Growth Behavior and Mechanisms in Cemented Carbides

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Abstract

To test the correlation between grain shape and growth behavior we prepared WC-TiC-Co samples with rounded (Ti,W)C grains and faceted WC grains. The growth of rounded (Ti,W)C grains was normal. In contrast, the growth of faceted WC grains was abnormal or suppressed depending on the initial size of WC particles. These observations were explained using growth theories of crystals in a liquid and were also confirmed by a simulation using their growth equations. The present results thus demonstrate that the growth behavior of carbide grains in a liquid is governed only by their shape, irrespective of the presence of another phase.

Keywords: **cemented carbide, abnormal grain growth, liquid-phase sintering, TiC-WC-Co, grain shape**

1. Introduction

Cemented carbides with cobalt binder, which has wide applications as a wear-resistant tool material, are usually fabricated by using liquid-phase sintering. During liquid phase sintering of metal-based carbides, carbide grains often exhibit abnormal growth of some grains (AGG), [1-2] resulting in a duplex microstructure with large abnormal grains in a fine matrix, which can cause degradation of mechanical properties. Considerable efforts have been made to prevent AGG as well as to understand the mechanism of AGG. Recent investigations have shown that grain growth behavior in a liquid matrix is related to the shape of grains, rounded or faceted.[3-4] When the grain is faceted, abnormal grain growth occurred or suppression of grain growth resulted. For rounded grains, normal grain growth occurred. The present investigation studies the growth behaviors of two types of grains, rounded and faceted, in the same matrix to confirm the growth behavior dependence on grain shape. The effect of initial powder size on growth behavior was also studied. For the experiment, the TiC-WC-Co system was taken as a model system.

2. Experimental and Results

Prepared samples with a composition of 70(25TiC-75WC)-30Co (wt%) were sintered at 1450℃ for various periods of time in vacuum furnace. After liquid phase sintering rounded (Ti,W)C and faceted WC grains were uniformly distributed in a Co-based matrix as shown in Fig. 1. As the sintering proceeds, the growth behavior appears to be very different between the two types of grains. Rounded (Ti,W)C grains grew normally, following a cubic law which indicate diffusion-controlled growth. On the other hand, the growth of the faceted WC grains resulted in a bimodal grain size distribution, showing abnormal grain growth. With increased initial size, however, abnormal growth of WC grains was suppressed. As a result of the difference in grain growth behavior among the samples with different WC particle sizes, the change in average size of WC grains with sintering time also varied between the samples and this result well fit with simulated growth of faceted grains with three different sizes as shown in Fig. 2. These predicted growth behaviors confirm that our explanation based on the crystal growth theories is relevant to predict the growth behavior of faceted grains, even in a system with two types of grains.

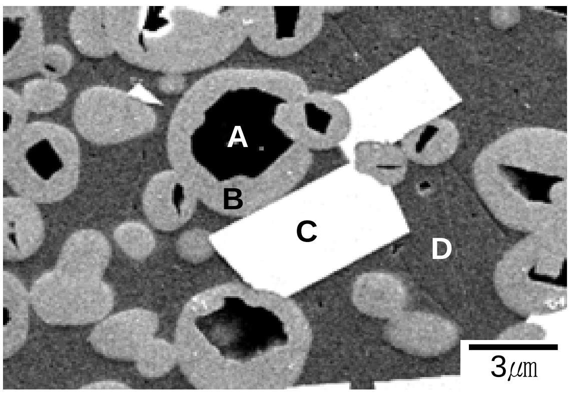

Fig. 1. Microstructure of 70(25TiC-75WC)-30Co system. (A) Ti core, (B) (Ti,W)C shell, (C) WC grain, (D) Co-based matrix.

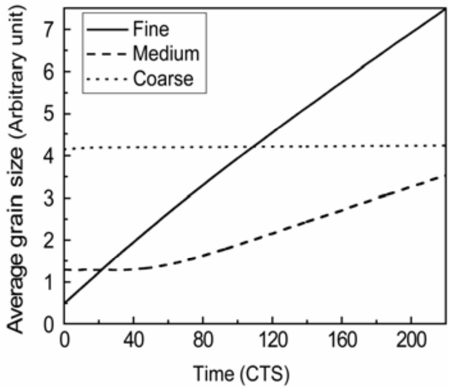

Fig. 2. Result of computer simulation showing increase of average size of grains with three different sizes with calculation time step (CTS).

3. Summary

Rounded (Ti,W)C grains with a rough interface showed a unimodal and a stationary distribution of normalized grain sizes, indicating normal grain growth. In contrast, faceted WC grains with a singular interface showed abnormal grain growth when the WC powder was fine and suppressed grain growth when the WC powder was coarse. This growth behavior of WC grains was in good agreement with a calculated prediction based on the growth theories and equations of faceted single crystals in a liquid matrix. The present observations demonstrate that the growth behavior of grains in a matrix is governed only by their shape, irrespective of the presence of another phase.

4. References

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