ti1B master alloys

Master alloys	Temperature /℃	Holding time /min	Prepared alloy
AlTi-1 + AlB-1	850	45	Al5Ti1B-1
AlTi-2 + AlB-2	850	45	Al5Ti1B-2

3 RESULTS AND DISCUSSION

The microstructures of AlTi master alloys are shown in Fig. 1. The gray particles are $TiAl_3$, whose morphologies are block-like and bar-like, respectively, as shown in Fig. 1(a) and Fig. 1(b).

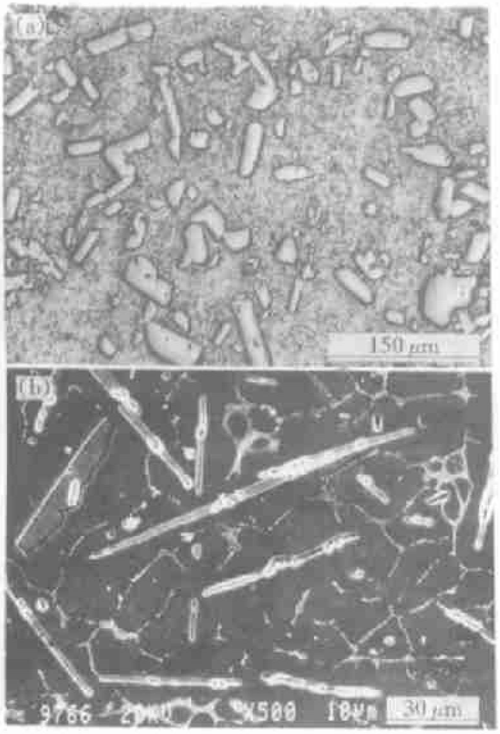

Fig. 1 Microstructures of Al-9.5% Ti master alloy
(a)—AlTi-1 sample(block-like $TiAl_3$);
(b)—AlTi-2 sample(bar-like $TiAl_3$)

The microstructures of AlB master alloys are shown in Fig. 2. AlB_2 particles are block-like, as shown in Fig. 2(a); but AlB_{12} particles are needle-like, as shown in Fig. 2(b).

The microstructures of Al5Ti1B master alloys prepared by original AlTi and AlB master alloys at 850 ℃ are shown in Fig. 3(a) ~ (c).

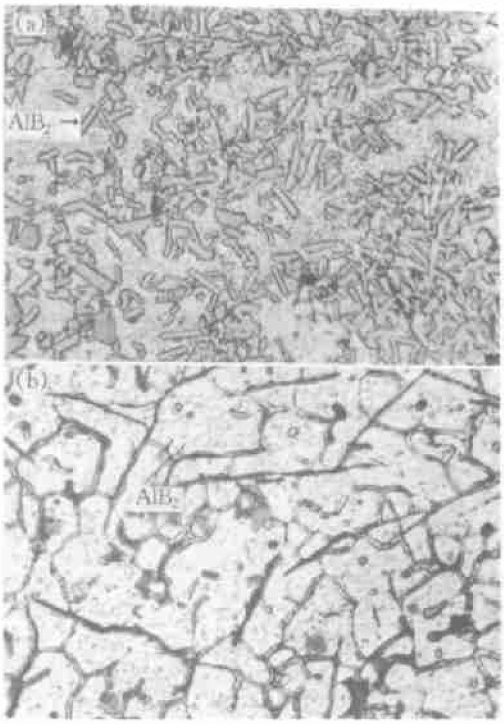

Fig. 2 Microstructures of Al-2.1% B master alloy
(a)—AlB-1 sample; (b)—AlB-2 sample

Fig. 3(a) refers to the Al5Ti1B-1 master alloy prepared by AlTi-1 and AlB-1 master alloys; Fig. 3(b) refers to the Al5Ti1B-2 master alloy prepared by AlTi-2 and AlB-2 master alloys.

It can be shown from Fig. 3(a) ~ (c) that the structures of original AlTi and AlB master alloys have remarkable structure hereditary influence on the phases and morphologies of Al5Ti1B master alloy, and the $TiAl_3$ morphologies of Al5Ti1B master alloys depend on original AlTi master alloys. This is due to the morphologies of $TiAl_3$ crystals can retain in the melt, and then affect the solid structure of Al5Ti1B master alloys.

In addition, it can be seen from SEM structures of the Al5Ti1B master alloys that there are a lot of compound rings, shown in Fig. 3(a). The rings can be retained at 850 ℃ for 180 min although the rings become smaller, as shown in

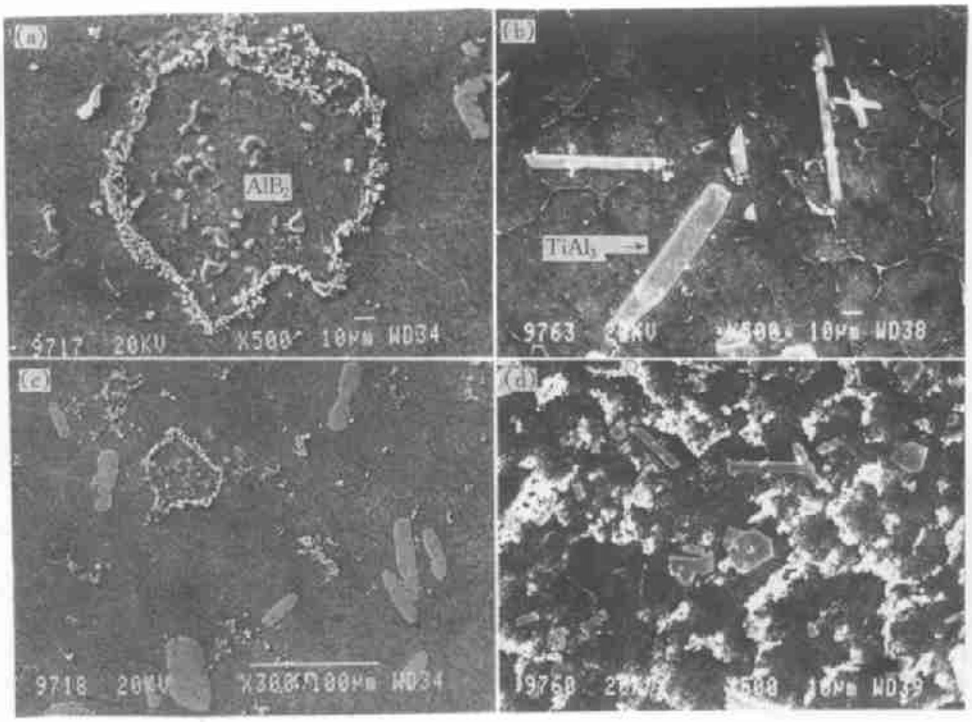

Fig. 3 Microstructures of Al5Ti1B master alloys
(a)—Prepared by AlTi-1 and AlB-1 master alloy samples(Al5Ti1B-1, holding 45 min);
(b)—Prepared by AlTi-2 and AlB-1 master alloy samples(Al5Ti1B-2, holding 45 min);
(c)—Prepared by AlTi-1 and AlB-1 master alloy samples(holding 180 min);
(d)—Prepared by K_2TiF_6 and KBF_4(one-step method)

Fig. 3(c). But there is no structures in Al5Ti1B master alloy prepared by K_2TiF_6 and KBF_4 (one-step method), as shown in Fig. 3(d). The compounds which form the rings are likely TiB_2, and the compounds inside the rings are likely AlB_2 according to their morphologies. The X-ray diffraction results show that there are AlB_2 in Al5Ti1B-1 sample in deed, as shown in Fig. 5 (c).

The formation mechanism of the compound rings can be illustrated by Fig. 4.

The X-ray diffraction results (Fig. 5) show the relationship of melting temperature and formation phases of AlB master alloys, the hereditary relation of phases between AlB and Al5Ti1B master alloys.

The phases of AlB master alloy are depend on melting temperature, AlB_2 can be formed at 850 ℃ and AlB_{12} can be formed at 960 ℃, as shown in Fig. 5(a) and Fig. 5(b).

The phases of Al5Ti1B master alloy are depend on AlB master alloy, for example, if

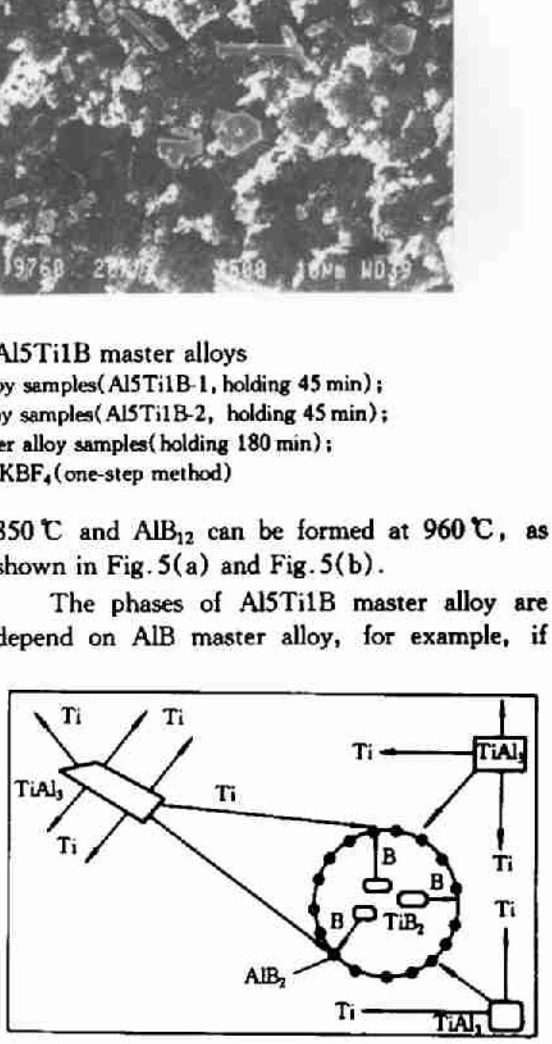

Fig. 4 Schematic represention of structure forming process model of Al5Ti1B master alloy

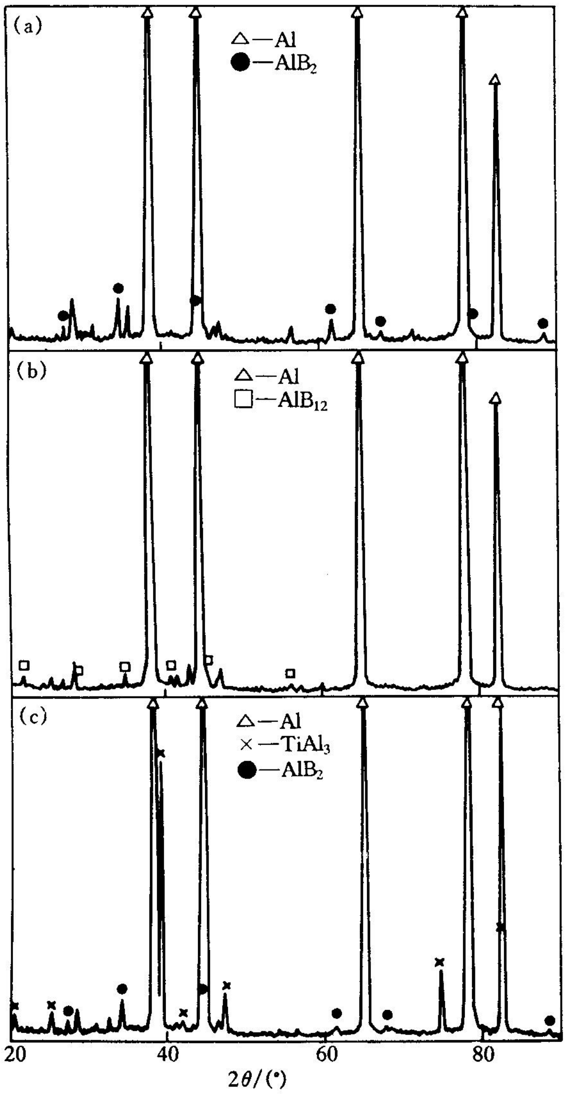

Fig.5 X-ray diffraction analysis results of AlB-1 and AlTiB master alloy samples
(a)—AlB-1 sample; (b)—AlB-2 sample; (c)—Al5Ti1B-1 sample

Al5Ti1B master alloy is prepared by AlTi and AlB master alloy contained AlB_2, then it can contain AlB_2, as shown in Fig.5(c). This is due to AlB_2 can be retained in the melt, then affect the structure of the alloy melt and retains in the solid Al5Ti1B master alloy.

4 CONCLUSIONS

(1) When Al5Ti1B master alloy is produced by two-step method, the morphologies of $TiAl_3$ depend on AlTi master alloy and the boride phases depend on AlB master alloy, It shows remarkable structure heredity relation between Al5Ti1B and AlTi, AlB master alloys.

(2) Theoretical analyses show that AlTi, AlB master alloys can change the melt structure of Al5Ti1B master alloy, and then affect the solid structures of Al5Ti1B master alloy.

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