FUNCTIONALITY AND RELIABILITY ASSESSMENT ON CONDUCTIVE INK FOR WEARABLE APPLICATIONS

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ABSTRACT: This paper represents the functionality and reliability assessment on conductive ink for wearable applications. Basically, the assessment on conductive ink is very new around the world. There is too little open literature discusses on this particular area. Therefore, this project is a very interesting area to be further discussed. In addition, electronics components are continued to be developed with smaller size, smarter and powerful due to functionality and computationally. According to this opportunity and challenges, it can arise and that push the creativity of researchers to provide very small but powerful electronics products with desirable functionality in a convenient package. The wearable electronics basically have been developed but it is still fail to capture and counter the widespread of usage because it is physically grid, bulky and also lack of computational and functional capabilities. Because of that, this project namely as mechanical and electrical comprehensive assessment on conductive ink are developed to counter measure all the problems stated and finally, one comprehensive conclusion can be make on mechanical and electrical capabilities of conductive ink.

KEYWORDS: *Functionality test; reliability test, conductive ink, wearable applications.*

1.0 INTRODUCTION

From the open literature, there are many countries all over the world including Southest East Asia are now focusing and increasing the research on conductive ink, in order to gain its performances and finally it can be used and applicable for various applications such as electronic packaging (Zhang et al., 2016). Nevertheless, it is an ever increasing need to develop and produce the conductive inks formulation with new characteristics demanded from the customers. Most of the researchers had been agreed there are few characteristics should be follow for new electronics such as environmental friendly, low cost, long-time endurance, lower energy consumption will be used, simple method to fabricate, higher efficiency and most importantly can be used in various electronic components.

In order to meet the requirement, researhers should used their efforts to come out the new manufacturing techniques and also the new advanced materials method. All of these have been solved by researchers where the promising manufacturing techniques for printing the conductive ink has been developed, and also recognized worldwide. Polymer materials had been choosen as a main materials in order to make sure the ink is more flexible and stretchable. The fillers of conductive ink is from metallic materials such as silver, gold, copper and many more. In addition, this fillers must be in nano-size to make sure it is suitable for mixing and printing. Binders will be add on to this fillers. The main objective using this binder is to mix the fillers and finally become the conductive ink. Besides that, the usage of binders is to make sure the conductive ink is more flexible and stretchable.

The long term of functionality and reliability of conductive ink also been measured and evaluated. The functionality and reliability due to environmental has been conducted previously (Merilampi, 2009). All of these studied are encouraging due to good environmental tolerance of conductive ink. The objective of these study is to evaluate and investigate the mechanical and electrical performance of commercial ink by using screen printing technique. At the end of this study, the researhers found certain parameters is very important to optimize the ink properties for long-time endurance (Caglar et al., 2008; Karttunen et al., 2008).

Therefore, this paper represents the functionality and reliability assessment on conductive ink for wearable applications using mechanical mechanism theory. This paper also encouraged to evaluate and examine mechanical and electrical performance of conductive ink using new design of test rig. The stretchable, flexible and bending tests will be stimulated by applying continuos cycle of rotational loads using uniform speed. All of these test rig were developed in lab scale prototype including product design, fabrication and testing.

2.0 BASELINE CONDUCTIVE INK

All the conductive ink samples prepared with different manufacturing paramenters and composition. A nanoflakes filler with approximate surface area of 500 m*m per gram was used, and epoxy resin as a binder. The basic composition of this sample shown in Table 1. Then, the baseline conductive ink using nanoflake materials was printed in glass slice and shown in Figure 1. Three rectangular samples were printed and each of them have 3 mm width. In addition, three selected points have been chosen at the center, top and bottom of the ink. These three points basically represents the ink distribution along the line and also averaging the characteristic of the ink, respectively. According to this samples, the electrical properties of the ink were evaluate using four-point probe. Based on the observation, by increasing the filler, the resistivity level of ink was poor, and it means the conductivity of ink were rapidly increased. All the results have been recorded and Sample C was chosen for further investigation using the comprehensive assessment. Sample C was chosen because the filler is less but the conductivity is good compare Samples D to I. Then, composition of Sample C was printed on polyethylene terephthalate (PET) and thermoplastic polyurethane (TPU), and shown in Figure 2.

Table 1: The composition of conductive ink

Sample	**Filler (%)**	**Binder (%)**	**Total (%)**
A	10	90	100
B	20	80	100
C	30	70	100
D	40	60	100
E	50	50	100
F	60	40	100
G	70	30	100
H	80	20	100
I	90	10	100

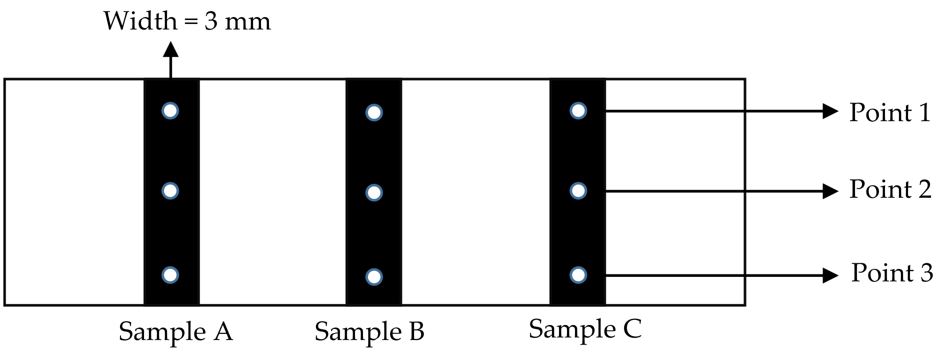


Figure 2: Baseline of conductive ink

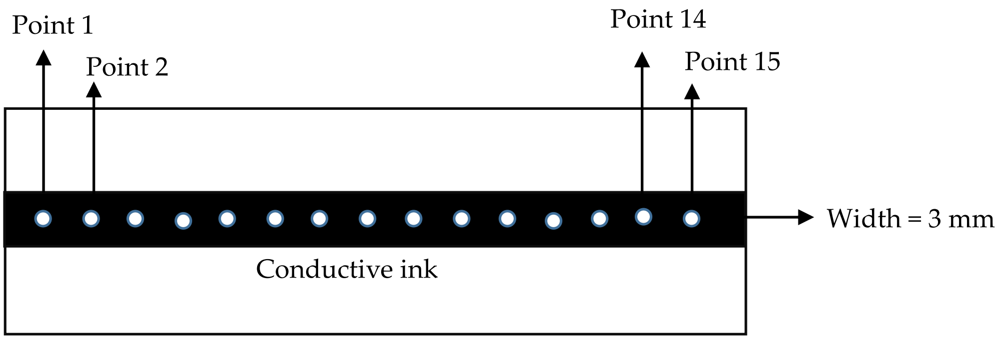


Figure 3: Conductive ink printed on TPU and PET

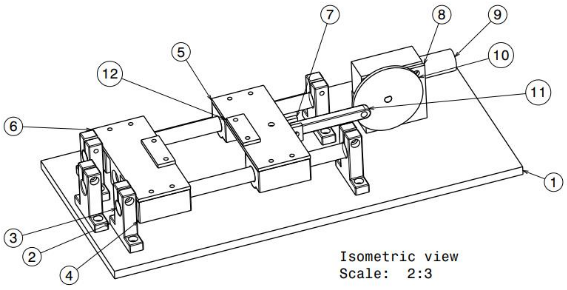
3.0 MECHANICAL MECHANISM TEST RIG

This section elaborate on the wide usage of rotary equipment and the necessity of the testing of the comprehensive assessment of conductive ink. The testing system for conductive ink is very new around the world. There is too little open literature discusses on this particular area. Therefore, it is a very interesting topic to be further discussed. Recently, electronics components are continued to be developed with smaller size, smarter and powerful computationally and functionally. An oppurtunity and challenges are continued to arise and that push the creativity of researhers to provide very small but powerful electronic products with desirable functionality in a convinient package. The wearable electronics have been developed but it is still fail to capture and counter the widespread of usage because it is physically rigid, bulky and also lack of computational and functional capabilities.

Flexible and stretchable conductive ink and it is 100% wearable and suitable for electronic circuit. The conductive ink is basically the combination of filler and binder, and mostly filler is from metallic materials and binder is from polymer. The polymer itself should be made from thermoplastic elastomers, which allow the metallic filler to be combined and dipersed. From other point of view, this polymer also allows the ink to become an electrical circuit, which can be stretched and flexibled when force is applied and released, and returns back to the origin

Generally, conductive ink can be made with flexible and stretchable characteristics. Both flexible and stretchable wearable systems' performance can be tested by using conductive ink with substrate. The conductive ink is basically used as a circuit for processing logic, memory, input and output devices or communication devices in electronic packaging. In simple ways, conductive materials are used as an interconnect agent for one or more of the other circuit components. All the circuit components are attached to the ink permanently. This attachment allows wearable activities such as flexible and stretchable and finally it becomes more interactive electronic device.

Figure 4 shows the detailed design of stretchable system test rig. Conductive ink sample on substrate is positioned on the platform and clamp at both end of the sample. One end will be fixed and the other one is free boundary condition. These two boundary conditions are chosen to make sure the stretchable condition can be applied to the conductive ink Then, one electric motor, which is attached at the base will be powered from 12V power source. This motor is used to move the circular wheel and it is connected with the rod to make it moves forward and backward. This motion will move the free boundary end of the sample and its stretchability performance is observed by stretching the sample repetitively. Figure 5 shows the actual stretchable system test rig.

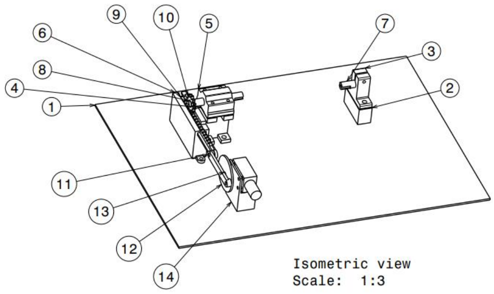


Quantity	Part Number	Number
1	Part1	1
5	linear rail guide support	2
2	rod 8mm	3
4	linear bearing	4
1	connecter linear bearing	5
1	connector linear bearing front	6
1	connector rod	7
1	motor holder	8
1	motor	9
1	wheel	10
1	rod	11
2	clamp	12

Figure 4: Detailed design of the stretchable system test rig

Figure 5: Stretchable system test rig

The detailed design of flexible systems test rig is shown in Figure 6. The sample is fixed at both ends with the clamps. One end of the clamps is connected with the gear. This gear is then interconnected with linear gear and attached to the circular wheel. This circular wheel is rotated by using one electric motor that is powered using 12V power source. The movement of the circular wheel will cause the sample to have twisting motion. This motion is observed to determine the flexibility performance of the conductive ink sample. Figure 7 shows the actual flexible system test rig.



Quantity	Part Number	Number
1	BASE_FLEX	1
1	step	2
1	guide rail	3
1	base_for_bearing	4
1	linear_bearing	5
1	rail linear gear	6
1	CLAMP_ROD_30	7
1	CLAMP_ROD_60	8
1	linear gear 1	9
1	gear 2	10
1	connecter 2	11
1	wheel	12
1	motor	13
1	motor holder	14

Figure 6: Detailed design of the flexible system test rig

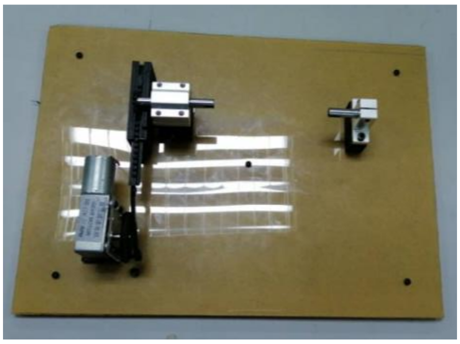


Figure 7: Flexible system test rig

4.0 CONCLUSION

Two test rig were developed to determine and analysis the mechanical behavior of conductive ink. This is the first and foremost developing test rig for stretchable and flexible conductive ink. Future assessment will be carried out focusing on mechanical behavior and also cyclic phenomenon.

5.0 REFERENCES

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