Research on Two Sintered Techniques of Nanometer WC-Co Powder

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Abstract

This paper concerned with SPS (spark plasma sintering), hot pressing of sinter nanometer WC-Co powder and discussed the density, hardness, microstructures and grain sizes of the alloys sintered. The results showed that the two sintered techniques could produce high density alloys and play well on the grain growth, but SPS could lower the sintering temperature and shorten sintering time. Besides, the hardness of the sintered cemented alloys that was dependent on the grain size and densification could also be improved.

Keywords : WC-Co carbide; sintering; spark plasma sintering; hot pressing

1. Introduction

Tungsten carbide/cobalt (WC–Co) cemented carbides or cermets, characterized by their high hardness and strength, are applicated in areas where materials of high wearability and toughness are required [1]. However, a key point of the process on block ultrafine tungsten carbide is the sintering of the nanometer scale WC-Co powder. The sintering of nanometer powder is an important process to get ultrafine block materials. In order to get more excellent products, in the sintering of nanometer powder, the product must achieve high density and ultrafine grain size [2].

Spark plasmas sintering（SPS）which is a new rapid sintering technology has high quality, uniform sintered compacts at lower temperature and in shorter periods than conventional sintering methods. Hot pressing sintering has the characteristic that the mixed powder is synchronously heated and pressed to be shaped.

This research has used two sintered technique above to densify nanometer WC-Co powder, made a comparation of each other and educed the optimal parameters in sintering process to prepare WC-Co hard alloys of ultrafine grain size and high quality.

2. Experimental and Results

Nanometer WC powders (≥99.5%, ~80 nm) and Co powders (≥99.5%, ~60 nm) The oxygen in WC and Co powder is less than 150 ppm (≤0.015%). The powders composite of nanometer scale WC-11Cos were wet ball-milled through ethanol in a high vibration ball milling machine for 2h.

These sintering parameters are presented in Table 1.

Table 1. Sintering parameters in SPS, hot pressing

parameters	SPS	hot pressing
Sintering temperature [˚C]	900～1100	1000~1300
Press [MPa]	25	25
Keeping time [min]	5	90
Mould size [mm]	Φ10	Φ10
atmosphere	vacuum	

Fig. 1 gives XRD of WC and Co powders and the products of the SPS and hot pressing. The results show that in 2h's milling nanometer WC-Co during SPS and hot pressing sintering, only have WC phase and Co phase. No new phase is formed. Fig.2 and Fig.3 give the relationship between the density and grain size of WC of sintered samples and sintering temperature for SPS and hot pressing. SPS could rapidly realized full density from 950~1100 ºC, but hot pressing, it was at 1300 ºC. The grain size of WC grows along with the sintering temperature. The WC grain size of SPS sintered samples at 1000 ˚C is about 610 nm. At 1100 ºC, the grain size of WC has already got 780 nm. For the hot pressing, at 1200~1300 ºC, with the increasing density, the grain size of WC grows up rapidly.

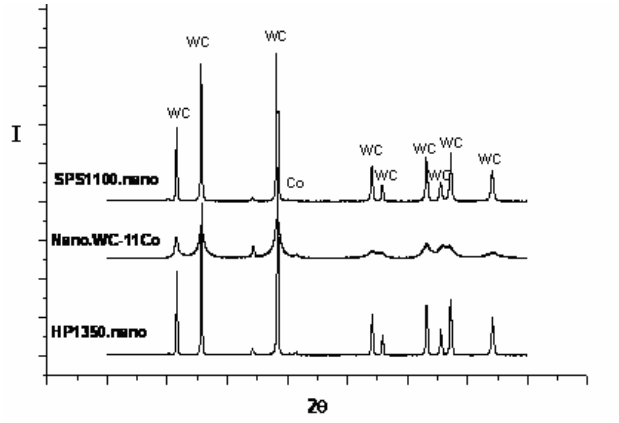

Fig. 1. The comparation of the XRD apex.

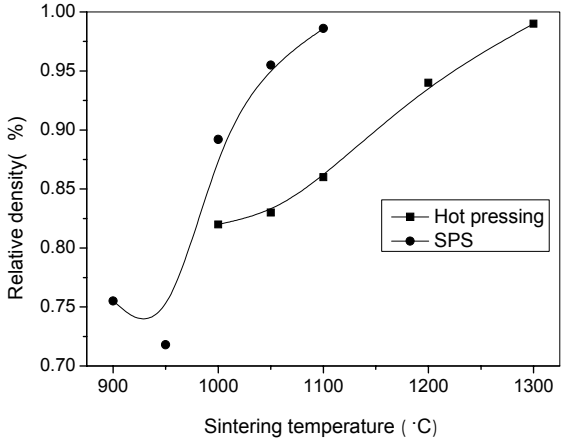

Fig. 2. The relationship between the density and sintering temperature.

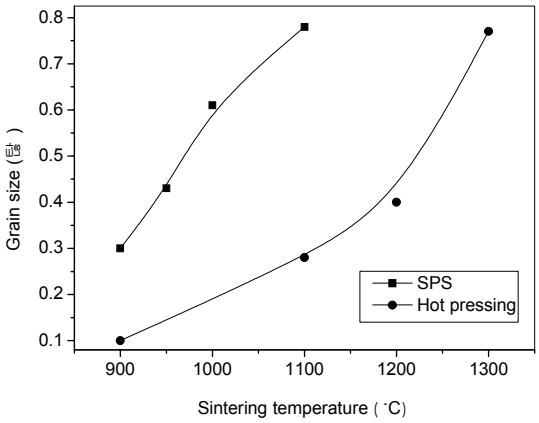

Fig. 3. The relationship between the grain size of WC and sintering temperature.

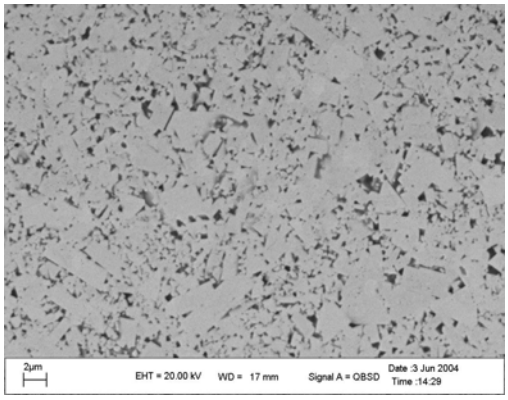

Fig. 5. Microstructure of sintered WC-Co sample in hot pressing (1300°C).

Fig. 5 shows the microstructure of sintered samples in hot pressing. It can be seen that the grain size of WC is rather uniform, the surface of particles is smooth, the WC particles is compact-linked and the Co phase equably exists among the WC particles.

3. Summary

SPS can lower the sintering temperature, obtain ultrafine WC-Co alloys with a density thicker than 98%, WC grain size about 780 nm at 1100 ˚C, the hardness about HRA92.8. Hot pressing sintering can realize full density of WC-Co hard alloy and inhibit the growth of WC particles. SPS which compared to the hot pressing is an effective process to sinter WC-Co cemented carbides and can obtain the carbides with full density, fine size and good properties in the lower temperature.

4. References

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