Fe-Ti(O,N) Composites Produced from Mechanically Alloyed Powders

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Abstract. Spark plasma sintering of mechanically alloyed powders was used to obtain Fe-Ti(O,N) microcomposites, with nominal contents of 25 and 40 vol\% of the ceramic phase. Sintering temperatures up to 900 °C together with a pressure of 50 MPa were used in the a sintering process, resulting in densification levels of about 91\%. The microstructure of the sintered microcomposites was characterized by X-ray diffraction, scanning electron microscopy, transmission electron microscopy and microanalysis techniques; additionally, Young’s modulus, flexural strength and microhardness were also determined.

In the bulk of sintered specimens, a dispersion of nanometric Ti(O,N) particles within alpha-iron grains was observed. A surface layer containing cementite was also found on the surfaces of specimens sintered at 900 °C. As a result of this, a hardness of about 715-765 kg/mm\textsuperscript{2} was measured on the specimen surface, while the value determined in the bulk was between 540 and 580 kg/mm\textsuperscript{2}. The calculated values of Young’s modulus were close to estimates made by the law of mixtures and proper consideration of the residual porosity. On the other hand, despite the similarities in microstructures and other characteristics (densification, hardness, Young’s modulus) in specimens of nominally different ceramic content, the measured flexural strength changed from about 765 MPa for Fe-25\%Ti(O,N) to about 225 MPa for Fe-40\%Ti(O,N) composites. The surface layer rich in cementite increased the hardness and toughness of the composites.

Introduction

From its conception, mechanical alloying has been recognized as a useful powder production method in the fabrication of composite materials [1]. In addition, it is well known that milling is also an effective way of promoting the chemical combination of metals with gaseous elements through solid-gas reactions, such as in the preparation of metal nitrides [2]. Mechanical nitriding is a nonequilibrium process and frequently results in the formation of solid solutions supersaturated with nitrogen, as well as metastable nitrides which can not be prepared by conventional processes [3]. Also, metal-nitride dual phase alloys have been prepared by mechanically nitriding powder mixtures of strong and weak nitride-forming elements [2,3]. Since the nitried powders usually possess either a nanocrystalline or an amorphous nature, their subsequent consolidation may result in bulk materials having ultrafine structures [2-5]. Ordinarily, keeping a small particle or grain size in the consolidated material requires the use of sintering methods which do not require too high temperatures or too long sintering times. In this respect, spark plasma sintering (SPS) represents a novel consolidation technique [6], in which on-