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Cermets Sintered from TiC@Ni Nanopowders at Low Temperature†

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Intergranular-type TiC-Ni cermets acquired by spark plasma sintering were reported. Composition and microstructure were studied by X-ray diffraction, field-emission scanning electron microscopy and transmission electron microscopy. Results revealed that TiC@Ni nanopowders less than 100 nm could be effectively used as raw materials to fabricate TiC-Ni cermets at lower sintering temperature by spark plasma sintering.

Keywords: Cermets, Nanopowders, Sintering, Spark plasma sintering.

INTRODUCTION

Titanium carbide-based cermets are widely used as cutting tools, because of their high strength, hardness, chemical stability and excellent wear resistance[1,2]. Presently, nanometer science technology has been applied widely in developing a new material and modification of conventional materials. Some stage research results have been achieved in the fields such as coating nanomaterials, high strength structural nanomaterials, magnetic and optical nanomaterials and bionic material[3,4]. In this article, TiC-Ni cermets from TiC@Ni nanopowders were obtained by spark plasma sintering (SPS) at low temperature. The microstructure and fractural properties were studied.

EXPERIMENTAL

The green samples were prepared by a conventional powder metallurgy technique (PM).The experimental progresses are as follows: Firstly, the TiC@Ni nanopowders were successfully prepared by a reduction-precipitation method. Secondly, the TiC@Ni core-shell powders with proper contents of WC and Mo_2C were mixed and pressed into rectangular-shaped specimens. Finally, the green specimens were sintered at 1200 ºC for 2 h by SPS. X-ray diffraction patterns were measured on a Philips X'pert diffractometer using CuK_α radiation (0.15419 nm). Morphology of the product was observed on a Sirion 200 FEG field emission scanning electron microscope (FE-SEM). Transmission electron microscopic (TEM) examination was conducted on a JEOL-2010 microscope attached with an energy-dispersive X-ray spectrometer (Oxford, Link ISIS).

RESULTS AND DISCUSSION

Phases of raw materials and as-prepared cermets: Fig. 1a-b show the TiC raw powders and the TiC@Ni powders, respectively. Fig. 1c shows the XRD pattern of the as-sintered TiC-Ni cermets acquired by spark plasma sintering at 1200 ºC for 2 h. All of the diffraction peaks can be readily indexed from the standard powder diffraction file of the cubic phase TiC (JCPDS 02-1179) and Ni (JCPDS 65-0380). These data clearly show that TiC-Ni composites have been obtained after the sintering processing is performed at low temperature.

Morphology and compositions of as-prepared TiC@Ni nanopowders: Fig. 2a shows the morphology of TiC@Ni core-shell nanoparticles. Under transmission electron microscopic (TEM) fields, a Ni layer on the TiC particles are found clearly. Fig. 2b shows the chemical composition of TiC@Ni nanoparticles.

Morphology of as-prepared TiC-Ni cermets: Fig. 3a shows the typical FE-SEM microstructure of TiC-based cermets with a core/shell structure. It gives a microstructure consisting of ceramic phase and metal phase. The core generally consists of TiC ceramic phase surrounded by a shell which is a solid solution of (Ti, W, Mo)C. The metal phase distributes among ceramic grain boundaries continuously. The mechanisms and composition of core/shell structure have been researched by

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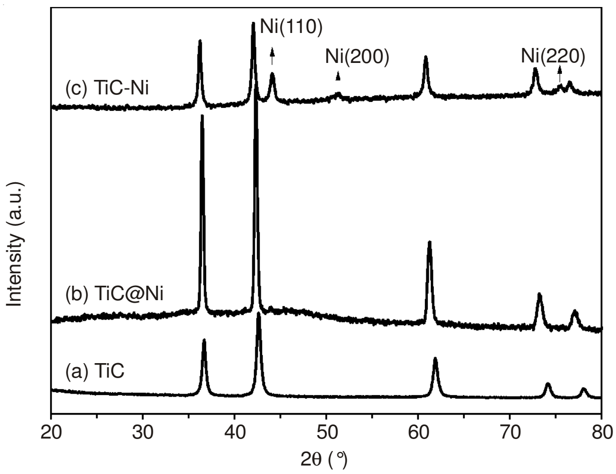

Fig. 1. XRD patterns of TiC raw materials (a), TiC@Ni powders (b) and TiC-Ni cermets(c)

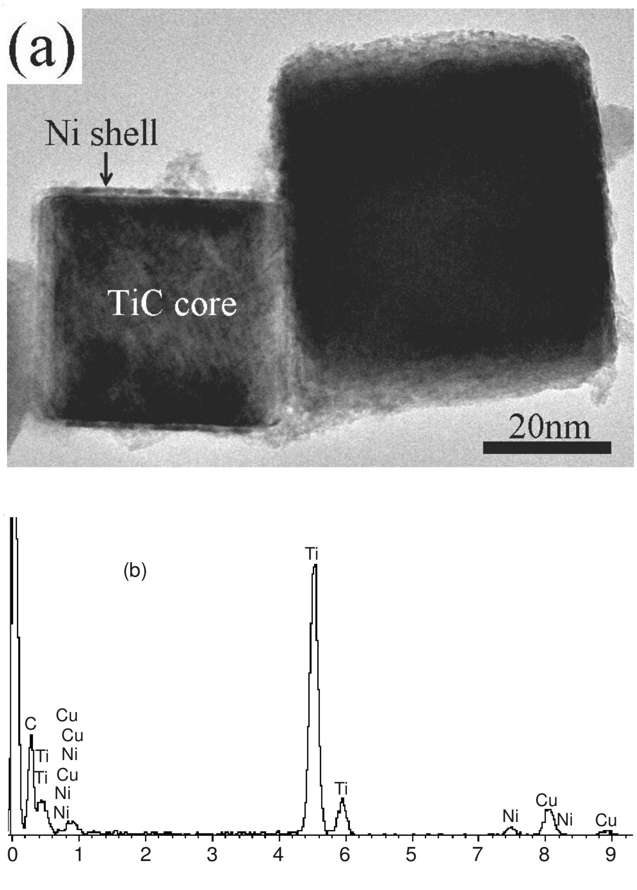

Fig. 2. TEM image (a) and corresponding EDS (b) of TiC@Ni nanopowders

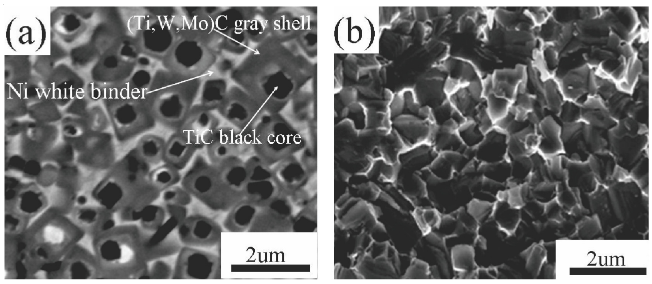

Fig. 3. FE-SEM images of TiC-Ni cermets sintered by SPS at 1200 ºC

Bolognini *et al.*[5] and Ahn *et al.*[6]. Fig. 3b shows the fracture surface of the tested cermets at room temperature. It can be found that the main fractural feathers are the cleavages of the TiC grains with well defined facets and mental binder. It means that the TiC grains fail dominantly by intergranular fractural modes.

Conclusion

A shell of Ni was directly grown on the surface of TiC cubic nanoparticles suspended in aqueous solution by means of a precipitation process. The as-prepared TiC@Ni nano-powders with proper contents of WC and Mo_2C were used to fabricate TiC-Ni cermets at low temperature. The ceramic phase grains exhibited a core/shell structure and Ni metal phase distributed among ceramic grain boundaries continuously. The fracture surface of the tested cermets was dominantly by inter-granular fractural modes at room temperature.

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