

# Dense $\text{Al}_2\text{O}_3 - \text{TiC}$ Ceramics Made by Self-propagating High-temperature Synthesis

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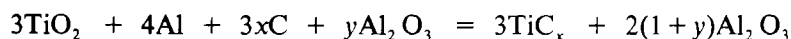
**ABSTRACT** Electro-thermal explosion-pressing (ETE-P) and hot pressing composite powders synthesized by self-propagating high-temperature synthesis (SHS+HP) were used to produce dense  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics. The mechanical properties and cutting performance of SHS  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics were better than those of conventional hot pressing  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics cutting tools. The microstructure and densification mechanism of SHS  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics were discussed.

**KEY WORDS** SHS,  $\text{Al}_2\text{O}_3 - \text{TiC}$ , ceramics

Self-propagating High-temperature Synthesis (SHS), or combustion synthesis as a new method for producing materials has been worldwide interesting<sup>[1, 2]</sup>.  $\text{Al}_2\text{O}_3 - \text{TiC}$  composites can be used as a ceramic cutting tool. Conventional  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics are fabricated by hot pressing mixtures of  $\text{Al}_2\text{O}_3$  and TiC powders. Recently, Cutler, et al prepared  $\text{Al}_2\text{O}_3 - \text{TiC}$  composite powders and dense  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics by SHS<sup>[3, 4]</sup>, which reduces the cost of  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics. Dense  $\text{Al}_2\text{O}_3 - \text{TiC}$  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  $\text{TiO}_2$ , Al and C were used as raw materials. The nominal particle size of the  $\text{TiO}_2$ , Al and C were 0.5, 44 and 0.02  $\mu\text{m}$  respectively. The combustion reaction is formulate as follows:



where  $x=1.0, 0.9, 0.67$  and  $y=0$  or 1. The dense  $\text{Al}_2\text{O}_3 - \text{TiC}$  ceramics were produced by two different ways: Electro-Thermal Explosion-pressing (ETE-P) and hot-pressing  $\text{Al}_2\text{O}_3 - \text{TiC}$  composite powders synthesized by SHS (SHS+HP). In

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  $\text{Al}_2\text{O}_3$ -TiC powders synthesized by SHS were milled for 24 hours and screened -325 mesh. The powders in graphite die were hot-pressed at  $1650 \sim 1700^\circ\text{C}$ . 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 examined by using X-ray diffraction analysis, SEM and TEM.

## 2 Results and Discussions

The properties of SHS  $\text{Al}_2\text{O}_3$ -TiC ceramics are listed and compared with typical properties of conventional hot pressed ceramics in Table 1<sup>[5, 6]</sup>.

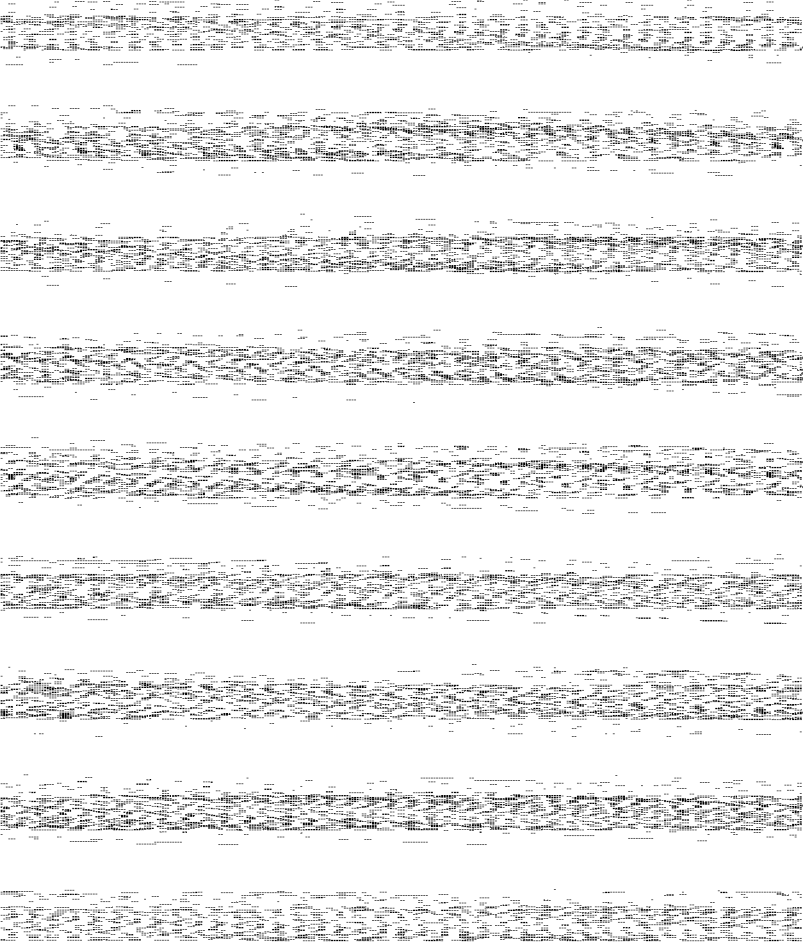
Table 1 Properties of  $\text{Al}_2\text{O}_3$ -TiC ceramics

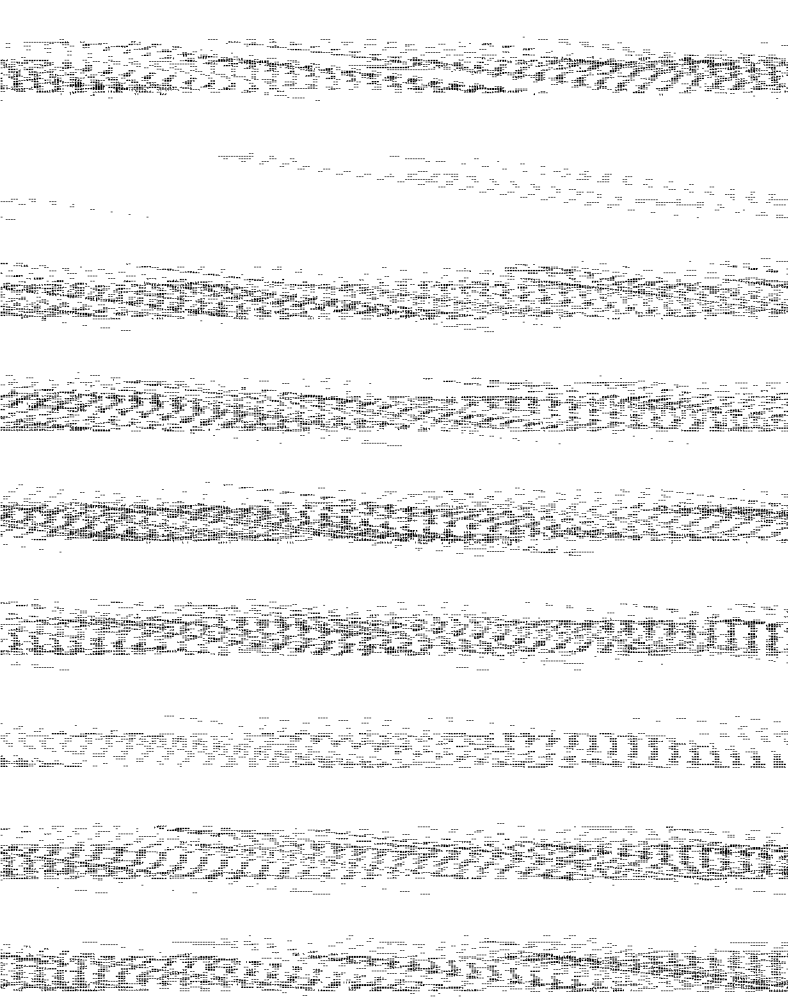
| Method       | Composition<br>/%                  | Density<br>/g · cm <sup>-3</sup> | Bending strength<br>/MPa | Hardness(HV)<br>/GPa | Fracture toughness<br>/MPa · m <sup>1/2</sup> |
|--------------|------------------------------------|----------------------------------|--------------------------|----------------------|-----------------------------------------------|
| ETE-P        | 45TiC <sub>0.67</sub>              | 4.39                             | 643                      | 20.0                 | 5.4                                           |
| SHS+HP       | 46TiC <sub>1.0</sub>               | 4.27                             | 567                      | 22.9                 | 5.8                                           |
| SHS+HP       | 46TiC <sub>0.9</sub>               | 4.41                             | 624                      | 23.9                 | 5.9                                           |
| SHS+HP       | 45TiC <sub>0.67</sub>              | 4.36                             | 578                      | 23.5                 | 6.3                                           |
| SHS+HP       | 40TiC <sub>0.9</sub> +<br>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                                     |

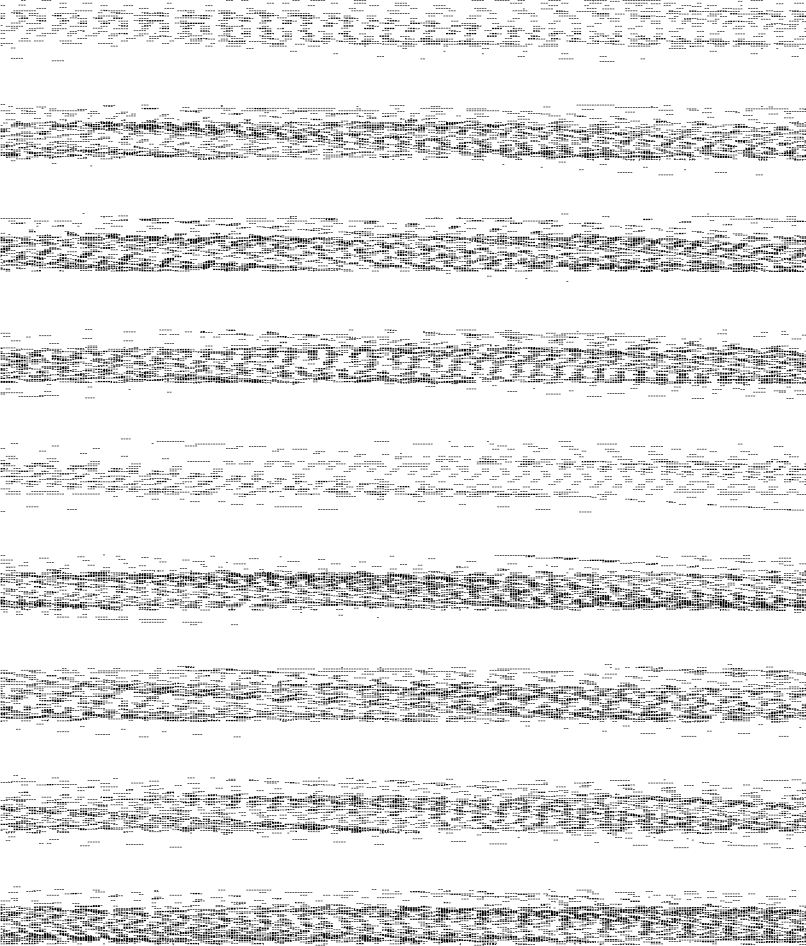
The comprehensive properties of SHS+HP samples are a little better than those of ETE-P. The mechanical properties of SHS+HP ceramics are higher than those of conventional hot pressed  $\text{Al}_2\text{O}_3$ -TiC ceramics. The comprehensive properties of  $\text{Al}_2\text{O}_3$ -TiC ceramics with TiC<sub>0.9</sub> are better than those with TiC<sub>1.0</sub> and TiC<sub>0.67</sub>. 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.

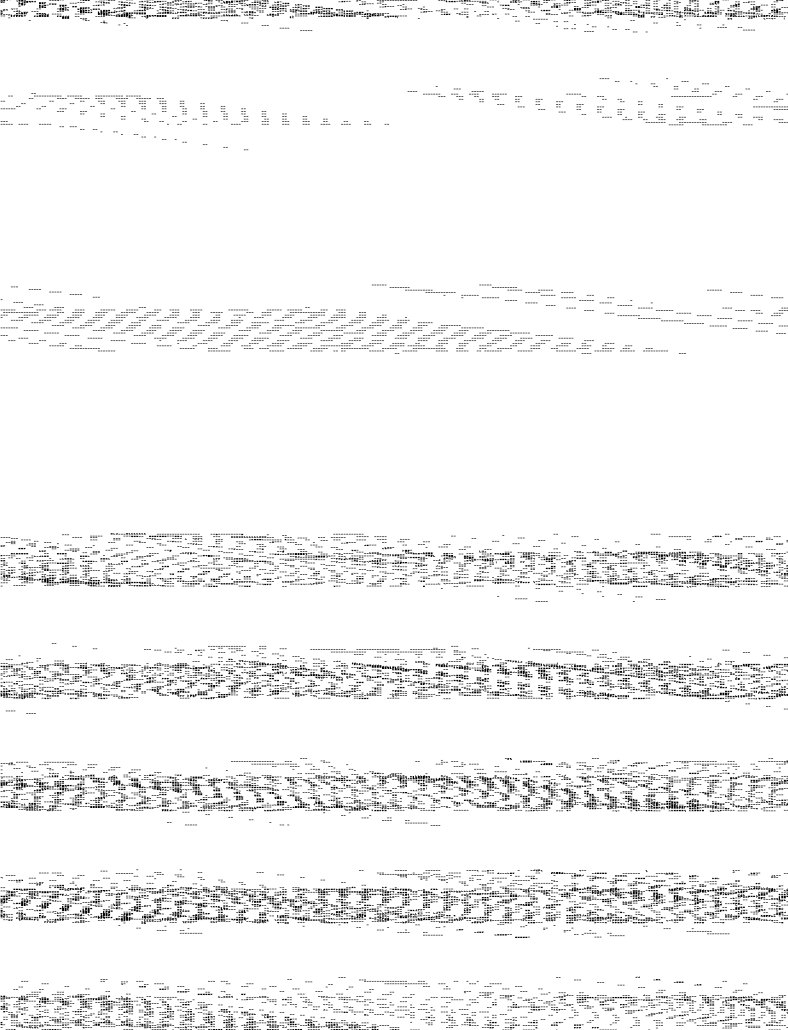
X-ray diffraction patterns consist of alpha- $\text{Al}_2\text{O}_3$  and TiC in ETE-P ceramics, and in SHS+HP samples without metal binder. In SHS+HP samples with Ni(Mo) binder, Ni and (Mo<sub>2</sub>C)12F phase are also present.

Fig.1 shows the SEM micrographs of  $\text{Al}_2\text{O}_3$ -TiC ceramics produced by ETE-P. The dark phase is  $\text{Al}_2\text{O}_3$  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<sub>2</sub>O<sub>3</sub> - 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<sub>2</sub>O<sub>3</sub> 陶瓷。研究表明, SHS Al<sub>2</sub>O<sub>3</sub>-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<sub>2</sub>O<sub>3</sub>+TiC 陶瓷刀具。并对 SHS Al<sub>2</sub>O<sub>3</sub>+TiC 的显微结构及致密化机制作了研究。

**关键词** SHS, Al<sub>2</sub>O<sub>3</sub>-TiC, 陶瓷

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