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Preparation of Intermetallic Compound of Ternary Al-B-C System by Mechanical Alloying

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Abstract

Metallic compound of ternary Al-B-C system was prepared by mechanical alloying (MA) using Al, boron and graphite powders as starting materials. MA was carried out using Spex 8000 mixer/mill for 50 hours in an argon atmosphere without process control reagent such as methyl alcohol. The MA powders obtained were heat-treated in vacuum at the temperature of 873 and 1273 K for 5 hour. Pure ternary Al-B-C compound was obtained in the chemical content of Al:B:C=55:27:18. The ternary compound obtained in this study has a new phase whose crystal structure is not identified yet.

Keywords : Al-B-C ternary system, mechanical alloying, intermetallic compound, X-ray diffractometry

1. Introduction

One of the authors has been studying the preparation of boride particle-dispersion strengthened aluminum alloys[1]. In that study, the transition metal boride particles such as TiB_2, ZrB_2, HfB_2, VB_2, NbB_2, TaB_2 were adopted as dispersoids which were precipitated *in-situ* in the aluminum matrix by mechanically alloying using aluminum, transition metal(Ti, Zr, Hf, V, Nb, Ta) and amorphous boron. It was clarified that very fine transition metal boride powders were precipitated *in-situ* in the aluminum matrix uniformly when the powders mechanically alloyed for 20 h followed by heating in a high vacuum atmosphere at 873K for 1 h.

In order to obtain the higher specific strength of aluminu m alloys, the ternary aluminum borocarbide[2] having lowe r specific gravity than the transition metal borides is effectiv e. One of the authors has reported on the *in-situ* preparatio n of aluminum borocarbide particle-dispersion strengthened Al alloys[3,4]. Because the crystal structure and propertie s of aluminum borocarbide are unknown, it is necessary to c larify its characteristics. In this study, we tried to confirm the region of Al-B-C intermetallic compound mono phase g enerating at 873K in the ternary Al-B-C system.

2. Experimental and Results

Figure 1 shows the experimental points in this study. In this figure, the each set of three numerals shows the atomic ratio of Al, B and C. The experimental points on the line connecting Al corner and at%C on the B-C side of triangle are called as numerals of at%C. A square shown in Fig.1 is the area corresponding to Fig.3 described after.

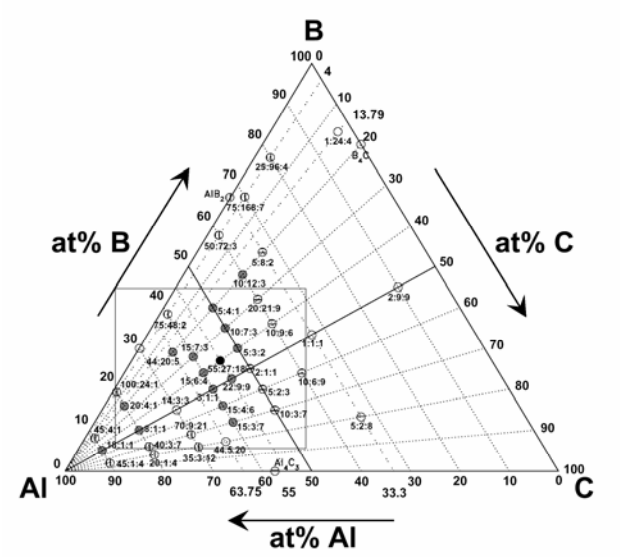

Fig. 1. Experimental points in this study. Each set of three numerals shows the atomic ratio of Al, B and C;Al:B:C.

Starting materials are Al(mean particle size;150μm), amorphous B(0.7μm) and graphite(2μm) powders. These powder were weighed 10g each batch and mechanically alloyed(MA) with Spex 8000 mixer/mill for 50h with no process control reagent such as methyl alcohol. Mixing container and mixing media were stainless steel and chromium steel balls, respectively. The mass ratio of powder to chromium steel balls is 0.23. The powders obtained by MA were heat-treated in vacuum at 873 and

1273 K for 5 h, then a part of them was consolidated by plasma assisted sintering(PAS) method. Observation of microstructure and measuring of specific gravity were carried out. X-ray diffractometer(CuKα,40kV,40mA) and transmission electron microscope (TEM,200kV) were used in order to identify the MA powders and consolidated body.

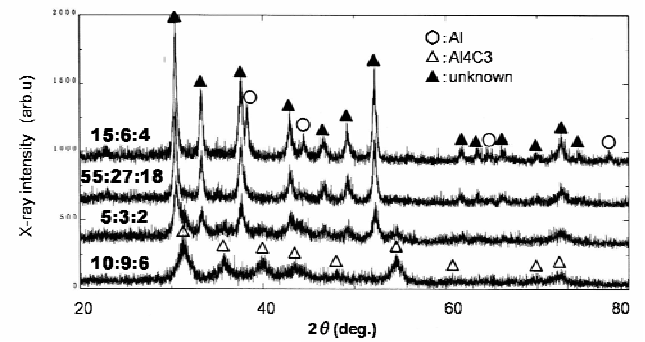

Fig. 2. X-ray diffraction patterns of experimental points on the line of 40at%C (B:C=3:2).

Figure 2 shows the X-ray diffraction patterns of experimental points on the line of 40at%C (B:C=3:2). On the point of 15:6:4, Al in addition to the unknown phase was identified, on the other hand, on the point of 55:27:8 only unknown phase was recognized. On the point of 5:3:2, Al_4C_3 in addition to the unknown phase was identified. On the point of 10:9:6, just Al_4C_3 was recognized.

Figure 3 shows the summary of the crystal structure observed in this study. Ternary Al-B-C intermetallic compound mono phase can be generated on the point around 55:27:18 at 873K. Al, AlB_2 and unknown phases were generated in the left area of each boundary line, on the other hand Al_4C_3 was generated in the right area of its boundary line. In the area around over contents of C compared to Al:B:C=55:27:18, Al_4C_3 was predominant.

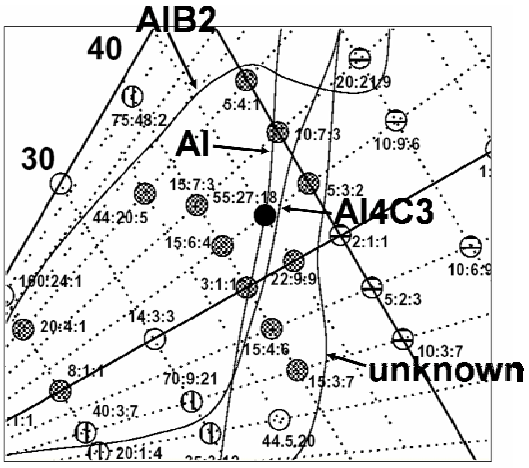

Fig. 3. Boundary lines of the generation of Al, AlB_2, Al_4C_3 and unknown phases.

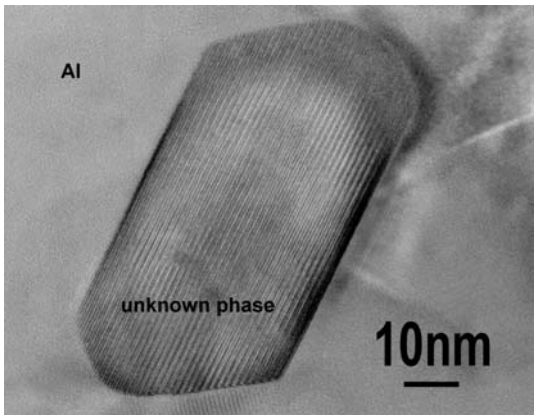

Fig. 4. Typical TEM image taken from 5:4:1 sample mechanically alloyed followed by heating at 873K and hot-extrusion

To clarify the characteristics of the consolidated body, the specific gravity of 55:27:18 disc sintered by PAS method was measured, then it was clarified that the value is 2.2g/cm^3 with 81% of theoretical value. Also, it was clarified by the SEM observation that many micro pores exist in the sintered body, especially around their center. Figure 4 shows the typical TEM image taken from the mechanically alloyed 5:4:1 sample followed by heating at 873K and hot-extrusion. This alloy exists in the area of coexistent region of Al and unknown phase in Fig.3. This result coincided with that has been reported already[3].

3. Summary

Pure ternary Al-B-C compound was obtained in the chemical content of Al:B:C=55:27:18. The ternary compound obtained in this studyhas a new phase whose crystal structure is not identified yet. In the area around over contents of C compared to Al:B:C=55:27:18, Al_4C_3 was predominant. On the other hand, in the area around over contents of B, the amount of AlB_2 and Al_4C_3 was increased. In the area of Al rich, Al and the new phase were increased.

4. References

1. T.Takahashi, K.Yamada and M.Motoyama, *Proceedings of The 6th International Conference on Aluminum Alloys, ICAA-6, Vol.3*. p.1823 (1998).
2. K.Saito : *Kagaku Daijiten*,vol.8, p.587.
3. T.Takahashi and M.Motoyama,Novel Powder Processing, Advances in Powder Metallurgy & Particulate Materials, Vol.7. p.413 (1992).
4. T.Takahashi, K.Yamada and M.Motoyama, *Proceedings of 2000 Powder Metallurgy World Congress,* p.1096 (2000).