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Writing with conducting polymer

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Abstract

In this paper, we present an original and straightforward route to prepare conducting polymer pattern in substrates such as, plastic, transparence sheet, glossy paper or in any substrate material found in standard working office. This process consist in replacing the conventional ink used in any DeskJet printer, for a solution of transition metal that will be used to print the desired pattern on a substrates previously soaked in an aqueous solution of conducting polymer monomer. Soon after the patterns are written a UV light is used to develop the printed characters. The measured conductivity of the printed conducting polymer patterns in glosss paper is the order of 2×10^{-2} S/cm. This contribution describes the use of a fast and low-cost technology to produce organic microstructures for microelectronic applications.

Keywords: Polyaniline; UV-irradiation; Silver nanoparticles

1. Introduction

Since the discovery of conducting polymers (CP) three decades ago in 1977 [1] there have been many efforts of the scientific community to understand its fundamental charge transport mobility and to find new technological application that explore the advantages that electronic polymers possess over conventional metals and inorganic semiconductors. Although conducting polymer is a versatile material, unfortunately the majority of conducting polymer has low solubility in almost all solvent, is infusible, besides is difficult to process into a useful product. Since the processing of polymer material is a major issue, when considering device implementation, many different synthetic routes to prepare conducting polymer has been implemented to overcome these problems. Among several technological applications with CP, the development of low-cost disposable plastic/paper electronics or all plastic electronics devices seems to be the breakthrough for many practical and inexpressible applications for the next decade [2]. Many organic electronics devices, such as field effect transistor (FETs) using conducting polymer, have been already developed [3–8]. However, the fabrication of FETs involves the process of photolithography, vacuum deposition, or printing of polymers, which requires multiple processing steps and special equipments. Recently, MacDiarmid has developed a quite simple and inexpressibly method to obtain custom patterns from conducting polymer namely the "line patterning" [2], using office equipments such as a standard laser printer. Considering this recently development and the synthesis route developed in our laboratory, to prepare conducting polymer using transition metal ions assisted by light [9], in this paper, we present a straightforward and low-cost method to produce conducting polymer patterns using a conventional DeskJet printer.

2. Experimental

Aniline and pyrrole (Nuclear) were distilled twice under atmospheric pressure and stored in dark and at low temperature prior to synthesis. Ammonium hydroxide (Merck), ethanol (Merck), nitric acid (Merck), silver nitrate (Merck), DMSO (Merck), acetonitrile (Aldrich) and all other reagents

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were used without further purification. All aqueous solutions were prepared using distilled and deionized water. Stock solution of aniline and pyrrole, of desired concentration, in nitric acid and silver nitrate in aqueous solution was prepared and stored at low temperature before use.

First, the ink of the printer ink cartridge of a Cannon BCJ-4000 DeskJet printer, was replaced by a silver nitrate solution, then the patterns (lines or characters) were designed on a computer using a drawing software and printed on a substrate (paper, glossy paper or transparence sheet) previously soaked in an aqueous solution of conducting polymer monomer. The next step a germicide lamp 20 W was used to reveal the patterns.

The UV–vis spectral characterization was performed with a Perkin-Elmer spectrophotometer model Lambda 6 and the X-ray diffraction (XRD) patterns using a Rigaku DMAX model 2400 X-ray diffractometer with a Cu target ($\lambda = 1.54178$ Å). Samples conductivity was measured using standard four probe method employing a Keithley 617 current source and ET-2500 Minipa DVM instrument.

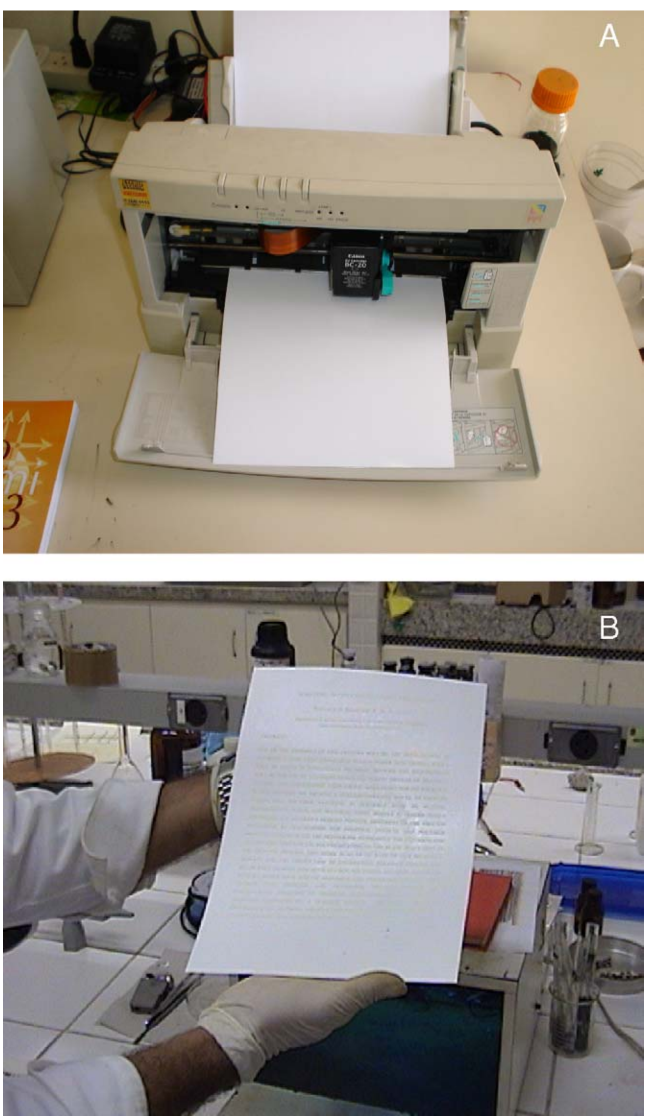

Fig. 1. Patterns printed on a glossy premium film substrate with a Canon BCJ 4000 DeskJet printer (A) and no developed patterns (B).

3. Results and discussion

Figs. 1 and 2 show the complete sequence for the printing and development of the conducting patterns process. In Fig. 1(A), the DeskJet printer is printing the patterns or character on a glossy premium film substrate, as we can see in Fig. 1(B), after the printing process is finished nothing can be seen on the paper sheet, however, after the development with the UV lamp Fig. 2(A), a clear image can be seen in Fig. 2(B), The reaction is instantaneous, as soon as the glossy film interacts with the light, the green or black (depends on the monomer aniline or pyrrole) polymer patterns is revealed as a indication that the conducting polymer is synthesized. Additionally, in the case of polyaniline, the green color is an indication that the polymer is synthesized in the conducting

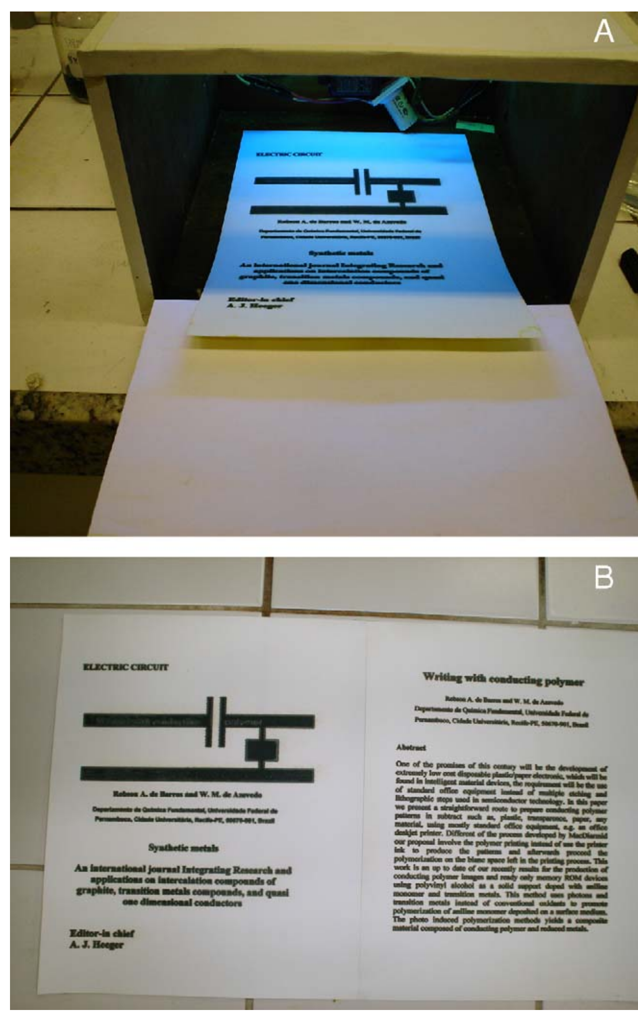

Fig. 2. UV photo development with the germicide lamp (A) and developed patterns (B).