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Preparation of graphite@Cu powders from ultrasonic powdering technique

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ABSTRACT

Cu-coated graphite (graphite@Cu) powders were fabricated using our invented device through ultrasonic flow electrodeposition. The effects of NaH_2PO_2, ultrasonic, current density, load of graphite powders, flow velocity, and deposition time on copper were investigated. The results showed that graphite@Cu composite powders with copper content of 50–75 wt.% were electrodeposited in the proper electrolyte. NaH_2PO_2 could decrease polarization resistance of electrodeposition and improve the Cu coverage of graphite particles. The composite powders could be effectively dispersed in the electrolyte by ultrasonic.

1. Introduction

As a core–shell structured composite material, graphite@Cu particulate composites possess both the properties of copper and graphite, such as excellent thermal and electrical conductivity, solid lubricating and small thermal expansion coefficient. Therefore, graphite@Cu materials could be used as brushes of electrical machines, sliding electrical contacts and inserts for current collectors of electrical vehicles. Two traditional techniques have been developed to produce conventional metal–graphite systems. One is the dry powder metallurgy technique [1–3], involving the solid-state sintering of pre-molded mixtures of metal powder and graphite powder or hot pressing of the powder mixtures. The other is the metal infiltration technique [4], involving pressure infiltration of molten metal into the open pore volume of graphite or carbon–graphite skeletal structure. The metal infiltration technique is widely used for making composites consisting of a low melting metal and refractory metal material. However, it is still a strong challenge for high efficient usage of the metal constituent. Furthermore, a uniform mixture consisting metal and graphite powders was hardly obtained through simple mechanical mixing, due to the great different densities of the components and extremely low wettability of graphite on liquid copper. As a result, the interface strength of copper–graphite was very weak. Copper coated on graphite powders could evidently enhance the electrochemical reaction rate at the interface between electrode and electrolyte, minimizing the reactions between the matrix and reinforcement particles [5]. Coating of graphite powders would lead to better compaction, higher sinter densities, and considerable reduction of losses in carbon particles during sintering process [6].

Several methods, including chemical [7,8], electrochemical [9] and chemical vapor-phase deposition [10], have been developed for synthesis of metal-coated graphite composites. Among of them, chemical plating was widely used, involving the reduction of copper ion with formalin or reducible metal powders such as zinc and iron. The copper was adherently precipitated on the surfaces of specially pretreated graphite powder particles. However, this method had many disadvantages, such as complicated pretreatment of graphite, unstable plating bath, complicated composition and plentiful loss of metal forming a highly dispersed suspension.

Several experiments have been carried out by chemical plating, in which graphite powders were copper-plated and then followed by electrodeposition. The flake graphite powders were lightly coated and copper content of 20–25 wt.% was obtained by electroless plating. Without being dried, the copper-coated graphite powders were transferred into the electrodeposition bath and the graphite powders continued to be deposited electrolytically. With this technique, a more compact metal coating was obtained, but the plating process was time consumed.

However, up to date, to our best knowledge there is no report about the synthesis of graphite@Cu composite powders by ultrasonic flow electrodeposition. In this paper, a highly dispersed graphite@Cu powders with uniform copper coating are obtained via our invented device of ultrasonic flow electrodeposition. The process of copper deposited on the graphite particles is thoroughly

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