International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072

Effect of Corona Treatment on Spreading Behavior of UV Ink over Inkjet Printed Silver Nano-Particle Layer

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Abstract : *Corona treatment is referred as a surface modification technique that is used to impart changes in the properties of a surface. It uses low temperature corona discharge plasma to impart the changes or to modify the specific surface. Here, an attempt has been made to improve or to check to spreading behavior of UV ink over an inkjet printed silver layer. Also, a comparison has also been made between a dot printed on a corona treated silver layer and an untreated silver layer. To measure the effect of corona treatment, single dots were printed on a corona treated and untreated silver layer and measured in both horizontal and vertical direction. The circumference of the printed dot (With corona treated silver layer) was found to be more influenced by this. Even, corona treatment increased the surface roughness of the silver layer when it was compared to the non treated silver surface.*

Key Words: Corona treatment, Inkjet printing, Silver nano-particle ink, UV ink

1. INTRODUCTION

Inkjet process has always been used as a leading technology for printing of printed electronics. In addition, UV ink also has always been used for various applications. Today, it is also used in printed electronics devices where thin and homogeneous layer are foremost criteria. The devices like organic thin film transistors, light-emitting diodes, capacitors, solar cells, conductive structures, memory devices, sensors can be fabricated using inkjet technology [1, 2]. There has always been a requirement of improving the device and make it usable for more and more applications. In this paper an effort has been made to find the way to improve the spreading of UV ink with the help of corona treatment. So that, a thinner layer can help to achieve a great result in a printed electronic device; where, a thin layer is the foremost criteria to achieve an excellent result i.e. a parallel plate capacitor. Here, a silver nano particle layer was printed on a glass substrate and the comparison was made between an untreated silver layer and a corona treated silver layer. Corona treatment performed at 0.4 kW enhanced the surface roughness of the silver layer which resulted in enhancing the spreading of UV ink too.

The printer used for this work was Dimatix Material Printer 2831.. It is based on piezo inkjet technology. Within this work a drop volume of 10 pL was used to print silver nano-particle layer and UV dots. It has 16 individually controllable nozzles at 254 µm space. Ink is filled in cartridge with the help of a syringe and to compensate the viscosity of the ink, print head can be heated up to 70°C. [3].

1.1 Surface Treatment

To remove the foreign particles over the surface of the glass substrate, cleaning was done with the solvents such as acetone and ethanol. A fiber free tissue was first soaked in ethanol and wiped over the substrate to clean the dust particles attached on it. Then acetone was used to clean the substrate in the identical manner. Finally, compressed air was used onto to the substrate to dry the residual solvent. Usage of two different solvent makes the organic particle to come in contact with two different organic solvents and expose it to two different strength of solvent. The main purpose of subjecting the substrate with solvents is to prepare it, so that ink do not feather outward while printing. Therefore, no pin holes would immerge within the layer and the desired layer would be printed.

2. MATERIAL

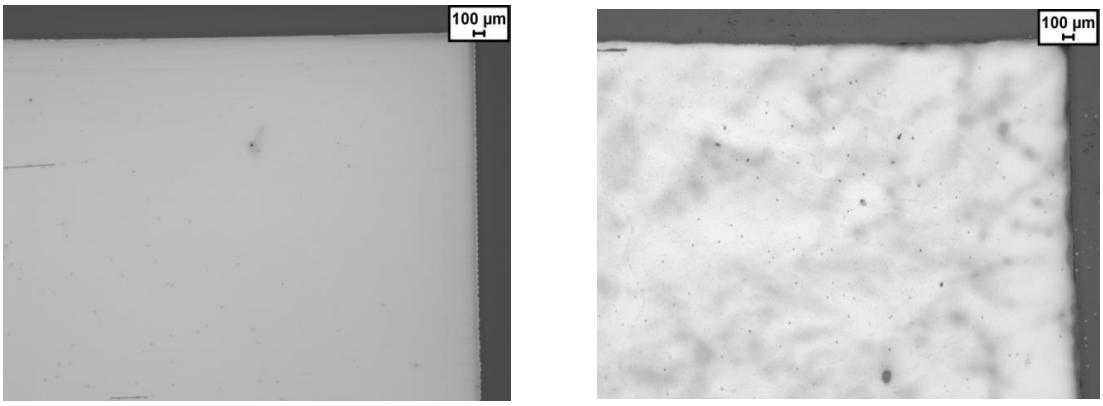
The silver layer was printed with silver nano-particle based ink from SunChemical (SunTronic EMD5603). This ink is inflammable and contains a value of 25 % to 60 % of Ethanediol and 25 % to 60 % of Ethanol as the prime solvents [4].

UV curable Hyperion Prowet ink from Tritron. This is a black ink which does not contain any Volatile Organic Compounds (VOCs) [5]. This ink was used to pattern the dielectric layer because it is cured instantly. It is named as UV ink in further sections.

3. METHOD AND RESULTS

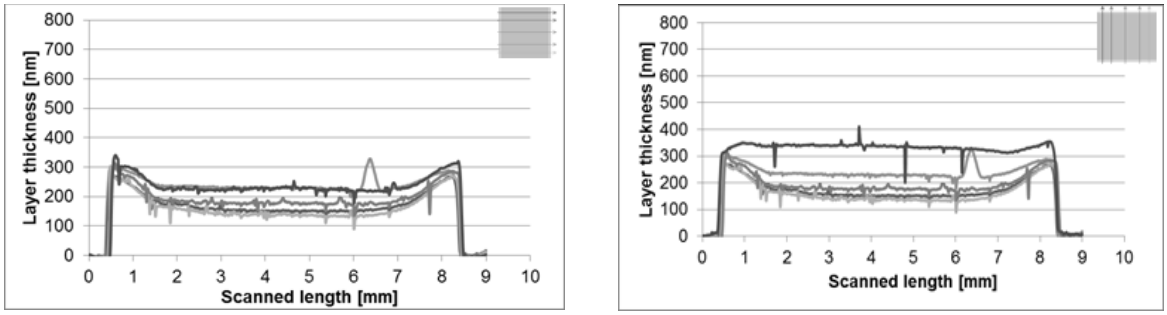
3.1 Silver Electrodes

The surface characterization for silver layer was performed with the help of Dektak 150. For the measurements, two silver layers were printed with a dimension of 8 mm in x direction and 8 mm in y direction on a glass substrate. One measurement was performed for corona pretreated and other for untreated silver layer. The roughness and thickness of the printed layers was measured by placing the test sample on the manual table with vacuum activated. The used stylus radius (an L shape needle) was 12.5 µm and the amount of force exerted by the stylus during the measurements was 3.0 mg. The resolution for the scanning was set at 3.0 µm per sample and the scanning length was set according to the layer dimensions. The scan duration was determined according to the adjusted scanning length and resolution per sample. The other parameter was measurement range, which was found optimum at 6.5 µm. All parameters were set and then the measurement was performed with the scan along and across the dimension of the silver layer. The scan was done five times along and five times across the print direction to get an average thickness of the silver layers. The corona pretreated silver layer and untreated layer can be seen with the microscopic images in Figure 1.



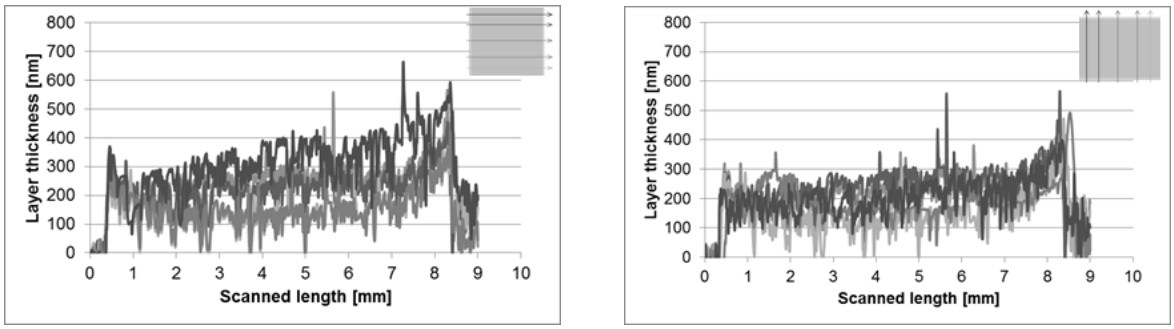
(a) (b)

Figure 1: Microscope images of (a) Untreated silver (b) Corona treated silver layer.



(a) (b)

Figure 2: The surface profile of the bottom silver electrode without corona pretreatment at a drop space of 25 µm in (a) print direction (b) across print direction; with representation of five scans from dark grey color to light grey color for first to last scan respectively.



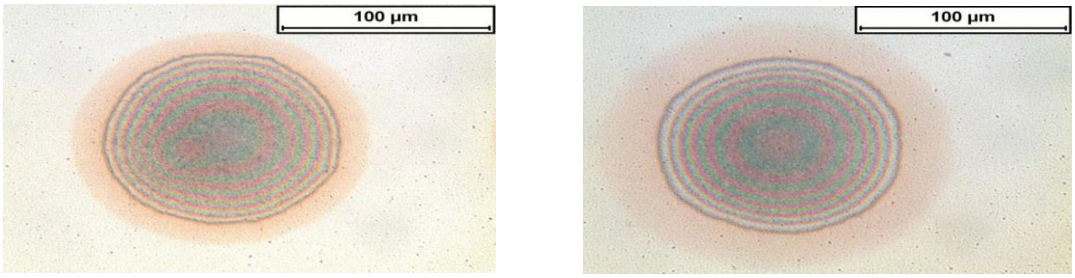
(a) (b)

Figure 3: The surface profile of the bottom silver electrode with corona pretreatment at a drop space of 25 µm in (a) print direction (b) across print direction; with representation of five scans from dark grey color to light grey color for first to last scan respectively.

The corona pretreatment was performed on the bottom silver electrode to enhance the surface energy. But, by analyzing the difference between the corona pretreated and untreated silver layer Figure 1, it could be concluded that the corona pretreatment deteriorates the silver's surface. The surface profile of both surfaces, along and across the print direction can be seen in Figure 2 and Figure 3 respectively. Dark grey color of the profile is representing the very first scan of the layer and the lightest gray color represents the fifth scan of the layer. Also, the surface of corona pretreated layer was found in-homogenous than untreated silver layer. The reason for the rougher surface can be the diminishing of the silver electrode due to the corona pretreatment which created peaks in the measurements. Figure 2 (b) also shows that the layer had thicker surface (first scan in dark grey color) than other scans performed in the same direction. On the other side, Figure 3 shows a certain increase in the scans from left to the right side of the layer. Also, more peaks were observed in right side of the layer in both directions. This problem can arise if the printed layer has rougher surface (corona pretreatment) in right side than left. From the surface profile of both the layers, it was found that the pretreated layer is rougher than untreated one. The peak points were occurring more in the pretreated layer and showed a lot of variations. To find the average height of the printed layer, an average of the nominal heights of the curves were calculated. The found average height for the untreated silver layer was 200-300 nm (with surface roughness of 35 nm) and for pretreated layer the obtained average height was 300-400 nm (with surface roughness of 72 nm).

3.2 UV Ink Measurements

To measure the effect of corona pretreatment, ten single drops were printed on untreated silver and corona treated silver electrode Figure 4. These drops were cured for 3 seconds with UV radiation. A time interval of 15 seconds was provided between the printing and curing activity. The dot dimensions were measured in both directions, vertical and horizontal. An average of the dimension for corona pretreated sample was calculated, which are (173 ± 11) µm and (159 ± 7.6) µm in horizontal and vertical directions respectively. Also, the measured average dimension for an untreated sample in horizontal and vertical directions was calculated, which are (148 ± 14) µm and (159 ± 7.6) µm respectively. Circumference of the dots was found to be more influenced by the corona pretreatment phenomenon. Circumferential spreading of the dot at corner of untreated silver (12 µm) was half the value of treated silver (24 µm). Thus, it can be concluded that the corona pretreatment influences the spreading behavior of the drop and lets the opportunity for the ink layer to spread more at circumference.



(a) (b)

Figure 4: Drop test on (a) untreated silver and (b) corona treated silver.

4. CONCLUSION

In this paper the effect of corona treatment has been realized over a corona treated silver layer. It has been found that corona treatment has been affected the spreading behavior of the dot and circumferential area of the printed dot. Corona treatment has also influenced the surface characteristics of printed silver layer. Corona treatment deteriorated the silver surface and increased the roughness of the silver layer. The found average height for the untreated silver layer was 200-300 nm (with surface roughness of 35 nm) and for pretreated layer the obtained average height was 300-400 nm (with surface roughness of 72 nm).

Average heights of printed UV dots were measured in both horizontal and vertical direction. The measured average height for corona pretreated UV sample was (173 ± 11) μm and (159 ± 7.6) μm in horizontal and vertical directions respectively. Also, the measured average dimension for an untreated UV sample in horizontal and vertical directions was (148 ± 14) μm and (159 ± 7.6) μm respectively. Circumference of the dots was found to be more influenced by the corona pretreatment phenomenon. Circumferential spreading of the dot at corner of untreated silver (12 μm) was half the value of treated silver (24 μm). Thus, it can be concluded that the corona pretreatment influences the spreading behavior of the drop and lets the opportunity for the ink layer to spread more at circumference.

5. REFERENCES

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