

Electroless nickel plating on hollow glass microspheres

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Abstract

Electroless nickel plating on hollow glass microspheres with hypophosphite as a reducing agent in an alkaline bath was studied. Three pretreatment methods were used. The hollow glass spheres via coupling agent solution pretreatment adsorbed more palladium catalytic active centers on their surfaces, hence continuously and uniformly covered microspheres were achieved. The magnetic property of microspheres was improved by adjusting the pH and the concentration of the reducing agent in a certain range. The morphology, composition and structure of deposits were investigated. It was found that the deposits on hollow glass microspheres grew thicker with prolonged plating time. Posttreatment of the coated Ni glass spheres improved the crystalline structure of the plated Ni layer.

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1. Introduction

Electroless nickel platings have found wide uses in many fields, because the technique of electroless plating was invented and the high performance product with high hardness, wear resistance and corrosion resistance were produced. Several advantages like low cost, easy formation of a continuous and uniform coating on the surface of substrate with complex shape, and capability of depositing on either conductive or nonconductive parts have attracted a lot of interests from the academe and the industry [1–3]. Nowadays, electroless nickel plating has also even been attempted in nanofabrications in optics and in the decoration on carbon nanotubes [4,5], SiC powder [6,7], other metal powder [8] and polystyrene resin balls [9].

Hollow glass spheres are a kind of particulate material which have found wide uses in paint and coating systems for their low density, high thermal resistance and high wear resistance. It can be expected that if the hollow glass spheres were coated with a layer of magnetic metal, wider use would be developed in some fields, such as immunoassay, catalyst and magnetorheological fluids [10,11], as they combine the properties of hollow glass spheres and the metal together. Several deposition technologies, such as physical and chemical vapor deposition, sputtering or electroless plating, could be chosen to coat hollow glass spheres. Electroless plating is a favorite method for its advantages described above. But to our knowledge, coating hollow glass microspheres with metal by electroless plating is seldom reported. The possible reason for this may be that there are some difficulties to undergo the active treatment on hollow glass microspheres due to their microspheric shapes and very low density.

In this paper, electroless plating method was applied to deposit a layer of nickel on the surface of hollow glass spheres. Several pretreatment methods were used to

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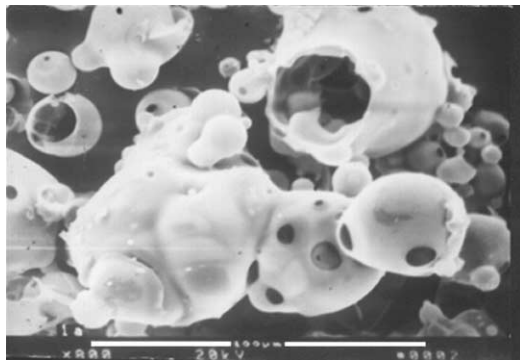


Fig. 1. Hollow glass spheres etched by HF solution.

improve the active effect of the hollow glass sphere in order to obtain a uniform and continuous deposit layer. The parameters of alkaline plating bath were optimized in order to deposit nickel more efficiently.

2. Experimental

2.1. Raw materials

The hollow glass spheres (diameter: 10–100 μm ; apparent density: 0.1–0.2 g/cm^3) were supplied by the Qinhuangdao Glass Sphere Company of China. Nickel (II) sulfate ($\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$), sodium hypophosphite ($\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$),

thiourea, triethanolamine, tin(II) chloride ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$), ammonium hydroxide, ethanol, sodium tinate, palladium(II) chloride, sodium pyrophosphate decahydrate ($\text{Na}_2\text{P}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$), 3-aminopropyltriethoxysilane (KH550, a silane coupling agent), hydrofluoric acid, and hydrochloric acid were purchased from Xi'an Chemical Reagent Factory and Tianjun Chemical Reagent Factory. All chemicals were of reagent grade and were used as received. Distilled water was used during sample preparation.

2.2. Electroless nickel plating process

Before electroless plating, pretreatments including surface treatment and activating treatment were performed. Two surface treatment methods were used in order to improve the surface properties of hollow glass microspheres: (1) etching hollow glass spheres in HF solution (10 vol.%/vol.%) for 30 s, then rinsing in distilled water and drying at 100 $^\circ\text{C}$; (2) immersing hollow glass microspheres in coupling agent ethanol solution for 2 h and drying at 100 $^\circ\text{C}$. Activating treatments were carried out in a colloid–palladium solution at 30–40 $^\circ\text{C}$ for a period of time, then the activating glass spheres were separated from the activating solution, rinsed with distilled water and immersed in 10 vol.%/vol.% HCl for 2 min, and later rinsed with distilled water. After the pretreatment procedures, deposition of Ni on the glass

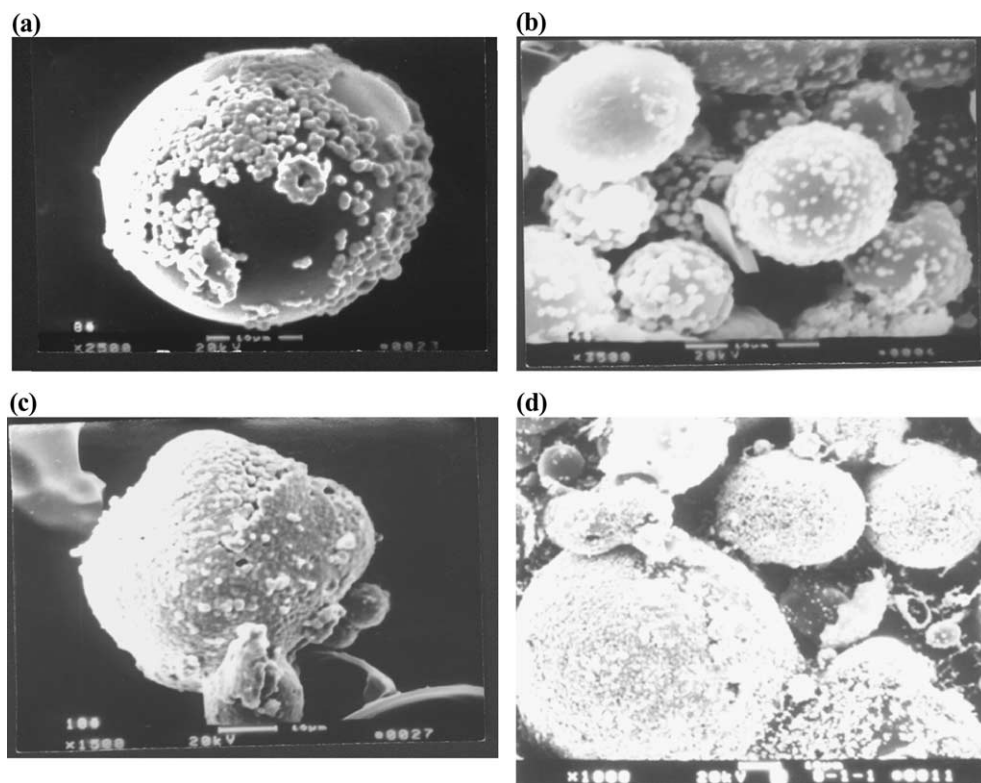


Fig. 2. SEM micrographs of the nickel coated hollow glass spheres: (a) and (b), plated for 5 h pretreated by method 3; (c) and (d), plated for 2 h pretreated by method 2.

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