# Investigation of silver nanoparticles ink resistivity on polyethylene terephthalate

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**ABSTRACT** – The aim of this study is to identify the effects of resistivity for silver nanoparticles conductive ink. The research was conducted by following several processes such as formulation process, curing process, and testing process. In the testing process 4-point probe is used to study the resistivity effect on the silver nanoparticles ink using a polyethylene terephthalate. The electrical properties of silver nanoparticles conductive ink can be indicated in the result show on 4-point probe.

## 1. INTRODUCTION

Conductive ink has been widely studying due to its popularity in printed electronic and the market. Conductive ink is the ink that can conduct electricity. Conductive ink is an innovation have been fabricated after research have been conducted in which able to reduce cost and faster to fabricate the electronic component [1]. There are many advantage of this technology such as its capability to print a controlled amount of ink, at high frequency and on almost any type of substrate, low cost, additive and efficient handling of expensive materials. The materials of conductive filler various in shapes and sizes which are consist of metal properties such as carbon (C), copper (C), gold (Au), and silver (Ag) particles.

There are many type of stretchable substrate that were used in conductive ink like glass slide substrate, polyethylene terephthalate (PET), thermoplastic poly urethanes (TPU), polyurethane (PUT), and poly dimethyl siloxane (PDMS). Basically, these substrate does not tend to be very smooth and have a very low glass transitions temperature (Tg). Therefore, in curing process the temperature generally under 150℃. Another challenging is compatibility issue, this can cause to metal delamination under mechanical and thermal stress. These stretchable substrate is tending to be quite thin (1 mil to 5 mils thick), hence these substrates are easily stretch. Therefore, it is easily to get deformed when the printing process take place leading to distortion in the print image [2].

In this research, conductive ink consists of silver nanoparticles as a conductive filler, epoxy as a binder and hardener. A silver nanoparticle has been used in this due to its characteristic which are high electrical conductivity, high stability and low sintering temperature. Meanwhile, the binder was used in this study since binder provide adhesion to the substrate and cohesion to each other. The ink will print into PET substrate. PET stands for "polyethylene terephthalate" is a type of plastic that available in many variations depending on specific applications. PET is a thermoplastic polymer and it is a naturally transparent. PET have a poor adhesion on silver nanoparticle ink, low cost substrate could be and used in many applications such as conductive ink. There are two ways to increase the adhesion PET between substrate and ink which are the wet of ink are increasing and control the composition of ink [2].

The objective for this study is to investigate the effect of resistivity study on silver nanoparticles ink using polyethylene terephthalate. The electrical properties will be studied by using a 4-point probe. The 4-point probe was used to investigate the presence of resistivity.

## 2. RESEARCH METHODOLOGY

### 2.1 Ink development

To develop the samples of conductive ink in this research, the material involved were silver nanoparticles (AgNPs) as a conductive filler, epoxy as a binder and hardener as a solvent. The total material used in this research is 2 g. All materials were weighed using a measuring cylinder. Ther percentage of silver nanoparticles used were 60% from the total weighed which are 1.2g and epoxy is 40% from the total material which are 0.8g. The quantity of hardener is 30% from the epoxy. Formulation is a material or mixture prepared according to a formula. The formulation in this stage is to mix the filler loading, binder and hardener to form a conductive ink. The stirring process is to mix the filler loading, binder and hardener until they completely dissolved. The three material which are silver nanoparticles, epoxy and hardener were stirred by using glass rod in the same direction and constant speed for 10 minutes.

### 2.2 Preparation of the ink

For the preparation of conductive nanoparticles ink, the synthesis AgNPs were deposited into a substrate this is PET by applying blade coating process. Subsequently, the synthesis AgNPs was cured using an oven at 160℃ and 60 minutes in order to preserve the adhesion between ink and substrate. Finally, the last process, the sample were dry at the room temperature within one or two days until the ink fully dried and does not sticky.

### 2.3 Samples characterization

After the conductive ink form, the analysis process was conducted. The analysis process was to test the resistivity of the conductive ink by using a 4-point probe. Three reading of resistivity will be taken.

## 3. RESULTS AN DISCUSSION

In this part, results from 4-point probe will be discussed in detail. By following the required step in the previous, the conductive ink was testing the resistivity by using 4-point probe. The testing of the presence of resistivity of synthesis AgNPs were taken with three different point. Figure 3.1 shows the conductive ink printed on the substrate.

Figure 3.1 Conductive ink printed on the substrate

From the testing there is no resistivity presence on the conductive in. Even though, three difference point were testing, no resistivity presence. Thus, there are some error on this experiment. The error occurred may be caused from the curing temperature. The curing temperature for the PET must below than 150℃ or better 120℃ [2]. In this research the curing temperature used was 160 ℃. Therefore, there is no resistivity presence on the conductive ink.

In this research, to obtain a good result resistivity a holistic approach needs to be considered because there are many parameter and that will be affecting the final result. The experiment should set up properly such as formulation process, printing process, curing process and analysis process, are all required for a successful process. The aspect that should be considered to obtain a successful process are proper squeegee, screen, ink substrate and the environment [3].

The factor effecting the quality of the ink such as viscosity, morphology, stability, binder system, particle distribution, size of particles, and compatibility with the substrate. Next the factor effecting the quality of the substrate are surface roughness, compatibility with ink, chemical resistance, cleanliness, mechanical strength and glass transition (Tg). Besides, the factor effecting on the environment are temperature, humidity and contaminants. Therefore, the factor affecting of conductive ink should be consider getting a best result and resistivity in the experiment.

## 4. SUMMARY

This research was conducted to investigate the effect of resistivity on the silver nanoparticles using polyethylene terephthalate. The research was conducted by following several processes such as formulation process, curing process, and testing process. The 4- point probe was used to measure the resistivity of the sample in ohm-cm. From the result, the resistivity of the sample does not present. This is because of the curing temperature is highest then the glass transition (Tg) of the substrate. The properties of the electrical can be identified through the presence of resistivity from the 4 point-probe.

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