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Preparation of Copper-coated Polyester Fabric via Electroless Plating Using Glyoxylic Acid as Reducing Agent ⋆

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Abstract

An environmental-friendly electroless copper plating process was employed in preparing copper-coated polyester fabric with excellent conductivity. The effects of bath temperature on the plating rate, compositions and crystal structure of the electroless copper deposits were studied. The results showed the deposition rate increased with the rise of the bath temperature. X-ray Diffraction (XRD) scan indicated that the copper coating deposited was well crystallized and Scanning Electron Microscopy (SEM) scan showed copper coating had good surface morphology. Surface resistance of copper plated polyester fabric was evaluated. The surface resistance was 16.5 mΩ/sq as the temperatue was 65 °C.

Keywords: Glyoxalic Acid; Electroless Copper; Polyester Fabric; Surface Resistance; Bath Temperature

1 Introduction

Metallization of non-conductive surfaces is important in many industrial applications as it allows more flexibility in parts design, and reduces weight compared to its metal counterpart [1–3]. In recent years, a great interest in the deposition of metallic coatings on fabric has gradually been increased for either decorative or functional purposes in applications such as food packaging, microelectronics packaging, Electromagnetic Interference (EMI) shielding and wear protection [4–6]. Copper (Cu) has been widely studied and a variety of fabric have been plated with Cu such as cotton, glass fiber, and polyester due to its excellent electrical conductivity and relatively inexpensive [7–9]. To alter and tailor properties of non-conductive surfaces, several copper coating techniques have been developed such as sputtering [10], electrodeposition [11], Physical Vapor Deposited (PVD) [12] and electroless deposition [13–15]. Electroless copper deposition, which is a self-initiating, autocatalytic process, has become popular for many industrial applications because of their stability, ease of operation and cost effectiveness. However, traditional electroless copper

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plating uses formaldehyde or its derivatives as reducing agents. As is well known, formaldehyde is volatile, flammable and possibly carcinogen liquid, which is hazardous to health. Hence, researches are developing towards alternative reducing agents such as potassium borohydride [16], Fe(II) [17], Co(II) [18], dimethylamine borane [19], glyoxylic alcohol or glyoxylate [20], and sodium hypophosphite [21] for electroless copper deposition. Among them, glyoxylic acid (CHOCOOH) is considered as a good choice with its higher deposition rate and less environmental pollution. In addition, the plating bath is easily stable with glyoxylic acid as a reducing agent [22–24].

The aim of this study is to develop an efficient and environmental-friendly method to deposit copper coating on the polyester fabric by electroless plating using glyoxylic acid as a reducing agent. The effects of bath temperature on deposition rate, surface morphology, crystal structure, chemical composition and surface resistance of copper plated polyester fabric were investigated.

2 Experimental

2.1 Material

Plain weave 100% polyester fabric (47×40 counts/cm^2, 84 g/m^2) in white color was used as the substrate. All chemicals were of analytical grade.

2.2 Electroless Copper Plating

Polyester fabrics were washed with deionized water. The fabrics were impregnated into 5 g/l copper sulfate solution for 10 min, and then they were placed into 5 g/l sodium borohydride solution for 10 min without being washed. After that, the fabrics were impregnated into copper plating solution at different temperature. The solution for copper plating was prepared by copper sulfate, EDTA, potassium ferrocyanide, deionized water and glyoxylic acid. Sodium hydroxide was used to adjust the pH of the plating solution. After copper plating, the fabrics were washed by deionized water and dried at 70 °C.

2.3 Characterization

The electronic balance (HangPing FA2004N) was used to weigh the fabrics before and after copper plating. The deposition rate was calculated by the following equation.

$$\mathrm{d} = \frac{m_2 - m_1}{S \times t} \tag{1}$$

where d is deposition rate; m_1 and m_2 are the weight of fabrics before and after copper plating, respectively; S is area of the fabrics and t is time of copper plating.

SEM images were obtained using TM-3000 Tabletop Microscope with various magnifications to study the surface morphology of the polyester fibers and the copper coated polyester fibers. Elemental composition of the copper plated fabrics was obtained by EDX Detector on JEOL JSM6490.

Crystal structure of copper deposits on the polyester fabrics was characterized by D8 DISCOVER X-Ray Diffractometer. Surface resistance of the copper coated polyester fabrics was measured