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Abstract

Zinc-Based Electrically Conductive Adhesive for the Transfer of SMD Components on Paper PCB †

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Abstract: We report on an eco-friendly zinc-based electrically conductive adhesive (ECA). The composition and process for the implementation of the paste to fix surface-mounted devices (SMDs) components were investigated and optimized. The ECA was used to transfer SMD resistors onto paper with printed zinc contact pads. The stability of the paste was assessed for 1 month at room temperature with less than 1% change in resistance. Mechanical bending of SMDs bonded onto the substrate was evaluated. The paste was also implemented to fabricate a zinc paper-based RFID card.

Keywords: conductive adhesive; eco-friendly; paper electronics; SMD; zinc

1. Introduction

Hybrid printed electronics composed of silicon surface-mounted devices (SMDs) and printed PCBs has relied on silver or harmful solders [1] to ensure the proper electrical connection of the SMD components. Envisioning more sustainable printed circuits boards (PCBs) made on paper, we have been focusing on the development of an environmentally friendly and electrically conductive adhesive (ECA) composed of degradable materials with the use of zinc conductive particles and polyvinylpyrrolidone (PVP) as binder. The electrical properties of the adhesive after its electrochemical sintering and its stability over time as well as its mechanical reliability were studied.

2. Materials and Methods

An eco-friendly electrically conductive adhesive based on zinc nanoparticles was developed for the transfer of surface-mounted devices (SMDs) onto a paper substrate. The newly developed ECA incorporates 500 nm zinc nanoparticles mixed with PVP 360,000 M.W. as a binder in a 25:1 weight ratio. Pentanol was selected as the solvent in a 1:5 weight ratio. Chemical sintering using acetic acid (AA) in a 12.5% to 50% concentration in pentanol was used to reduce the oxide on the zinc particles after deposition [2] to enable an appropriate electrical connection to the SMD components. A schematic view of the process flow and a picture of the test structure is depicted in Figure 1a.

The performance of the ECA was compared on polyimide and paper substrate using either printed silver or zinc contact pads. The zinc-based ECA was stencil printed over the contact pads and 10 Ω SMD resistors of two sizes (1.6 mm and 5 mm) were picked and placed onto the ECA. Using 4-wire probing, the evolution in resistance was studied over a month as well as its change when bending.

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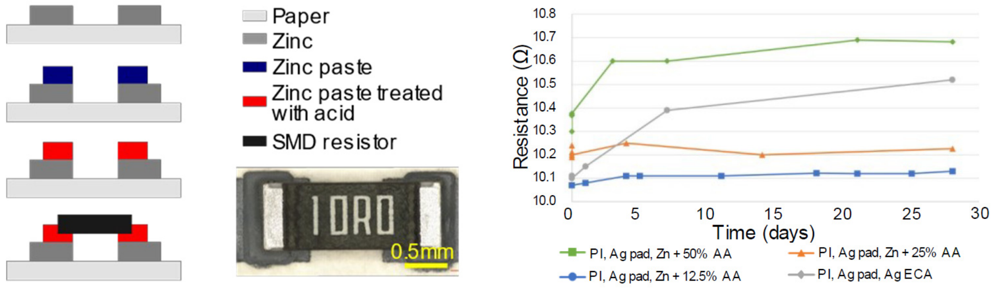


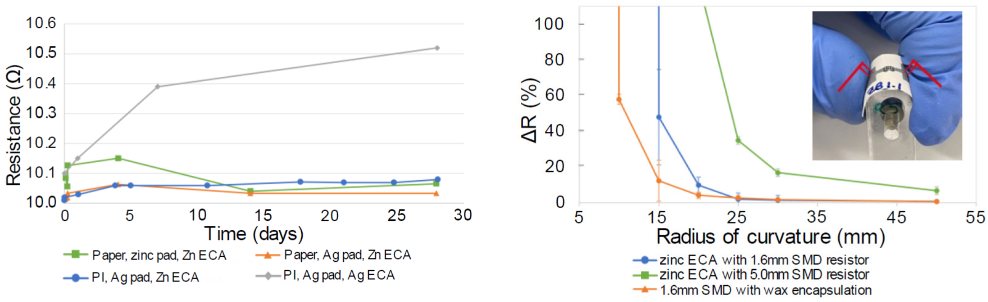
(**a**) (**b**)

Figure 1. (**a**) Test structure schematic and photo of SMD resistor fixed using the ECA; (**b**) evolution of the resistance using the zinc ECA on polyimide for 30 days for various acetic acid concentrations.

3. Results and Discussion

The zinc paste was compared to a standard silver ECA sintered at 80 °C for 3h. The cured zinc paste's stability over time at room temperature (RT) was monitored for different concentrations of acetic acid from 12.5% to 50%, where a lower concentration resulted in a smaller increase in the initial resistance of the SMD component (10.1 Ω with 12.5% AA and 10.3 Ω with 50% AA) and better stability with a 1% change in resistance across the attached 10 Ω SMD resistor after 30 days, as shown in Figure 1b.

The produced eco-friendly ECA showed a small resistance increase after connecting the SMD going from 10.05 to 10.12 Ω on the first day at RT, dropping back to its initial value after 2 weeks, as seen in Figure 2a. After 1 month, the zinc ECA on zinc or silver pads displayed a similar drift in resistance of 1%, while the commercially available silver ICA on silver showed a higher variation of 5%. A bending test performed on paper with the zinc contact pads showed that smaller SMD elements, 1.6 mm in size, connected with the ECA could withstand a bending radius of 15 mm, while larger resistors, 5 mm in size, started failing after a 20 mm radius of curvature, as illustrated by the sharp increase in resistance change in Figure 2b.



(**a**) (**b**)

Figure 2. (**a**) Stability of the zinc ECA with 12.5% acetic acid over one month for different substrate and transducing materials; (**b**) evolution of the resistance for various radii.

Finally, for demonstration, the ECA paste was implemented to fix an RFID chip onto a printed zinc paper card. The tag was successfully wirelessly encoded using a smartphone.

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