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Dense Al_2O_3 – TiC Ceramics Made by Self – propagating High – Temperature Synthesis

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ABSTRACT Electro – thermal explosion – pressing (ETE – P) and hot pressing composite powders synthesized by self – propagating high – temperature synthesis (SHS + HP) were used to produce dense Al_2O_3 – TiC ceramics. The mechanical properties and cutting performance of SHS Al_2O_3 – TiC ceramics were better than those of conventional hot pressing Al_2O_3 – TiC ceramics cutting tools. The microstructure and densification mechanism of SHS Al_2O_3 – TiC ceramics were discussed.

KEY WORDS SHS, Al_2O_3 – TiC, ceramics

Self – propagating High – temperature Synthesis (SHS), or combustion synthesis as a new method for producing materials has been worldwide interesting[1, 2]. Al_2O_3 – TiC composites can be used as a ceramic cutting tool. Conventional Al_2O_3 – TiC ceramics are fabricated by hot pressing mixtures of Al_2O_3 and TiC powders. Recently, Cutler, et al prepared Al_2O_3 – TiC composite powders and dense Al_2O_3 – TiC ceramics by SHS[3, 4], which reduces the cost of Al_2O_3 – TiC ceramics. Dense Al_2O_3 – TiC ceramics were fabricated by Electro – Thermal Explosion – Pressing (ETE – P) and hot pressing powder mixtures synthesized by SHS(SHS + HP) in this work.

1 Experimental Procedure

Commercial powders of TiO_2, Al and C were used as raw materials. The nominal particle size of the TiO_2, Al and C were 0.5, 44 and 0.02 μm respectively. The combustion reaction is formulate as follows:

$$3TiO_2 + 4Al + 3xC + yAl_2O_3 = 3TiC_x + 2(1+y)Al_2O_3$$

where $x = 1.0$, 0.9, 0.67 and $y = 0$ or 1. The dense Al_2O_3 – TiC ceramics were produced by two different ways: Electro – Thermal Explosion – pressing (ETE – P) and hot – pressing Al_2O_3 – TiC composite powders synthesized by SHS (SHS + HP). In

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ETE−P process, the mixture reactants were charged in a graphite die and ignited bypassing electrical current through the graphite die. When the sample was at high temperature, pressure was applied to make materials dense. In SHS+HP process, the Al_2O_3−TiC powders synthesized by SHS were milled for 24 hours and screened −325 mesh. The powders in graphite die were hot−pressed at 1650 ~ 1700℃. Bending strength measurements were performed in three−point bending on rectangular dense samples. The hardness and fracture toughness were measured on polished samples using Vickers indentation technique. The phase composition and microstructure were examinated by using X−ray diffraction analysis, SEM and TEM.

2 Results and Discussions

The properties of SHS Al_2O_3−TiC ceramics are listed and compared with typical properties of conventional hot pressed ceramics in Table 1[5, 6].

Table 1 Properties of Al_2O_3−TiC ceramics

Method	Composition /%	Density /g · cm^{-3}	Bending strength /MPa	Hardness(*HV*) /GPa	Fracture toughness /MPa · m$^{1/2}$
ETE−P	45Ti$C_{0.67}$	4.39	643	20.0	5.4
SHS+HP	46Ti$C_{1.0}$	4.27	567	22.9	5.8
SHS+HP	46Ti$C_{0.9}$	4.41	624	23.9	5.9
SHS+HP	45Ti$C_{0.67}$	4.36	578	23.5	6.3
SHS+HP	40Ti$C_{0.9}$+ 10Ni(Mo)	4.58	744	22.6	6.8
SHS+HP	30TiC	4.18	476	22.4	5.02
Conventional	30TiC	4.25	600 ~ 750	19 ~ 22	3.8 ~ 4.5

The comprehensive properties of SHS+HP samples are a little better than those of ETE−P. The mechanical properties of SHS+HP ceramics are higher than those of conventional hot pressed Al_2O_3−TiC ceramics. The comprehensive properties of Al_2O_3−TiC ceramics with Ti$C_{0.9}$ are better than those with Ti$C_{1.0}$ and Ti$C_{0.67}$. The fracture toughness and strength of ceramics containing 10%Ni (Mo) are higher than those without metal binder, and those with 45% TiC are higher than with 30% TiC.

X−ray diffraction patterns consist of alpha−Al_2O_3 and TiC in ETE−P ceramics, and in SHS+HP samples without metal binder. In SHS+HP samples with Ni(Mo) binder, Ni and (Mo_2C)12F phase are also present.

Fig.1 shows the SEM micrographs of Al_2O_3−TiC ceramics produced by ETE−P. The dark phase is Al_2O_3 and the light phase is TiC. The microstructure of cross sec-

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自蔓延高温合成法(SHS)制备致密的Al_2O_3 -TiC陶瓷

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摘 要 采用电热爆-加压法(ETE-P)和燃烧合成制粉+加压法(SHS+HP)制备了致密的 Al_2O_3 陶瓷．研究表明，SHS Al_2O_3-TiC 陶瓷的力学性能和切削性能均优于采用传统热压方法所制备的 Al_2O_3+TiC 陶瓷刀具．并对 SHS Al_2O_3+TiC 的的显微结构及致密化机制作了研究．

关键词 SHS, Al_2O_3-TiC, 陶瓷

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