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Short communication

Microstructure evolution of cobalt coating electroless plated on SiC whisker during electroless plating and heat treatment

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Abstract

SiC_w/Co nanocomposite particles were prepared by electroless plating cobalt on SiC whiskers and the microstructure evolution of the plated coating was investigated by SEM and XRD. SEM images show that growth occurs on the surface of the clusters at the initial stage; as they grow larger, the clusters converge to form a continuous coating, which is actually stacking of cobalt clusters. After heat treated at 500 °C in a hydrogen atmosphere, the cobalt coating transforms from an amorphous to a crystalline state. The thermal stability of SiC_w/Co composite is low because of the weak bonding between the substrate and the cobalt coating. The continuous coating aggregates to clusters through surface diffusion during heat treatment.

Keywords: Nanocomposite; Electroless plating; Microstructure evolution; Growth behavior

1. Introduction

SiC whisker is of great importance for its wide applications and it has been used as reinforcements in metal matrix composites and ceramic composites for many years [1,2]. SiC ceramic has found new applications in the electronic industry for its adjustable permittivity in recent years [3,4]. On the other hand, some researches have proved that ferromagnetic metal coatings plated on the dielectric substrate possess unique electromagnetic properties [5–8], for example, carbon fibers with FeCoNiP alloy coating plated on its surface have been used as high performance electromagnetic wave absorbers in GHz band [8].

Electroless plating is an easy process used to deposit metal or alloy film on a conductive, semiconductive or even insulated substrate, and especially, it can be used to deposit a metal coating on a fine substrate in the form of particles, fibers or whiskers. In the past decade or so, a lot of work has been done on how to deposit Ni or Co by electroless plating on fine substrates, including CNTs and carbon nanofibers [7,8], SiC particles [9,10], ZrO_2 particles [11]. Although electroless plating process has already been under study for many years, to the best of our knowledge, little work has been done on electroless plating metals on SiC whiskers and not much attention has been paid to the growth behavior of plated coating. This situation justifies our efforts to study the process of electroless plating metals on SiC whiskers, and the growth behavior of cobalt coating in particular.

Furthermore, the thermal stability of nanoscaled metal structures at high temperature is of great significance, because heat treatment at high temperature is usually required to condition microstructures. Although much work has been done on the thermal stability of metal coatings plated on bulk substrates [12,13], it is obvious that the thermal stability of metal coating plated on whiskers needs further investigation [14].

Therefore, we adopted an electroless plating method to deposit cobalt on SiC whiskers and studied the microstructure evolution of metal coatings during electroless plating and heat treatments.

2. Experimental

SiC whiskers of 0.1–1 μm in diameter were used as substrates and the morphology of raw SiC whiskers is shown in Fig. 1a).

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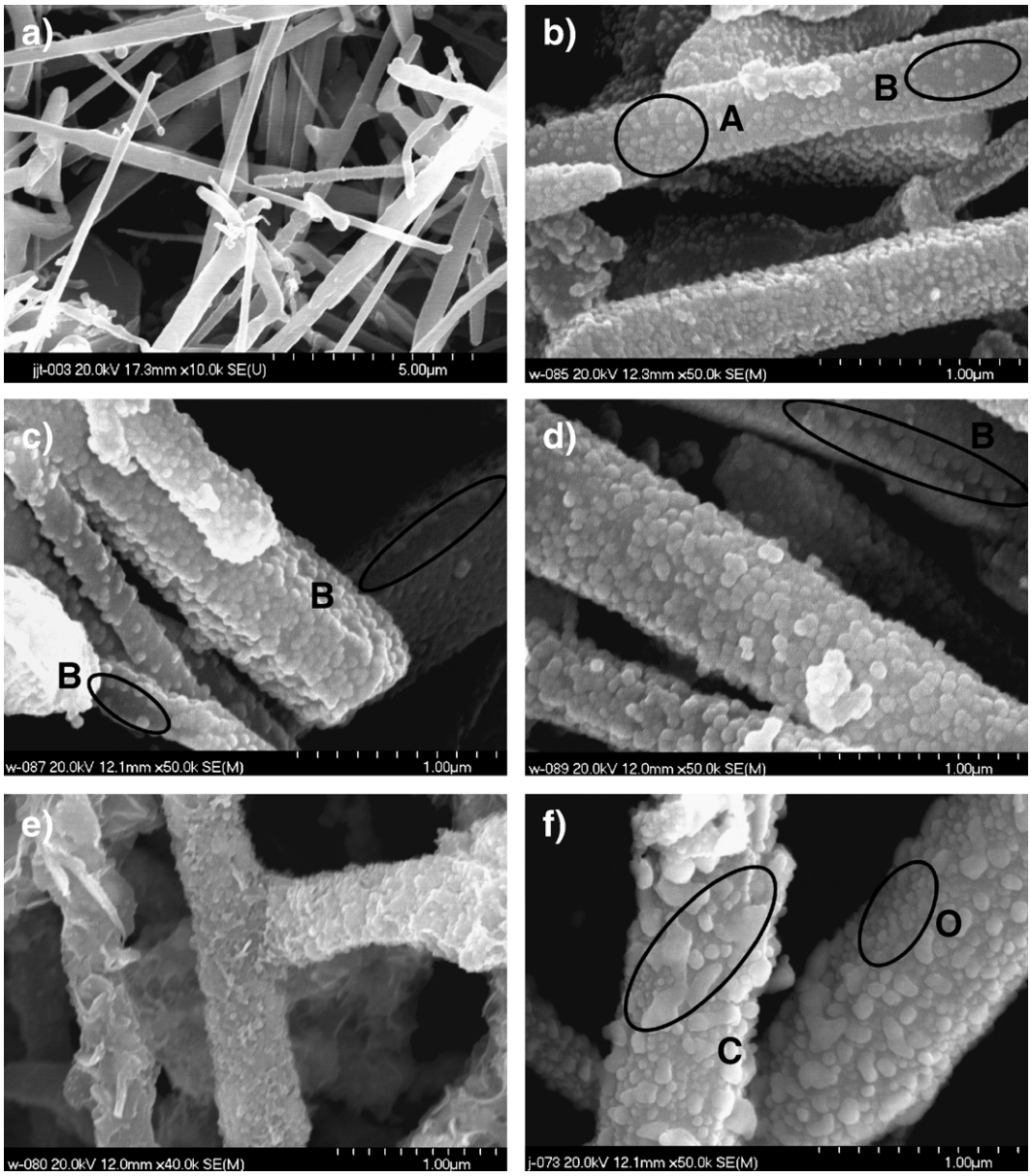

Fig. 1. SEM images of raw SiC whiskers and SiC_w/Co nanocomposite powders a) raw SiC whiskers; b) at 15th minute; c) at 30th minute; d) at 60th minute; e) at the end of electroless plating; f) after heat treatment.

Raw SiC whisker was pretreated to obtain catalytic activity before electroless plating because of its chemical inertness. The pretreatment included coarsening, sensitizing–activating and drying. 2 g of pretreated whisker was then added into 400 mL preheated plating solution, which contains 25 g L^{-1} cobaltous sulfate, 25 g L^{-1} sodium phosphite, 50 g L^{-1} sodium citrate and 25 g L^{-1} boric acid. During plating, the temperature of the plating solution was kept in the range of 50–55 °C by water bathing. The pH value of the plating solution was kept at 8.5 by instilling 2 M NaOH solution. Measly samples were taken from the plating bath with a sucker at the 15th, 30th, 60th minute and at the end as well, and these samples were named successively as S15, S30 S60 and SE. All these samples were rinsed in deionized water for three times and dried in atmosphere in an oven at 80 °C overnight. Some final nanocomposite powder was heat treated in hydrogen in an oven at 500 °C for 2 h and the heat treated sample was named as SH5.

The morphologies of these nanocomposite particles were observed with a FE-SEM (Hitachi S-4700) and their phase compositions were XRD analyzed (Regaku D/max-γB, Cuk_α, graphite filter).

3. Results and discussion

It can be seen from the SEM images of raw SiC whickers and samples taken at different process time shown in Fig. 1 that, fine cobalt clusters of 30–40 nm in diameter appeared on the surface of SiC whiskers at the 15th minute from the beginning of the reaction. In most of the areas, cobalt clusters distribute uniformly at an interval of about 100 nm as shown in region