Production of Nanosized WC Powder by Vapor Phase Reaction

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Abstract

In the present study, the focus is on the synthesis of nanosized WC powder by the chemical vapor condensation proces. The synthesized W-C system powder by the CVC process shows W_2C, W, WO_3 phases and can not shows WC phase. After recarburization heat treatment under mixture gas atmosphere of argon and hydrogen gases, the synthesized W-C system powder fully transformed to the pure WC. The synthesized WC powder after recarburization heat treatment has an average particle size of 20 nm. The nano-sized WC powder can be prepared by the combination of the CVC process and heat treatment methods.

Keywords : Nanosize, WC/Co powder, Vapor Phase

1. Introduction

The cemented carbides are composite material of hard carbides (WC, TiC, etc) and ductile metals (Co, Ni). Since the combination of hard and ductile properties produces outstanding mechanical properities, these materials commercially useful in machining, mining, metal cutting, metal forming, construction, and other applications. Among the hard alloys and refractory carbides, WC has found a wide range of industrial application because of its high hardness, wear/erosion resistant and low themal expansion coefficient. The cutting tool industry has approached increase hardness by altering the composition, primarily in the direction of increasing carbides content in the range of 94-97%WC. However, assiociated with this change, a corresponding decrease in both toughness and ductility has occurred.

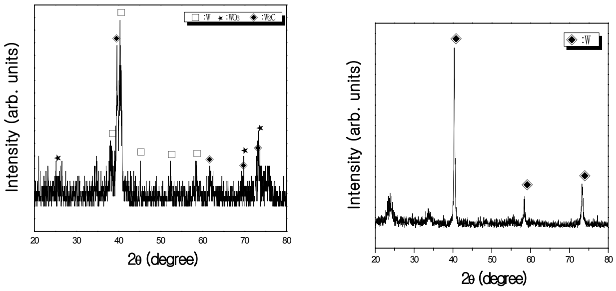
A solution proposed to slove this problem was a reducetion in the particle size of the intial WC/Co powder. Thus, the control of grain size of the phase is an important. The improved properties of a WC-Co alloy produced using nano-sized powder has been explained in terms of variety of factors, such as the short interparticle distance, the low melting point of the nano-sized Co matrix and small WC grain size. In general, decrease the carbide grain size increases mechanical properties; hardness, wear resistant, and transverse rupture strength. In order to produce nanocrystalline WC-Co alloy, therefore, nano-sized powders of WC and Co have been prepared by several methods, such as inert gas condensation, chemical vapor reaction, eletrodeposition, sputtering, high-energy ball-milling, and solution technique. Among many new powder preparation techniques, vapor-phase reaction method is attracted preparation method of ceramic powder. Because the vapor phase reaction technique can be characterized by high chemical purities and discrete ultrafine particles.[1-4)]

In this study we try to synthesize nano-sized WC powder by chemical vapor reaction process. The phase structure, particle size, and the degree of agglomeration of synthesized powder characterized by XRD, SEM and TEM.

2. Experimental and Results

In this present study, the formation of nanostructured WC powder in CVC reactor has been investgated to optimize the process with controlling powder characteristics. To synthesize nanostructured WC powder, tungsten hexa-carbonate ($W(CO)_6$) was used as the precursor materials. Nano-sized W-C system powders were synthesized by vapor reaction at 700-1300^oC under mixture gas atmosphere of helium, hydrogen and metane gases. After the reaction, most of the powder had a WC phase structure, but some of them still remained W_2C or other tungsten carbide phases. For the synthesis of pure WC phase, the synthesized W-C system powder by vapor phase reaction was heat treated at 1150^oC under argon or hydrogen atmpsphere.

Figure 1 shows the X-ray diffraction patterns of synthesized W-C system powders by the CVC process. The synthesized W-C system powder at 700^oC shows W_2C and W, WO_3 phases. However, the synthesized W-C system powder at 900^oC has only the diffraction pattern of W phase. It could not found diffraction peaks of WC phase from the synthesized W-C system powders by the CVC process. It needs that recarburization heat treatment for the formation of WC phase structure from the synthesized W-C system powders.



(a) (b)

Fig. 1. X-ray diffraction patterns of synthesized W-C system powders by chemical vapor reaction process at (a) 700°C and (b) 900°C.

Figure 2 shows the X-ray diffraction pattern of the heat-treated powder at 1150°C. The heat treatment was carried out under mixture gas atmosphere of argon and hydrogen gases. After heat treatment, the synthesized W-C system powder transfers to pure WC phase structure. The carbon content of the heat-treated powder was decreased with increasing heat treatment time.

Figure 3 shows TEM micrograph of the heat-treated powder. The heat-treated powder has an average particle size of 20 nm, and carbon content of about 7.0wt.%.

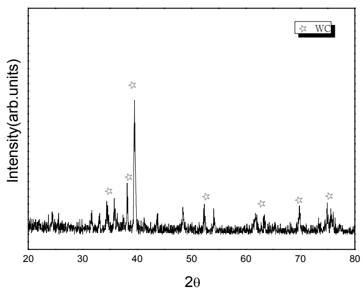


Fig. 2. X-ray diffraction pattern of the heat treated powder.

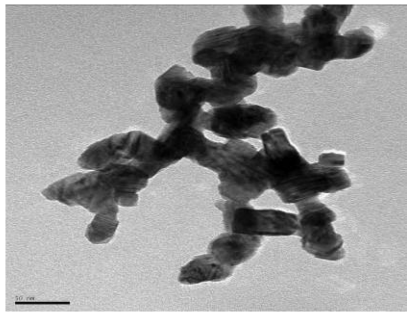


Fig. 3. TEM micrograph of the heat treated powder.

3. Summary

The synthesized W-C system powder by the CVC process shows W_2C, W, WO_3 phases and can not shows WC phase. After recarburization heat treatment under mixture gas atmosphere of argon and hydrogen gases, the synthesized W-C system powder fully transformed to the pure WC. The synthesized WC powder after recarburization heat treatment has an average particle size of 20 nm. The nano-sized WC powder can be prepared by the combination of the CVC process and heat treatment methods.

4. References

1. W.Chang, G.Skandan, M.Rose, A.G.Balogh H.Hahn and B.Kear, NanoStructured Materials.Vol 6, 321-324 (1995)
2. C.H, Allibert, International Journal of Refractory Metals & Hard Materials, 19, 53 (2001)
3. H.H Nersisyan, H.I Won, C.W.Won, J.H. Lee, Meterials Chemistry and Physis, 94, 153 (2005)
4. H.Hahn, NanoStructured Materials. Vol 4, 507-520 (1994)