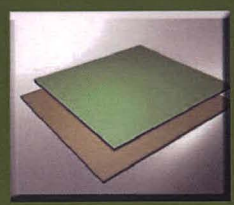
ADVANCES IN COMPOSITE MATERIALS



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Chapter 005

Synthesis and Characterization of Nanocrystalline Ni_3Al Intermetallic Produced by Mechanical Alloying and Reaction Synthesis

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Keywords: Intermetallic alloys and compounds, reaction synthesis, mechanical alloying.

Abstract: Stoichiometric nanocrystalline Ni_3Al was prepared by mechanical alloying of elemental Ni and Al powders under argon gas atmosphere for different time (4-48h). The nanostructured Ni_3Al powders were consolidated into bulk compacts and sintered in a small DTA furnace under flowing Argon to observe the exothermic reaction between the stoichiometric Ni and Al. The estimated crystallite size showed that the mechanically alloyed Ni_3Al grain size decrease from 127 nm to 9.36nm with increasing mechanical alloying time from 4h to 48h. Agglomerations of the powder particles prevalently occurred as observed from the SEM micrographs. Saturation magnetization, M_s value of the mechanically alloyed powders decreases as milling time increases due to smaller amount of elemental nickel responding to the applied fields. Following reaction synthesis of the compacted powders, thermal profile analysis revealed the presence of exothermic peaks in the DTA curves at about 400°C. Relative densities of the sintered compact were measured and found to be from 77-88% with the exception for the 48h mechanically alloyed sintered compact from milling balls contaminations. XRD results of the sintered compacts mechanically alloyed for 18h and above revealed the formation of pure nanocrystalline Ni_3Al. Crystallites size estimations showed the occurrence of grain growth during sintering.

Introduction

Intermetallics nickel aluminide, Ni_3Al has attracted significant attention in the area of aerospace, structural and engine applications at elevated service temperature due to its interesting combination of properties such as anomalous yield behaviour, high creep strength supplemented by low density and improved oxidation resistance. However, its brittleness and low toughness at room temperature has posed as a barrier for practical application. It has succeeded in increasing the nickel aluminide ductility by microalloying with boron and effectively suppresses the intergranular fracture [1]. It has also been suggested that brittle materials may develop some ductility by refining their grains below critical size through high energy ball milling [2]. The synthesis of nanocrystalline nickel aluminide compounds by ball milling has been successfully achieved by several researchers [3-6]. Nanocrystalline materials exhibit unique properties due to new deformation modes (i.e. superplastic behavior) because of large fraction of grain boundaries with high concentration of defects that the