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방전 플라즈마 소결된 Cu-TiB_2 나노복합재료의 열적 안정성

Thermal stability of spark-plasma sintered Cu-TiB_2 nanocomposites

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Abstract

In the present work, copper-based composites with dispersed TiB_2 nanoparticles are chosen for the study. These composites attract much interest due to advantageous combination of the properties at the phases. Copper is a high conductive materials and TiB_2 exhibits high melting point, high hardness and high electrical conductivity comparing with other ceramics. The Cu-TiB_2 nanocomposites are potential candidates for the welding electrode materials. The purposes of this work are to find the best processing to fabricate the Cu-low content TiB_2 nanocomposites and to investigate the thermal behavior of sintered samples at high temperature.

First, Cu-40wt%TiB_2 nanocomposites powder (SHS-product) was synthesized by high-energy ball-milling of Cu-Ti-B mixture and subsequent self-propagating high temperature synthesis method (MA-SHS). Then, SHS-product was "diluted" by copper by four kinds of processing including mixing and milling. The first processing (P1) is mixing of as-obtained SHS-product and additional copper powder in a tubular mixer for 2 hours.The second processing (P2) is mixing additional cooper and SHS-product powder milled in planetary ball mill at 500 rpm for 10 min. The third processing (P3) is milling of additional copper powder and as-received SHS product in planetary ball mill at 300rpm for 30 min. In the fourth processing (P4), the SHS-product was previously high-energy ball milled at 500rpm for 10 min and then milled with copper powder at 300rpm for 30 min. The full density bulk of Cu 2.5wt%TiB_2 nanocomposites were obtained by spark plasma sintering (SPS) at 650℃ for 5 minutes. Heat treatment was performed in the range of 850-950°C. The powder-products, sintered samples before and after heat treatment were observed and analyzed by Field Emission Scanning Electron Microscopy (FE-SEM), X-ray diffraction and Energy Dispersive Spectroscopy (EDS). The density, the electrical conductivity and Rockwell hardness of compacts before and after heat treatment was measured and compared.

XRD pattern of SHS-product shows only Cu and TiB_2 peaks. The TiB_2 particles, observed by FE-SEM, with the mean size of 250nm were formed in copper matrix after MA-SHS method.

The SEM images of Cu-TiB_2 nanocomposite powders show that the distribution of TiB_2 particles in copper matrix achieved by P4 processing is most uniform than that by other processing. The uniform distribution of the 250nm TiB_2 particles in copper matrix produced by P4 processing is caused by preliminary- milling of SHS-product and co-milling of cooper powder and the milled SHS-product. The preliminary-milling of SHS cause the size of agglomerates of SHS-product decrease facilitatingthe distribution of TiB_2 in Copper matrix during co-milling of copper and the SHS product.

The hardness Cu-2.5wt.%TiB_2 nanocomposite compacts sintered from the powders prepared by P1, P2, P3 and P4 processing is 15, 34, 62 and 72 H_RB, the electrical conductivity is 87, 86, 83 and 82 %IACS, respectively. The density of all compact after sintering at 650°C reaches over 97% of theoretical density. The high hardness of compact sintered from powder prepared by P4 processing is result of the uniform distribution of the 250 nm particles of TiB_2 in copper matrix.

Heat treatment was carried out on the sintered compact of Cu-2.5wt%TiB_2 composition powder prepared by P4 processing. The hardness decreases from 62 to 55 H_RB with increasing heat treatment temperature from 850 to 950°C. As a result, the softening temperature was determined to be around 900°C.