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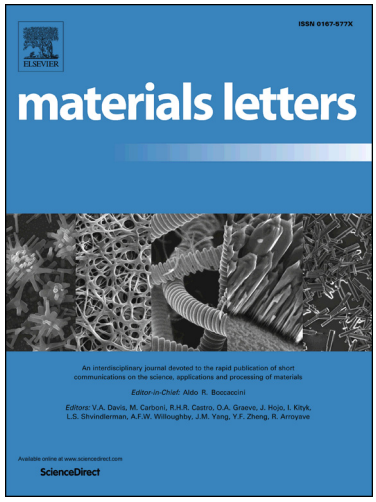

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Selective electroless metallization of non-conductive substrates enabled by a Fe_3O_4/Ag catalyst and a gradient magnetic field.

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Abstract:

The formation of printed circuit patterns on non-conductive substrates has many applications in high value sectors such as electronics manufacturing. Current semi-additive and subtractive circuit manufacturing processes use photolithography to pattern substrates coated with a thin or relatively thick metal film. This process is often wasteful and expensive. Using an innovative approach; composite Fe_3O_4-Ag nanoparticles were synthesized and attracted to a magnetic field. The nanoparticles catalysed electroless copper deposition. Such a catalyst is new to electroless plating and was deposited selectively on a dielectric substrate using a gradient magnetic field. In this way, subsequent electroless copper plating occurred exclusively where the magnetic field was applied, whilst the remaining surface was free of deposited metal. The advantage of this additive method of manufacture is that less material is needed and less waste is produced.

Keywords: Deposition, Electroless, Magnetic, Nanoparticles, Selective.

1. Introduction

The utilization of a gradient magnetic field to enable selective metallisation via electrodeposition has been widely researched [1-3]. The gradient magnetic field was created by permanent magnets which were applied behind the substrate during electrodeposition. The electrodeposited layer had a higher thickness in the area of maximum magnetic field and formed a pattern which replicated that of the magnet array.

Selective metallization of ***non-conductive*** materials such as polymers is used extensively in a wide range of high value manufacturing processes such as the formation of radio frequency identification tags and the use of circuits for connecting wearable technology. Electroless deposition is often used to metallise non-conductive materials. Typically, a Pd/Sn colloidal catalyst is employed although alternatives have been investigated such as Ag and Cu [4-6]. Although several groups have attempted to study the effect of a magnetic field on electroless plating, none had the specific aim of selective deposition [7-9].

The synthesis of Fe_3O_4-Ag nanoparticles has been an area of research interest because of their unique properties [10]. The objective of the present research was to synthesize composite Fe_3O_4-Ag nanoparticles for electroless copper deposition. The paramagnetic Fe_3O_4 particles would be attracted by the magnetic field and form the required pattern, whilst the silver would catalyse the oxidation and reduction reactions to initiate electroless plating. The aim of this study was to demonstrate that this innovative approach to selective metallization of non-conductive materials has the potential to be used for forming conductive circuitry on non-conductive substrates.

2. Methodology

The Fe_3O_4-Ag composite nanoparticles were synthesized according to a previously published procedure [11]. The synthesized particles were dried in an oven overnight at 50 ^{o}C. In order to prepare the catalyst solution, 0.01 g of Fe_3O_4-Ag composite nanoparticles were dispersed in 100 ml