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jmr&t Journal of Materials Research and Technology

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Original Article

# Fabrication of Al5083/$B_4C$ surface composite by friction stir processing and its tribological characterization

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ARTICLE INFO

*Article history:*
Received 13 October 2014
Accepted 8 February 2015
Available online 18 March 2015

*Keywords:*
Friction stir processing
Boron carbide ($B_4C$)
Number of passes
Hardness
Wear

ABSTRACT

Improved surface properties with the retainment of bulk properties are necessary for a component for enhanced wear characteristics. Friction stir processing (FSP) is used to produce such surface composites. Fabrication of 5083 aluminum alloy with reinforced layers of boron carbide ($B_4C$) through FSP was carried out. Micro and nano sized $B_4C$ particles were used as reinforcements. The friction processed surface composite layer was analyzed through optical and scanning electron microscopical studies. The number of passes and the size of reinforcement play a vital role in the development of surface composites by FSP. Mechanical properties of the friction stir processed surface composites were evaluated through micro hardness and universal tensile tests. The results were compared with the properties of the base metal. The role of reinforcement and number of passes on properties were also evaluated. Tribological performance of the surface composites is tested through pin on disk test. The surface composite layer resulted in three passes with nano particle reinforcement exhibited better properties in hardness, tensile behavior and wear resistance compared to the behavior of the base metal.



## 1. Introduction

The aluminum based metal matrix composites provide excellent specific strength, stiffness, high hardness, wear resistance, stability at high elevated temperature [1] with additional advantages of three dimensional isotropy and affordability [2]. The Al–$B_4C$ composites are used in the bicycle frame, bullet proof vests, armor tanks, containment of nuclear waste, neutron absorber in nuclear power plant, transportation applications, etc. owing to their high hardness, low density and excellent thermal and chemical stability [2–4]. Al–$B_4C$ composites are fabricated by various researchers in the past few years by stir casting [5–7], casting [8–10], squeeze casting [11] and mechanical alloying [12].

However, a surface property of the material is very important to achieve longer life of mechanical components. Dispersion of the nano reinforcements in the surface to have

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http://dx.doi.org/10.1016/j.jmrt.2015.02.006
2238-7854/

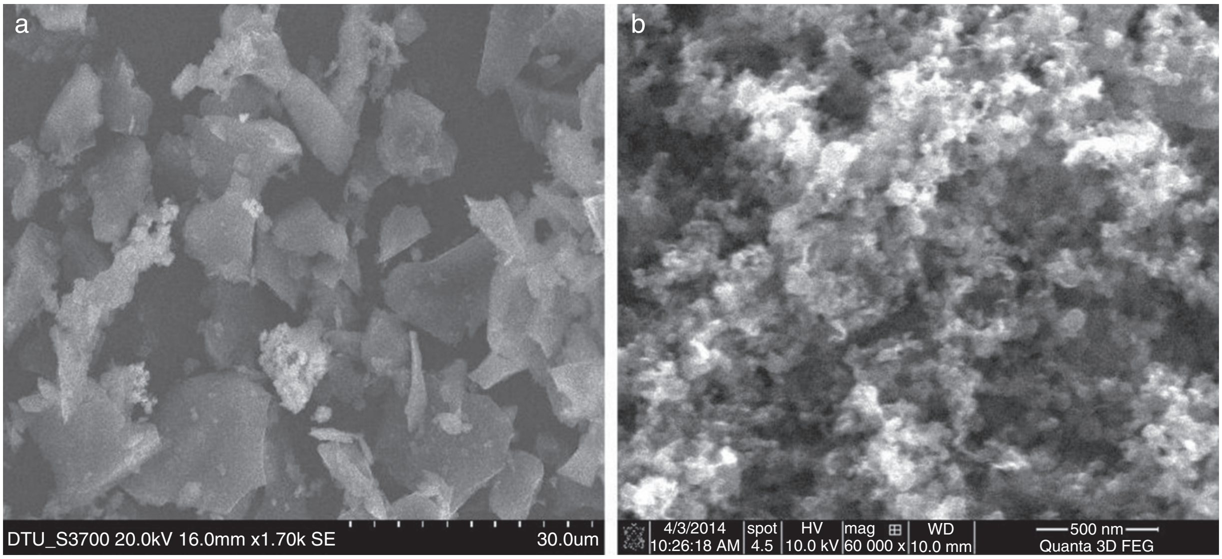


**Fig. 1 – SEM micrographs of as-received (a) $B_4C$ micro particles, (b) $B_4C$ nano particles.**

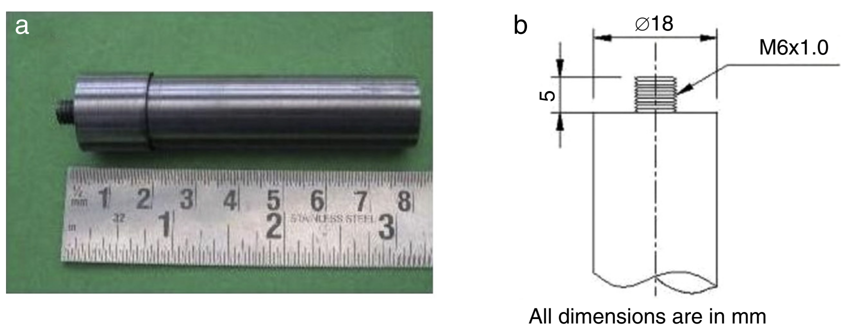


**Fig. 2 – Macrograph of FSP tool.**

a uniform layer is a difficult task. Existing processing techniques for processing of surface composites are based on liquid phase processing at high temperature such as laser melt treatment, electron beam irradiation and plasma spraying [13–15]. In these cases, there will be an interfacial reaction between the matrix and reinforcement, which leads to the formation of detrimental phases. The above problems can be eliminated by processing it below the melting point of substrate. The recent new surface modifying technique named Friction Stir Processing (FSP) [16] is developed by utilizing the principle of the friction stir welding (FSW). FSW was invented by the welding Institute UK in 1991 [17]. FSP is a solid state processing technique for producing a thick composite layer; the layer thickness can range from hundreds of micrometers to several millimeters. FSP is also useful to obtain a fine grained microstructure and to remove the cast defects with improved mechanical properties and wear resistance [18–20].

The successful fabrication of aluminum based metal matrix composites reinforced with particulates such as SiC

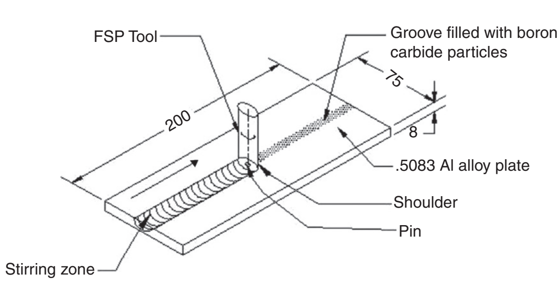


**Fig. 3 – Schematic of FSP experiment.**

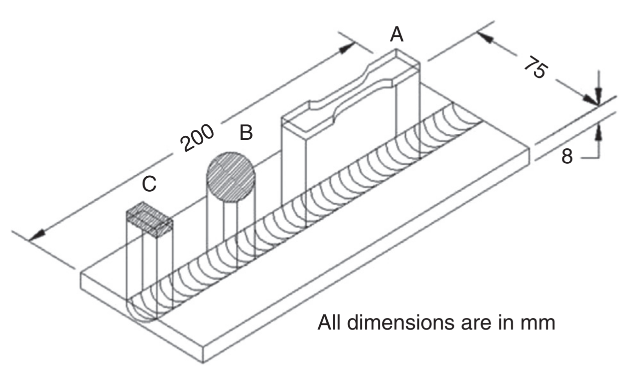


**Fig. 4 – Schematic illustration of the procedure for cutting (A) tensile specimen, (B) pin specimen for wear test, (C) hardness specimen.**