Densification of Binderless WC by Spark Plasma Sintering and its Mechanical Properties

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1.Introduction

WC has been known for its exceptional hardness, excellent wear resistance, a high modulus of elasticity, which is widely used in cutting tools and wear-resistant components. It is obviously difficult to sinter WC without Co or other binder using a conventional process because of the high melting point. Binderless cemented carbides have been developed for the improvement of hardness, wear resistance and corrosion resistance of conventional WC-Co cemented carbides. Binderless cemented carbides are constituted carbides can be sintered at low temperature of about 1500℃ by providing the diffusion path formed by added TiC and TaC cabides during sintering. WC-TiC-TaC binderless carbides, however, have low wear resistance and toughness because of the WC/TiC grain boundary with an enrichment of carbon. In this study, we tried to prepare pure WC body appling Spark Plasma Sinter processing. The sintering behavior and mechanical properties of binderless WC were studied.

2. Experimental procedure

Raw powder used in this study is pure WC powder with an average particle size of 0.5㎛, 0.8㎛ and 1.8㎛. Samples were spark plasma sintered at a temperature range from 1600℃ to 1850℃ under vacuum. and the holding time was at 0~30min. A pressure of 50MPa was maintained during the sintering process. The density of sintered WC body was measured according to method based on archimedes' principle. The microstructures of sintered WC body were observed by field emission scanning electron microscopy (FE-SEM) and an optical microscope. The hardness was measured by vickers hardness tester. The fracture toughness was evaluated by the vickers indentation technique. The wear resistance and young's modulus of sintered samples were investigated

3. Results

For the shrinkage behavior of binderless WC sintered body during heating up to 1800℃, the shrinkage starts at about 1100℃ and is finished at about 1800℃. During this process, a maximum densification ratio is observed at about 1650℃. The denstiy of the samples increased with increasing the sintering temperature. The binderless WC sintered at 1750℃ for 10min showed near full densification as a density of 15.58g/cm^3.

The field emission scanning electron microscopy images of binderless WC sintered at 1750℃ for 10min showed a dense and fine-grained structure. However there are very small pores less than 300nm in the triple points and these pores didn't disappeared in spite of sintering at higher temperature for a long holding time of 30min. The vickers hardness of samples sintered increased from about Hv1200 to about Hv2400 with increasing the sintering temperature. The fracture toughness of samples sintered decreased with increasing the vickers hardness of them. For the binderless WC with average particle size of 0.5㎛ sintered at 1750℃ for 10min , the vickers hardness and fracture toughness were about Hv2500 and 7.6MPa · m$^{1/2}$.

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