Synthesis of Dense WSi_2 and WSi_2-*x*vol.%SiC composites by High-Frequency Induction Combustion and Its Mechanical Properties

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1. Introduction

WSi_2 intermetallic compound with a tetragonal structure has received considerable attention recently as a material for high-temperature applications, as its properties provide the desirable combination of a high melting temperature (2160℃), good strength at high temperatures, good creep resistance, and high oxidation resistance at high temperatures. However, a major disadvantage of this material is its low fracture toughness below the ductile-brittle transition temperature. To improve on its mechanical properties, it is more effective to use as form of composite with a second phase. And silicide/SiC composites exhibit the excellent pest oxidation resistance. In this work, the addition of SiC to silicide phase has been investigated. Dense silicide composites are usually prepared in a multi-step process: the synthesis of the silicide phase and the subsequent consolidation with additive.

Recently, a new approach has been developed in which synthesis and densification can be effected simultaneously. This new process, referred to as the high-frequency induction heated combustion synthesis (HFIHCS), has been successfully used to synthesize and densify, in one step, some materials in a relatively short period of time (several minutes).

In this work, we apply this method to produce dense WSi_2 and WSi_2-*x*vol.%SiC (x=10,20,30) within 2 minutes in one-step from mixtures of W, Si and C elemental powders, and evaluate their mechanical properties.

2.Experimentalprocedure

Powders of 99.9% pure tungsten (<4.3 ㎛, Taegutec Co.), 99% pure silicon (-325 mesh, Aldrich Chemical Co.) and activated carbon (<20 ㎛, Kojundo Chemical Co.) were used as a starting materials. All powders were milled in a Universal Mill with a ball-to-powder weight ratio of 6:1. Milling was done in polyethylene bottles using zirconia balls and was performed at a horizontal rotation velocity of 300 rpm for 24 hrs.

After milling, the mixed powders were placed in a graphite die and then introduced into the high-frequency induction heated combustion system. The system was first evacuated and a uniaxial pressure of 60MPa was applied. An induced current was then activated and maintained until densification was attained as indicated by a linear gauge measuring the shrinkage of the sample. At the end of the process, the sample was cooled to room temperature.

The relative densities of the synthesized sample were measured by the Archimedes method. Microstructural information was obtained from product samples which were polished and etched. Compositional and microstructural analyses of the products were made through X-ray diffraction (XRD) and scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDAX). Vickers hardness and fracture toughness were measured by performing indentations at load of 10kgf and a dwell time of 15 sec.

3. Summary

Using the high-frequency induction heated combustion method, the simultaneous synthesis and densification of WSi_2-$x$vol.%SiC (x=0,10,20,30) composites was accomplished using elemental powders of W, Si and C. A complete synthesis and densification of the materials was achieved in one step within a duration of 2 min. The relative density of the composites was up to 97% for the applied pressure of 60MPa and the induced current. The average grain size of WSi_2 are 6.9, 6.1, 5.2 and 5.0 ㎛, respectively. The hardness and the fracture toughness increases with increasing SiC content. The maximum values for the hardness and fracture toughness are 1840 kg/mm^2 and 5.1 $MPa \cdot m^{1/2}$ at WSi_2-30vol.%SiC.