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Synthesis and characterization of nano hexagonal boron nitride powder and evaluating the influence on aluminium alloy matrix

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Abstract

An attempt is made to synthesize the nano h-BN powders by high energy ball milling and also aluminium reinforced h-BN composite by powder processing route. The impact of ball milling time on microstructure and particle size reduction of h-BN powder was investigated by FESEM, FTIR, XRD, UV-vis diffuse reflectance spectroscopy and particle size analyser.It was indicated that high energy ball milling is effective up to 10 hours in reducing the particles size a further increase in time is resulting in agglomeration. Microhardness of the composite increases in proportion to increases in weight percentage of reinforcement, h-BN exhibited a poor sinterability without any accelerating agentand with tin addition up to 0.5% low melting point metal.TGA and DTA study shows that there is reduction in melting point from 641°C to 638 °C with addition of 2% weight fraction of h-BN.

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Keywords:Ball milling; hexagonal boron nitride; aluminium; powder metallurgy; FTIR; micro hardness

1. Introduction

Aluminium alloy matrix in spite of its very good specific strength and low density is unable to find place as material in many potential areas in automotive and space applications due to its poor thermal stability and wear resistance,h-BN is being used increasingly because of its of important properties which include a low density (2.27

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g/cm^3 theoretical density), high temperature stability (melting point 2600ºC), low coefficient of friction, chemical inertness (corrosion resistance against acids and liquid metals), stability in air up to 1000ºC (in argon gas atmosphere up to 2200°C and in nitrogen up to 2400ºC), thermal shock resistance , good workability of hot-pressed shapes.Due to its high band gap and in-plane thermal conductivity, h-BN has been considered both as an excellent electrical insulator and thermal conductor. Key boron nitride properties are good thermal shock resistance, high thermal conductivity, low thermal expansion, high electrical resistance, low dielectric constant and loss tangent, nontoxicity, good machinability, non abrasive and lubricious, chemical inertness, non-wetting by most molten metals. The main issue of concern for the synthesis of these materials consists in the inadequate wettability of the reinforcement phase by the molten metal, which does not allow the synthesis by conventional casting methods. Its small coefficient of friction is retained up to 900ºC, whereas other solid lubricants like molybdenum and disulphidegraphite are burnt away at lower temperatures. Because of its high thermal stability and not reacting with against carbon and carbon monoxide up to 1800ºC it is as a refractory ceramic superior to the nitride ceramics Si_3N_4 and AlN andthe oxide ceramics MgO, CaO, ZrO_2[1-2].High energy ball milling is a solid state processing technique involves welding, fracturing and rewelding of powder particles during milling [3]. High energy ball milling technique has been used to produce commercially useful materials [4], h-BN reinforced AlN composites are synthesized by hot pressing technique, due to the poor sinterability of h-BN but this technique is inefficient because of high sintering temperature and long sintering time. AlN composites with different h-BN content were successfully produced by spark plasma sintering [5].

This paper reports the findings of manufacturing and evaluation of mechanical, physical and thermal properties ofhexagonal boron nitride reinforced Aluminium matrix composite by powder processing.Uniform distribution and wetting of hexagonal boron nitride is a challenge, an attempt is made to fabricate the composite by high energy ball milling, compacting and sintering in neutral atmosphere and also investigated the effect of ball milling time on microstructure and size reduction of h-BN. The current work focusses only the influence of h-BN particle size on hardness and also on thermal properties. h- BN is invariably used as soft lubricant and proved to reduce the coefficient of friction without sacrificing the hardness. Also the study focussed on the ball milling time on particle size. An attempt was also made to improve the sinterability with liquid phase additions like low melting metal tin.

2. Experimental details

2.1. Materials

Hexagonal boron nitride (UHP-S1) with 99.8% purity imported from Showa Denko K.K, Japan and commercial gas atomized aluminium alloy AA7050 powder obtained from Ampal, Inc has been used to synthesize the Nano composite. The chemical composition of h-BN and AA7050 alloy powder reported in Table 1 and Table 2 and also particle size distribution given in Table 3.

Table 1. Chemical Composition of h-BN

Chemical % by Wt.	B_2O_3CaO	C	BN	
h-BN	0.17	0.02	0.02	99.8

Table 2. Chemical composition of AA7050 alloy powder

Component	Amount (*Wt. %*)
Copper	2 – 2.6
Magnesium	1.9 – 2.6
Silicon	0.12 MAX
Chromium	0.04 MAX
Manganese	0.1 MAX
Iron	0.15 MAX
Zinc	5.7 – 6.7
Titanium	0.06 MAX
Zirconium	0.08 – 0.15
Others	0.15 MAX
Aluminium	Remainder