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EBSD analysis of spark plasma sintered SS316-B_4C composite

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Highlights

- EBSD pattern revealed deformed SS316 - 10% B_4C composite at higher temperatures.
- Grain sizes and crystal morphology were identified using GAM, GOS, KAM and IPF.
- Composite deformed at 900°C is better than other samples.
- Grain boundaries present in the sample are used to improve the resistance to failure.

Abstract

The Electron Backscatter Diffraction (EBSD) method has been characterized as a potential tool for analysing the microstructural changes that occur during the sintering processes and it possesses the ability to depict misorientation diagrams, pole figures and grain size distribution. The present work focuses on observing the microstructure evolution of the prepared 316 stainless steel with 10wt% of B_4C samples sintered at the temperatures of 800, 900, and 1000°C using the Spark Plasma Sintering (SPS) method. The samples are in the equiaxed form of recrystallized grains and they are elongated. Further, the samples sintered at 900°C are equally recrystallized compared to other samples sintered at 800 and 1000°C, where the microstructure is partially recrystallized with a high fraction. The result is explicable, by increasing the carbon content it causes the reduction of grain boundaries as well as decreases the migration rate of twin boundary generation. Hence, twin character loss is accelerated by the increase of carbon content with low-angle boundaries, and because of the typical drag effect, it has been discovered that the dynamically recrystallized grain size is reduced. The partitioning of these microstructures is done to differentiate the sintered sample and the recrystallized grains, based on the Grain Orientation Spread (GOS) map. The experimental investigation has suggested that the samples sintered at 900°C has a more favourable microstructure analysis than the other samples sintered at 800°C and 1000°C, respectively.

Introduction

Amongst the austenitic stainless steels, 316 stainless steel (SS) has the standard molybdenum-bearing grade. Boron carbide (B_4C) is a crystalline boron and carbon compound. It is a very strong synthetic material used in control rods of nuclear power plants, lightweight composite materials, abrasive and wear-resistant applications. Powder metallurgy is the most helpful method for manufacturing metal matrix composites to produce composite material with a large variation density and it cannot be possessed by casting (Zhou and Ding, 2013). Many metal matrix composite reinforcement materials have advantages such as lower density, low cost, toughness, and excellent wear resistance. The determination of the sintering temperature is related to the compositions, particle size, surface state, and the property required for the product. As mentioned previously, the ideal sintering temperature is 0.5 Tm (melting temperature). Considering the strength, hardness, toughness, ductility, porosity, and particularly mechanical strength, the sintering temperature shall be above 0.6–0.8 Tm (Liu and Chen, 2014). Hence, the composites are sintered at 800, 900, and 1000°C, using a spark plasma sintering process to analyse the best microstructure outcomes.

Grain growth, recovery, and recrystallization are the three steps in the evolution of microstructure and they cause defect of dislocations to form in order to accommodate the applied strain (Taylor and Hodgson, 2011a). SS316 with high stacking-fault energy (SFE) is more likely to demonstrate better recovery, even if the recrystallization process predominates in the softening mechanism with a low SFE. Controlling the process of recrystallization and its subsequent development allows the enhancement of mechanical properties of SS316 (Mirzadeh et al., 2013). The three main types of recrystallization processes are static, dynamic, and meta-dynamic. During Static Recrystallization (SRX), the duration between the successive deformations passes fewer concerns and considerable losses. Through the optimization of the process like strain, a material with low SFE and Dynamic Recrystallization (DRX) is reinforced, during the sintering process (Wahabi et al., 2003, Brinck et al., 1998, Dehghan-Manshadi et al., 2008, Taylor and Hodgson, 2011b). The investigation has been done to analyse the DRX behaviour of SS316 by focusing on optical microscopy and flow curve analysis (Brinck et al., 1998, Dehghan-Manshadi et al., 2008, Taylor and Hodgson, 2011b, Mandal et al., 2011, Jun Wang et al., 2013, Ponge et al., 1998, Roberts and Ahlblom, 1978).

Researchers have studied the mechanisms of nucleation and novel strain-free grain development. At grain boundaries, the bulged mechanisms, nuclei formation of subgrains, and merging processes are reported as different mechanisms (Belyakov et al., 2000, Ponge et al., 1998). The evolution of metallurgical and material science domains has involved in the continuous automation of EBSD technique. The crystallography of the polycrystalline material provides the most precise knowledge