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Effect of TiB_2 Content on Properties of Cu-TiB_2 Nanocomposite

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1. Introduction

There have been several efforts to develop high strength copper alloy at elevated temperature while maintaining a good conductivity. High strength/conductivity Cu alloys can be achieved by reinforcing or dispersing ceramic particles such as Al_2O_3[1, 2], SiC [1], TiC[3] and TiB_2[4-9]in the Cu matrix. Among these various ceramic particles, TiB_2 was found to be a potential candidate for reinforcement of copper metal matrix composite (CMMC) because of its high stiffness and hardness, higher electrical and thermal conductivity than others. Hence, TiB_2 ceramic is reinforced phase of Cu-matrix in this study.

For MMCs process, homogeneous distribution of ceramic particle and good bond with the matrix play important role. To improve the interfacial compatibility and avoid serious interfacial reaction, various new processing techniques are being used to fabricate the high-performance composites. Recently, an in-situ technique has been developed to fabricate ceramic particle-reinforced MMC. The major advantage of this in-situ process is that the dispersed TiB2is created by the reaction so that the particles are formed within the melt and there are fewer problems with distribution of the in-situ particles. Lots of attentions have been focused on self-propagating high temperature synthesis (SHS) because of its short time synthesis, low energy consumption and high purity of products.

Spark plasma sintering (SPS) process is a recently developed unique. SPS has offered access to sintering of high quality materials in possible short periods. This process involves simultaneous action of pressure, temperature and pulse electric current. It generates electric energy pulses in the gap between powders particles stacked in a die and directly applies the high energy of instantaneously generated high temperature plasma for sintering of the material. With such features SPS system offers a lot of advantages (e. g rapid sintering, less sintering additives, uniform sintering, low cost, easy experimental procedure) compare with conventional sintering systems like hot pressing (HP), hot isostatic pressing (HIP) or pressureless sintering and it's able to apply to many advanced materials such as functionally graded materials (FGM) fine ceramics, amorphous materials, nanocomposite, etc.

In the present study, in-situ formation of TiB_2 particles in a copper matrix through combination of mechanical treatment and subsequent SHS were investigated. The effect of TiB2 content on their microstructures and mechanical/electrical properties after SPS was studied.

2. Experiment

Raw powders of elemental titanium (99.5%, 10m), amorphous boron (97%, < 1 m) and copper (99.5%, 40m) were used in this investigation. To produce Cu-40wt% TiB_2 powder, the Cu, Ti and B elemental powders were mixed for 1h by using tubular mixer. Blended powder submitted in high energy mill (AGO-2 planetary ball mill) with ball acceleration of $600m/s^2$ to form a homogeneous component before it's ignited by mean of SHS to produce in-situ TiB2 nanoparticles in Cu-matrix. Balls and vials are made of stainless steel, diameter of the ball is 5mm and powder to ball ratio is 1:20. The vials were evacuated and subsequently filled with argon up to 0.3MPa. SHS was carried out by igniting of spiral tungsten wire connect with high electric power in argon atmosphere. Cu-40wt%TiB_2 powder product after SHS reaction was diluted by pure copper powder and second mechanically treatment to obtain desired homogeneous composites with 2.5, 5 and 10wt% TiB_2. These composite powders were spark plasma sintered in a vacuum atmosphere. A graphite mold of 15mm in inside diameter was used for this investigation. Applied pressure and sintering temperature were 50MPa and 950℃, respectively. It should be noted that effective temperature of sample is usually 50℃ higher than that measured by a thermocouple inserted in the wall of mold.

3. Results and discussion

Grain size of SHS-ed powder is smaller than 250nm. The hardness increased from 53 and 93 H_RB with increasing of TiB_2 contents from 2.5 to 10wt%, while the electrical conductivity decreased from 75 to 54% IACS.

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