Vacuum Carbonization of Nanometer Tungsten Powder with Carbon Black

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Abstract

Vacuum carbonization of nanometer tungsten powder was investigated in a simple designed apparatus. An X-Y recorder was used to plot differential thermal analysis (DTA) curves to determine starting temperature of carbonization of four samples with different specific surface area. The product was detected by X-ray Diffraction (XRD) and small angle X-ray scattering (SAXS). The results show that finer tungsten powder has lower starting temperature of carbonization. Tungsten powder, which BET surface area is 32.97m^2/g, is completely carbonized to tungsten carbide at 1050 ℃, although the starting temperature is 865 ℃. Particle grows sharply before carbonization.

Keywords : Tungsten carbide, Nanometer powder, Carbonization

1. Introduction

Because of it's excellent mechanical properties, ultra-fine grained cemented carbide has been the tide of hard alloy research works. Nanosized WC-Co holds promise for the future[1]. Researchers and manufacturers pay much attention to low cost and commercial process of ultra-fine grained cemented carbide nowadays. As well known, the key of nanosized hard metal is the synthesis of high quality nanometer tungsten carbide powder. The nanometer tungsten carbide powder with high quality used for producing nanosized cemented carbide includes at least two factors. First of all, the average particle size must be as fine as possible, since tungsten carbide grains grow sharply in the sintering process even at very low temperature. Secondly, the particle size distribution must be narrow, otherwise it will cause heterogeneous grain growth in sintering[2].

Synthesis of nanometer tungsten carbide is much more difficult than nanometer oxide powders such as Al_2O_3, ZrO_2 and TiO_2. Many approaches can prepare nanometer tungsten trioxide powder, but the particle size of tungsten carbide would become over 100nm after reduction and carbonization processes. Moreover, finer particle grows more sharply. By far the best way to provide qualified nanometer tungsten carbide powder is Chemical Vapor Reaction (CVR), which is very expensive and inefficient for commercial process.

In University of Science and Technology Beijing, Zhang Liying [3,4,5] prepared nanometer tungsten trioxide particle by ultra-sonic spray technology, a commercial scale process. Also tungsten powder was prepared by hydrogen reduction at a low temperature, whose mean size is under 50nm. Those tungsten powders were used in the experiments of this paper to investigate the effect of particle size of tungsten power on vacuum carbonization temperature, wherein nanometer carbon black was used as carburetant. The effect of carbonized temperature on particle size and the particle growth regularity was investigated too.

(2 line spacing)

2. Experimental and Results

Nanometer carbon black was used as carburetant for vacuum carbonization of nanometer tungsten powder in a simple designed apparatus. DTA curves were plotted by an X-Y recorder to determinate the starting temperature of carbonization since carbonization is exothermic reaction. The product was detected by X-ray Diffraction (XRD) and small angle X-ray scattering (SAXS).

Table 1. Characterizations of tungsten powder

Sample No.	Specific surface Area(m^2/g)	Particle size (nm)	O content (%)
1	5.89	60.8	0.8
2	10.46	54.4	0.7
3	26.58	45.6	1.6
4	32.97	32.3	1.5

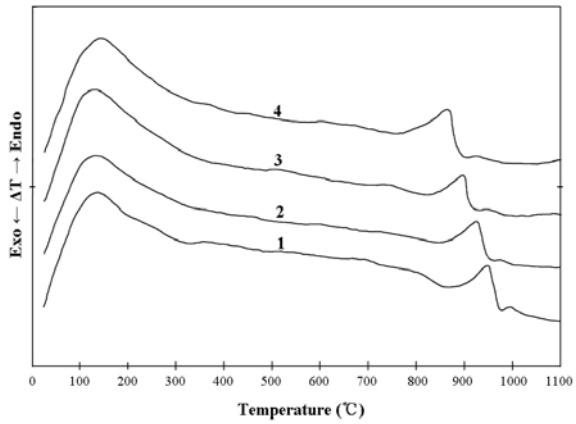

Fig. 1. DTA curves of each sample.

Table 2. Starting temperature of carbonization of each sample

Sample No.	1	2	3	4
Specific surface area(m^2/g)	5.89	10.46	26.58	32.97
Carbonizaion start point (℃)	945	927	892	865

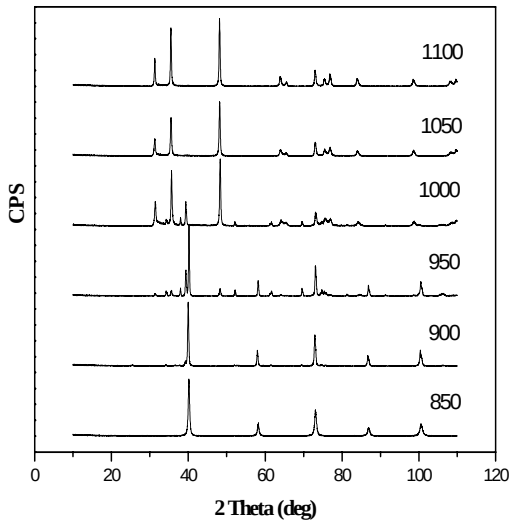

Fig. 2. XRD patterns of the product (sample 4).

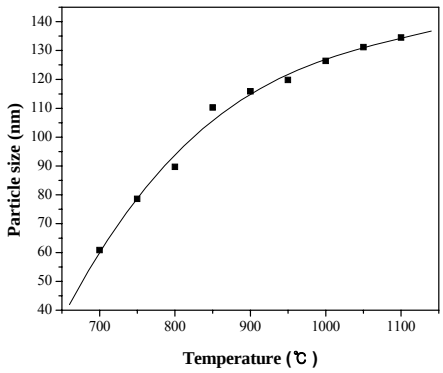

Fig. 3. Dependence of particle size on temperature (sample 4).

3. Summary

The specific surface area of nanometer tungsten powder affects starting temperature of vacuum carbonization using carbon black as carburant. Finer tungsten powder has lower starting temperature of carbonization. Tungsten powder with BET surface area of 32.97m^2/g has the starting temperature of 865℃. Tungsten powder, which BET surface area is 32.97m^2/g, is completely carbonized to pure tungsten carbide at 1050℃. The particle grows to 131.2nm after carbonization at that temperature. The starting temperature is the determinant factor of particle size of tungsten carbide since particle growth mostly occurs before carbonization from 640 to 850℃. After carbonization reaction starts, particle growth would slow down.

4. References

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