Synthesis and Mechanical Properties of Nano Laminating Cr_2AlC using CrC_x/Al Powder Mixtures

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Abstract

Cr_2AlC was synthesized by a reactive hot pressing of CrC_x (x=0.5) and Al powder mixture used as starting materials at the temperature range of 1200 ^oC~1400 ^oC under 25 MPa in Ar atmosphere. Fully dense Cr_2AlC with high purity was synthesized by hot pressing CrC_x and Al powder mixture at the temperature as low as 1200 ^oC. The average grain size of synthesized bulk Cr_2AlC was varied in the range of 10-100 ㎛ depending on hot pressing temperatures. The maximum flexural strength of synthesized bulk Cr_2AlC exceeded 600 MPa.

Keywords : Cr_2AlC, ternary carbide, synthesis, mechanical properties

1. Introduction

The ternary carbides and nitrides with layered structure have drawn much attention as they possess many good properties of both metals and ceramics [1-7]. Most of the previous studies on ternary carbide have been concentrated on Ti_3SiC_2 and Ti_3AlC_2 as demonstrated by the many investigations done on the synthesis process for those carbides has been intensively investigated. However, it has been reported that Ti-based ternary carbides such as Ti_3SiC_2, Ti_3AlC_2, and Ti_2AlN do not have a good high temperature oxidation resistance enough to be used at the temperature of above 1100 ^oC [7-11]. Recently, it was reported that bulk Cr_2AlC, which was synthesized by a hot pressing of Cr, Al, and graphite mixture at 1400 ^oC for 1 hr under 20 MPa in Ar atmosphere [12], was found to be difficult to synthesize with high purity. In this study, bulk Cr_2AlC with high purity was prepared by hot pressing of CrC_x and Al powder mixture at the temperature range between 1200 ^oC and 1400 ^oC, and, the mechanical properties of fabricated bulk Cr_2AlC were investigated.

2. Experimental and Results

Fig. 1 shows the XRD patterns of synthesized bulk Cr_2AlC that was produced by hot pressing a synthesized CrC_x and Al powder mixture under 25 MPa in an Ar atmosphere at the temperature range between 1200~1400 ^oC. As shown in Fig. 1, the bulk Cr_2AlC was successfully synthesized throughout the entire processing temperature employed in this study. It was found that the specimen, which was hot pressed at 1200 ^oC, consisted of mostly Cr_2AlC phase without any other crystalline phases. With increasing hot pressing temperature, the specimen consisted of mostly Cr_2AlC crystalline phase. Here, the trace amounts of Cr_7C_3 was found to appear as a secondary phase as shown in Fig.1(c). These observations suggest that Cr_2AlC starts to decompose above 1400 ^oC. The evaporation of Al seemed to be accelerated by the exothermal reaction between Cr and graphite during hot pressing. However, it was found that bulk Cr_2AlC with high purity could be synthesized simply by a hot pressing of CrC_x and Al powder mixture without forming secondary phase. However, chemical reactions in the CrC_x/Al system should be studied further to understand the synthesis mechanism of CrC_x from CrC_x/Al system exactly.

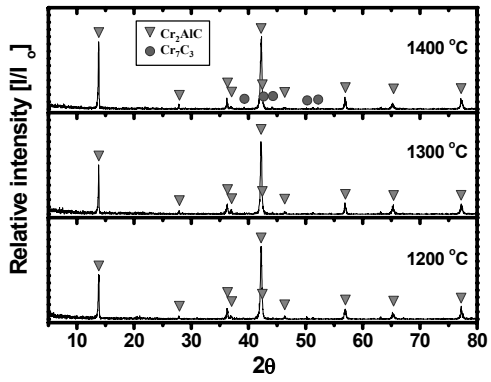

Fig. 1. XRD patterns of synthesized bulk Cr_2AlC by hot pressing of CrC_x and Al powder mixture.

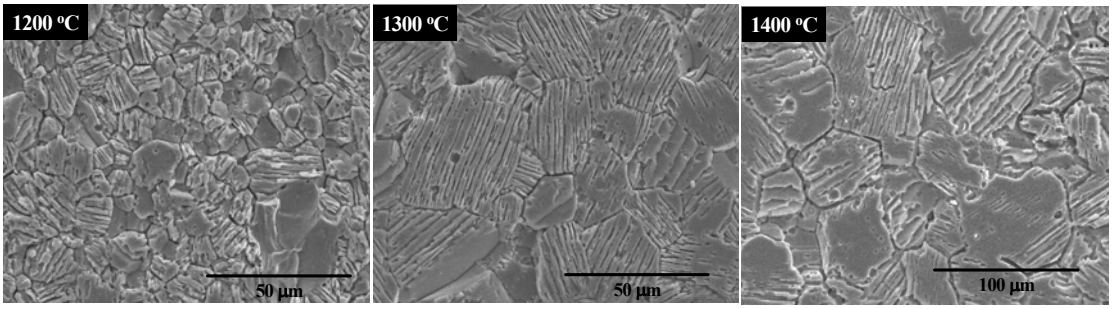

Fig. 2. SEM microstructures of bulk Cr_2AlC specimen synthesized by hot pressing of CrC_x and Al powder mixture at the temperature range of 1200 °C~1400 °C.

Fig. 2 shows SEM microstructures of etched polished surface of bulk Cr_2AlC synthesized by hot pressing of CrC_x and Al powder mixture at 1200 °C to 1400 °C. It was observed that each Cr_2AlC grain consisted of layered structures, which has been reported as a typical microstructure of other ternary carbide in previous studies [1-6]. With increasing hot pressing temperature from 1200 °C to 1400 °C, the grain size of bulk Cr_2AlC was abruptly increased from 10 ㎛ to 50 ㎛ without changing the grain shape. The measured densities of synthesized bulk Cr_2AlC were in the range of 5.208~5.229 g/cm^3, which was increased with hot pressing temperature. The relative densities bulk Cr_2AlC synthesized in this study was more than 99%. Fig. 3 show the flexural strength of bulk Cr_2AlC synthesized by hot pressing of CrC_x and Al powder mixture at 1200 °C~1400 °C. It was appeared that the flexural strength of bulk Cr_2AlC was varied with its relative density and grain size. The maximum of flexural strength of bulk Cr_2AlC was about 600 MPa which was twice higher than that reported in previous study [12].

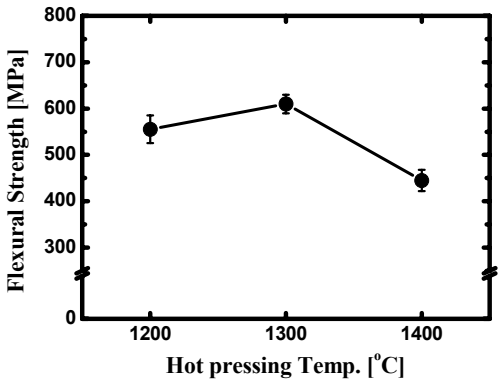

Fig. 3. Flexural strength of bulk Cr_2AlC as a function of Hot pressing temperature.

3. Summary

Bulk Cr_2AlC ternary carbide with high purity was successfully synthesized by hot pressing of newly prepared CrC_x and Al powder mixture under 25 MPa at the temperature range of 1200 °C ~ 1400 °C. The relative density of bulk Cr_2AlC synthesized in this study was above 99% of the theoretical density of Cr_2AlC. Synthesized bulk Cr_2AlC was found to have typical layered structure which has been reported in other ternary carbides such as Ti_3AlC_2 and Ti_3SiC_2. The average grain size of synthesized bulk Cr_2AlC was varied in the range of 10-100 ㎛ depending on hot pressing temperatures. The flexural strength of synthesized bulk Cr_2AlC was appeared to be varied depending on the relative density as well as grain size. The maximum flexural strength of synthesized bulk Cr_2AlC was over 600 MPa.

4. References

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