SELF-PROPAGATING HIGH TEMPERATURE SYNTHESIS OF BULK TiC-NiAl COMPOSITE

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1. Abstract

This study was based on production of TiC-NiAl by combustion synthesis method. TiC-NiAl composite was fabricated by reaction of Ti + Al + Ni + C → TiC-NiAl assistant heated coil on top surface of green body along with a medium 100 MPa pressure to obtain a bulk sample. The constituted phases were characterized by XRD and microstructure observation has been done with SEM. The density of the synthesized bulk samples was measured according to the Archimedes method. Micro and macro hardness, and fracture toughness of samples were measured by a vickers diamond indenter. Isostatic Pressing along with thermal reaction like to a thermomechanical process result in bulk TiC-NiAl composite.

2. Introduction

In recent years, many methods, such as sintering [4], hot pressing [5], hot isostatic pressing [6], spark plasma sintering (SPS) and solid-state reaction [7], have been developed to produce TiC-NiAl composite in bulk form sample. Combustion synthesis in powder metallurgy processes has been in attention, because it offers advantages as economics and process simplicity. Also the very high reaction rates and elimination of the need for high temperature furnaces used in conventional material fabrication due to the self generation of heat required for the process. Considering their low density and their high wear resistance and refractoriness, compounds of the system Al–Ni–Ti–C can be used to produce high temperature wear resistance components. This paper describes studies of combustion synthesis of bulk TiC-NiAl via SHS in its wave propagation mode, with pseudo hot isostatic pressing.

3. Experimental procedure

A homogeneous powder blend includes Ti, Al, Ni and C within the molecular ratio 1:1:1:1 in a low energy ball milling. The dried reactants were cold pressed into square pellets by a press at 30 MPa. For the SHS wave propagation experiments, a slightly compacted Ti–C-Ni-Al blend was inserted into a vertically placed stainless steel cylinder. A heated coil at one end ignited the pellets and self-sustained from this heated end to the full sample due to the highly exothermic reaction. The compact was immediately pressed just after wave passed, the products was in hot and soft condition too (delay time ≈ 5 s). The pressure (100 MPa) was kept for 10 s. Figure 1 is a schematic of the SHS/PHIP setup.

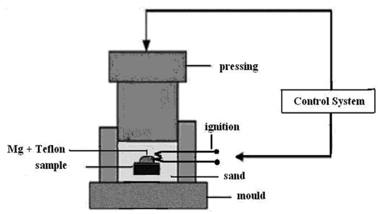

Figure 1. The schematic illustration of the SHS/PHIP setup.

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The dense products were then sectioned with cutter and grinded for microstructure and mechanical analysis. The constituted phases of the synthesized TiC-NiAl samples were characterized employing X-ray diffraction (XRD-Philips X'pert-MPD) and microstructure observation by scanning electron microscopy (SEM-XL3). Micro-hardness of dense samples was measured under 5 N loads, with vickers diamond indenter. The macro-hardness was evaluated by a Vickers diamond indenter at loads of 50 N. The fracture toughness was calculated using the following formula in equation 2. The density of the synthesized bulk samples was measured by using water, according Archimedes test method [3].

4. Results and discussion

For obtained a highly homogeneous starting mixture used a tumbler mill (low energy mill) with election a low time, because prevent mechanical alloying within milling [7].

The SHS reaction of the system Al–Ni–Ti–C was followed by powder reaction sample. TiC-NiAl composite was fabricated by combustion reaction of Ti + Al + Ni + C → TiC-NiAl. Figure 2 gives an overview of the recorded diffraction patterns as the reaction proceeds, which that compose TiC and NiAl phases.

With attention to high exothermic reaction (≈-183 Kj/mole)of Ti and C, composed TiC, and then done reaction Al and Ni, because of lower exothermic reaction(≈-118 Kj/mole) [1, 2]. Likewise NiAl has role of bonding phases. SEM observation is shown in figure 3. Product is composed of small, round TiC particles embedded in continues matrix of NiAl which TiC phases adhering by assistant NiAl intermetalics to compose a continues structure. Also exist slightly pore in sample similar to HIP process [4]. This result was similar to other researcher which fabricated this compound by hot isostatic pressing and spark plasma sintering [4, 7, 9].

Mechanical properties tests are put into table 1. These mechanical properties is almost similar to result of other researchers that produce by other process like sintering [4, 10-12].

compound	Relative density (%)	density	Micro hardness ($HV_{.5}$)	Macro hardness (GPa)	Fracture toughness (MPa√m)
TiC-NiAl	97.6	5.174	1077	9.95	7-10

Table 1. The mechanical properties of TiC-NiAl sample.

5. Conclusions

The SHS reaction of the quaternary system Al–Ni–Ti–C has been started with the synthesis of Ti and C to compose TiC, and then followed by melting and reaction of Al and Ni. The final product is composed of small, round TiC particles embedded in a continuous matrix of NiAl. Results show excellent properties of TiC-NiAl, >95% dense samples with density ≈ 5.17 gr/cm^3, micro hardness ≈ 1077 $Hv_{.5}$, macro hardness ≈ 9.95 GPa and fracture toughness ≈ 8.5 MPa√m. Furthermore primary evaluation has been shown by combustion synthesis can produce TiC-NiAl composite in bulk shape that has suitable mechanical properties in comparison with sintering samples.

6. References

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