The effects of line width cross-sectional geometry to stretchable printed circuit

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ABSTRACT – The purpose of this study is to investigate the effects of line width cross-sectional geometry to stretchable printed. Four-point probes are used to measure resistivity of the conductive ink. Different width of ink was used. As a result, the higher width conductive ink content gave lower resistance than using lower width conductive ink content.

1. INTRODUCTION

Stretchable printed circuit board (SPCB) also known as elastic circuits or elastic electronics is a technology for building electronic circuits by depositing stretchable electronic devices and circuits onto stretchable substrates or embed them completely in a stretchable material. The structures are nevertheless exposed to mechanical stress and no wiring is required because of their elastic behaviour. It can eliminate wire connections failures and increase the reliability of the devices. There are many type of substrate that can be used in stretchable printed circuit. For this research Thermoplastic polyurethane (TPU) was used to conduct the experiment. There are many characteristic make TPU extremely popular across a range of application and market. For example is famed for many things including its ability to resists oil, solvents, chemical, grease and abrasion, its high elongation and tensile strength its elasticity and to varying degrees [1].

Conductive ink is the ink that can conduct electricity. As stated above, when used the substrate that flexible, no wiring is required as it replace to conductive ink to conducts electricity. Conductive inks are manufactured by blending conductive fillers with resin, solvents and additive. Fillers are usually pigments, which differentiate the graphic ink from the functional ink. Conductivity of ink depends largely on the amount of metal filler loaded in the ink, particle size of the fillers, percentage and quality of binder used and continuity of the printed layer after printing and drying [2].

There are several having various type of ink for conductive ink such as silver and carbon. In this research, carbon was used as conductive. Carbon inks are providing low friction and excellent thermal stability. The properties of carbon ink are good adhesion to different substrates, high mechanical and chemical resistance and favourable curing conditions (lowest possible curing temperature and short curing times) [3]. There are also chemically inert with low reactivity to solvent and other chemical. Carbon inks are very resistant to flexing. It also is environmentally friendly. The objective of this study is to identify the sheet resistance due to width of ink. The resistance will measure by using four point probes.

2. RESEARCH METHODOLOGY

2.1 Sample Preparation

To run the experiment, there are four main components in screen printing which is commercialize carbon ink paste, cellophane tape for the pattern design, TPU as the substrate and razor blade as the squeegee which to spread ink paste through two lines of cellophane tape marked.

After all of them were prepared, the width on the glass slide or TPU was measured and placed the tape in the mark. Then, ink was slide until the end of the path by using razor blade as shown in Figure 2.1. Ink cure in room temperature before the resistance measure by using four point probes. Sample marked as shown in Figure 2.2 before measurement of resistivity.

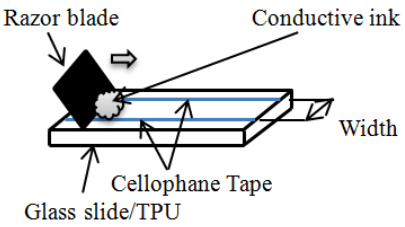

Figure 2.1 Illustration diagram printing process

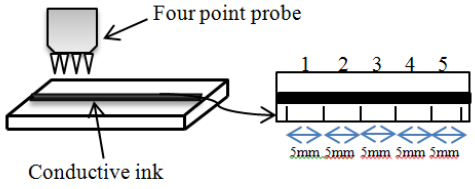

Figure 2.2 Marked sample

3. RESULTS AND DISCUSSION

In this section, results from the resistance due to different width will be discussed in detail. The width that were investigates are 3mm, 6mm and 9mm. Based from, initially the width of the ink printed on the substrates is less than 1mm but the width dimension were change after few attempt on taking the data due to the ink does not attach on the substrate when measure with four point probe.

The reasons printing the conductive ink on the glass slides are to focusing the result on the effect of the different width of the conductive ink to the resistivity and be a baseline data for TPU. This is the result obtains from different width printing on glass slides and TPU by measured using four point probe.

Table 3.1 Glass slide as substrate

Width (mm)	Average Resistance (ohm/sq)
3	332.08
6	239.6
9	76.67

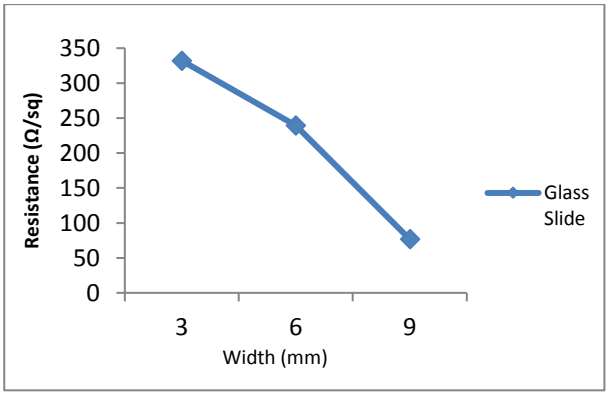

Figure 3.1: Glass slide as substrate

Based on Figure 3.1, the graph resistance versus width shown rapidly decrease. When width of ink increased the resistance value will be decrease. The lowest data and the highest data are 76.67Ω/sq and 332.08Ω/sq. The highest resistance occurs when the width measured at 3mm and the lowest resistance occurs when the width at 9mm. The resistance value for width 6mm is 239.6Ω/sq. The results shows obtain can be supported by previous journal from other researchers [4].

Table 3.2 TPU as substrate

Width (mm)	Average Resistance (ohm/sq)
3	410.36
6	266.31
9	177.53

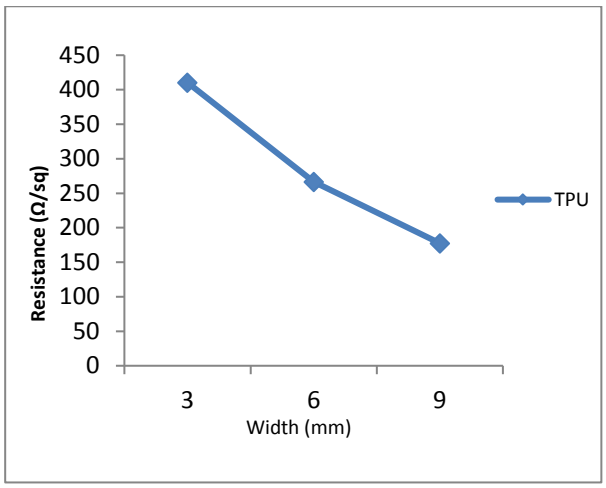

Figure 3.2: TPU as substrate

Based on graph in Figure 3.2, the pattern of the data of TPU is quite same with the glass slide data which is when the width of the ink increase,the reading of the sheet resistance will be the lowest. The pattern of the graph is constantly decreasing from the smallest width of conductive ink which is 3mm until the highest width taken as 9mm. As can be seen the highest sheet resistance is 410.39Ω/sq for width 3mm and the lowest sheet resistance is 177.5Ω/sq.

4. SUMMARY

The purpose of this study is to investigate the effects of line width cross-sectional geometry to stretchable printed. Obviously the decreases trend appears when width of ink increase. It can conclude that when the width of the ink increasing, the sheet resistance obtain will be decreasing.

REFERENCES

[1] Huntsman (2010).“A guide to thermoplastic polyurethanes (TPU),” *Huntsman*, p. 26.

[2] S. S. Bhore (2013).“Formulation and Evaluation of Resistive Inks for Applications in Printed Electronics,” pp. 1–94.

[3] A. Dipl, R. Dietrich, and D. J. Tekath, “Report 148 : Carbon-conductive inks – Fields of application and potential for rationalisation and cost reduction.”

[4] C. Phillips, A. Al-Ahmadi, S. J. Potts, T. Claypole, and D. Deganello (2017), “The effect of graphite and carbon black ratios on conductive ink performance,” *J. Mater. Sci.*, vol. 52, no. 16, pp. 9520–9530.