Synthesis and Properties of Ultra-fine (Ti, M1, M2)(CN)-Ni Cermets

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Abstract

TiC- and Ti(C,N)-based cermets are excellent in semi- and final finishing of work piece during cutting operations. Typical microstructure of the cermets is a core/rim structure. The undissolved Ti(C,N) cores contribute to their high hardness while the rim phases, (Ti,M1,M2)(C,N)-type solid solutions, play great roles in enhancing the toughness. In this paper, various ultrafine pre-mixed MeC-Ni powders were synthesized and the powders were sintered or hot pressed after mixing in order to control the size and volume fractions of core and rim phases in the system. This paper will present the factors determining the microstructure along with mechanical properties.

Keywords : Cermet, solid solution, toughness, nano-approach, pre-mixed

1. Introduction

TiC- and Ti(CN)-based cermets have attracted attracted considerable attention as a cutting tool. The titanium carbonitride has high hot hardness, melting temperature, chemical and thermal stability, wear resistance [1~3]. However, attempts to find substitute for WC-Co continue to be hampered, because of their low toughness.

Typical microstructure of the cermets is a core/rim structure. The undissolved Ti(C,N) cores contribute to their high hardness while the rim phases, (Ti,M1,M2)(C,N)-type solid solutions, play great roles in enhancing the toughness. [4,5]

In this paper, various ultrafine pre-mixed MeC-Ni powders were synthesized and the powders were sintered or hot pressed after mixing in order to control the size and volume fractions of core and rim phases in the system.

2. Experimental and Results

An anatase–TiO_2 of ~45 μm, WO_3 of ~20 μm, MoO_3 of ~20 μm, Nb_2O_5 of ~45 μm and NiO of ~45 μm (purity 99%) were used as starting materials. The amount of carbon was determined by assuming that most of the oxygen in the system is reduced by carbon in the form of CO during the reduction step. The powders were subjected to high-energy ball milling using a planetary mill (Fritsch Pulverisette 7). Tungsten carbide balls, as milling media, were mixed with the oxide and carbon powders at a ball-to-powder weight ratio of 40:1. A tungsten carbide coated bowl was used and all milling was conducted under anhydrous conditions at a speed of 250RPM for a period of 20h. No solvent was used during the milling process in order to convert the oxide mixture into nano-crystalline or amorphous powders. The milled powders were reduced and carburized completely under a vacuum at 1000~1250°C for 2 hr.

Pre-mixed MeC-Ni powders were blended in a planetary mill. The cermet compositions studied in present work were TiC-16MeC-20Ni(wt%). The blends were dried, sieved and coldcompacted nder a uniaxial load of 100 MPa. The ompacts were subjected to pressure-less sintering at 1783 K under 10^{-4} Torr vacuum for 1 h.

Fig. 1. shows the XRD results for the powders after carbothermal reduction at 1100°C. The phases are idenfied as MeC and Ni.

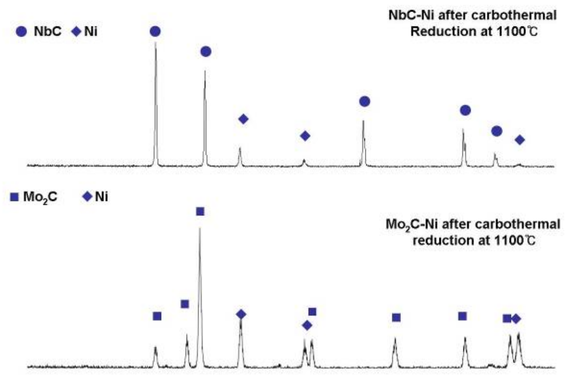

Fig. 1. XRD of MeC-Ni.

Milled oxide power mixture has a structure that is rich in defects. It reduced the reaction time and temperature.

Microstructure from mixing method was shown with core-rim structure. (Fig. 2.) Mixing method of MeC-Ni premixed powders increase dissolution rate during liquid phase sintering. It increases the rim phase fraction, which contributed to improved toughness.

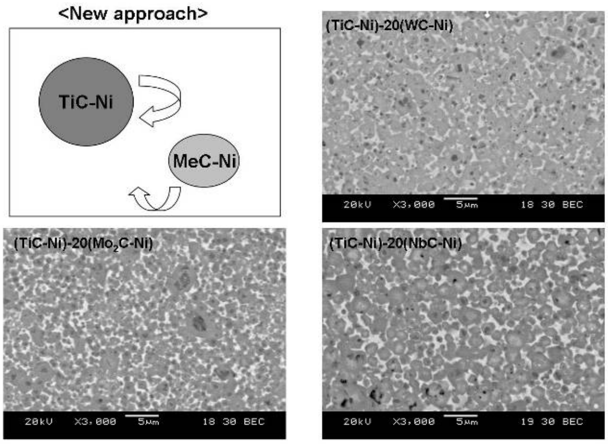

Fig. 2. Microsturcture of mixed nano powders.

In the converntional method, carbides and Ni are separated and dissolution rate is lower than that of mixing method during dissolution and re-precipitation process.

Table 1. Mechanical properties

	Hardness (Gpa)	K_{IC} ($Mpam^{1/2}$)	Porosity level
TiC-16WC-20Ni	14.0	10.9	A3B1
TiC-16Mo_2C-20Ni	13.6	9.7	A3B1
TiC-16NbC-20Ni	13.5	9.5	A3B1

The mechanical properties of mixing method are summarized in Table 1. It is superior to mechanical properties of conventional cermet. The increase in the rim phase fraction enhanced toughness of cermet.

3. Summary

Various MeC-Ni powders were synthesized by carbothermal reduction of ball milled oxide mixtures.

Microstructure of TiC-based cermet is core-rim structure. The rim phases contribute to toughness. Mixing method of these MeC-Ni powders increases dissolution rate and volume fraction of rim phases. The microstructural change controled the mechanical properties of the cermets.

4. References

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