Ink-Jet printed platinum counter electrodes for dye-sensitised solar cells

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Ink-Jet printed Platinum Counter Electrodes for Dye-Sensitised Solar Cells

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1. Introduction

Ink Jet printing (IJP) has been applied extensively to the Graphics industry over the last five decades. Recently the application into printed electronics has grown as it offers a facile, cost effective and environmentally friendly approach for deposition of materials.

Dye solar cells (DSC) have gradually increased in performance since their inception in 1991, however to compete with Silicon solar cells, DSCs need to be cost effective and environmentally friendly.

Applying IJP to DSCs offers a cost effective, environmental, facile manufacturing and highly tuneable process for deposition of DSC components. Here we investigate the ink jet printing of Platinum as a counter electrode for DSC.

2. Ink Jet Printing Drop-on-Demand

Our ink jet printer utilises 16 piezo-actuated nozzles which when controlled by a voltage waveform allows for drop-on-demand printing.

As illustrated in Figure 1, the voltage waveform influences the shape of the piezo-element there by influencing the pressure within the cavity. A low voltage (1) draws ink into the chamber. High voltage (2) pushes ink out through the nozzle. By relaxing the voltage (3) in steps the drop shape can be tailed off and snapped to form a droplet.

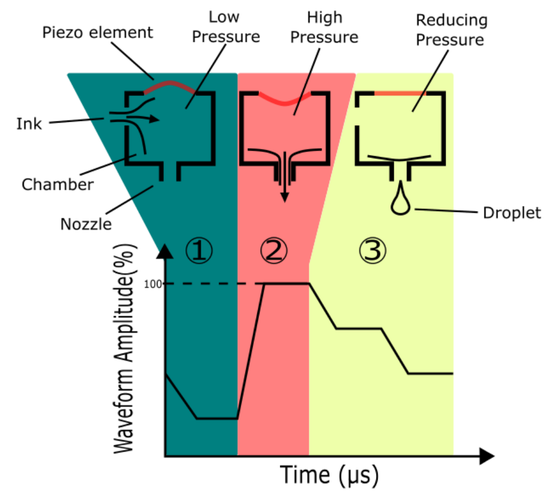

Figure 1. Drop-on-demand voltage waveform effect on Piezo-element and drop formation

3. Ink Jet Printing Platinum Ink

Platinum ink formulated by Ceimig was printed onto Fluorine doped Tin Oxide (FTO) coated glass substrate for application in DSCs.

The Z-number is a dimensionless number which is used to determine whether an ink is printable. This is defined in equation 1.

Figure 2 (A) illustrates the viscosity measurement, (B) surface tension and (C) contact angle of the ink fluid on FTO glass. From this data it was determined that the ink fluid is ink jet printable.

$$Z = \frac{\sqrt{\rho\sigma L}}{\mu}$$

(Equation 1)

Viscosity (μ)	= 10.802 mPa·s
Density (ρ)	= 0.95 g/ml
Surface Tension (σ)	= 31.47 mN/m
Contact angle	= 14.6 ± 0.09
Z-number	= 2.35

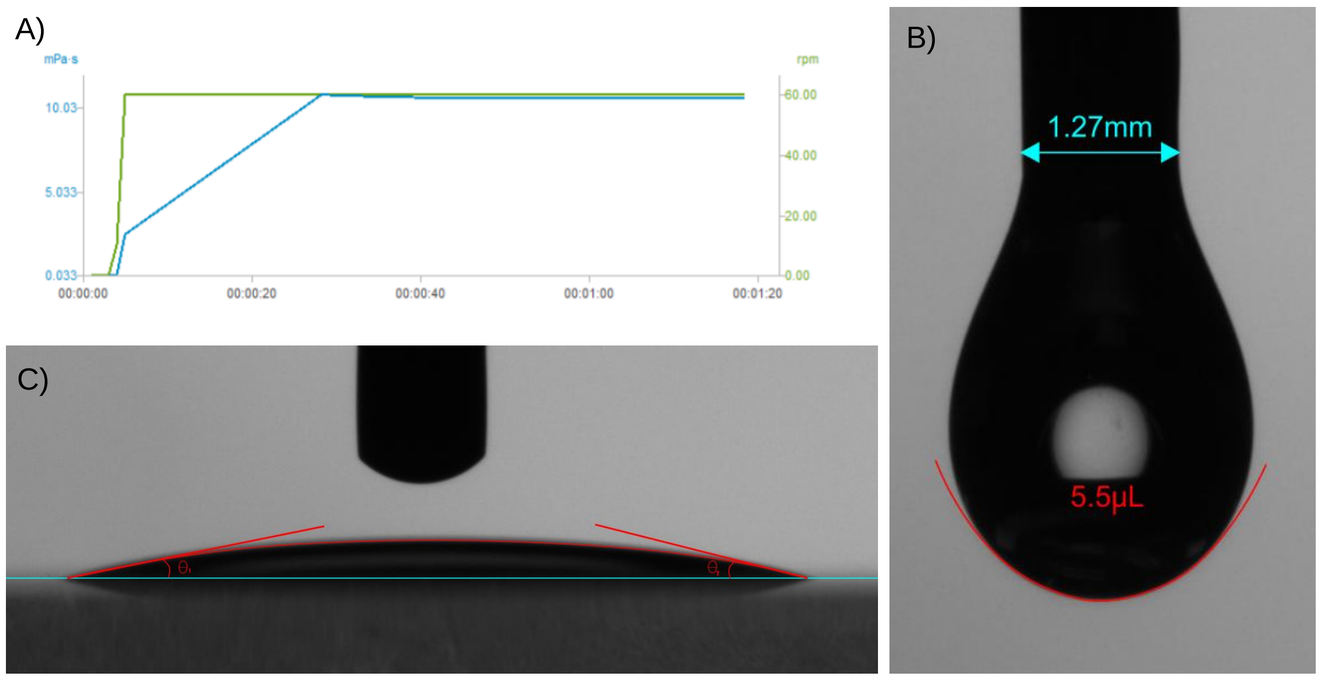

Figure 2. (A) Viscosity measured with Anton Paar Viscometer, (B) Pendant drop of Pt ink and (C) Sessile drop of Pt ink on FTO-glass showing high wettability, hysteresis of contact angles is illustration of a rough substrate surface.

4. DSCs with Ink Jet Printed Pt Counter Electrodes

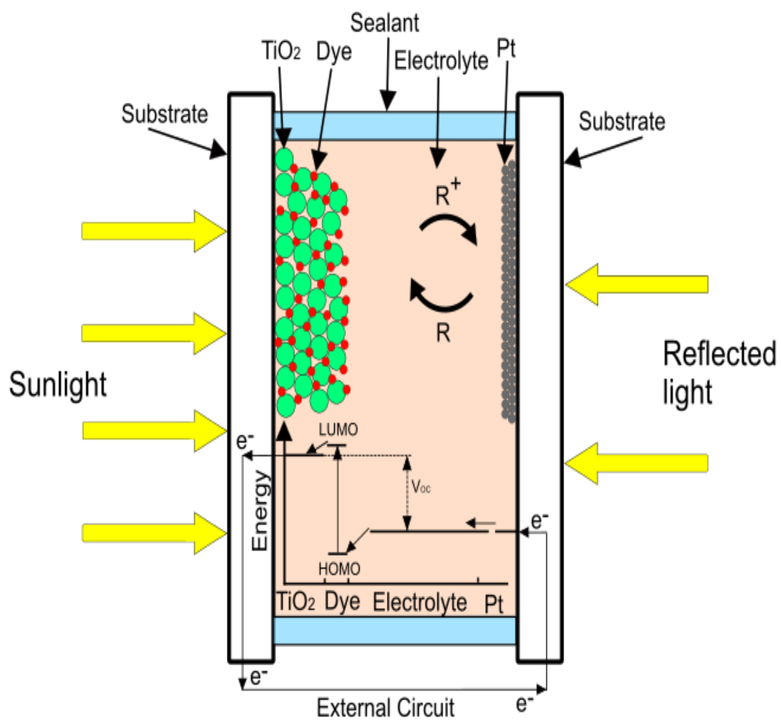

Figure 3. Diagram illustrating the workings of a Bifacial DSC.

In a DSC sunlight is absorbed by dye molecules exciting the electrons into a higher state where they are easily transferred to the TiO_2 conduction band. Electrons are returned to cell from an external circuit at the counter electrode (Pt) where a redox reaction occurs with electrolyte transferring electrons back to dye molecules (Figure 3).

DSCs are fabricated by depositing a mesoporous layer of TiO_2 which is then immersed into a Dye Sensitiser. The cathode is typically a Pt-sputtered thin film. These electrodes are sandwiched together and sealed with a low temperature thermoplastic and filled with an electrolyte (Figure 4).

Ink Jet printing Pt thin films for a DSC cathodes offers a facile method to produce intricate film with varying thicknesses by printing multiple layers and low wastage of expensive materials such as Pt due to the drop-on-demand printing process.

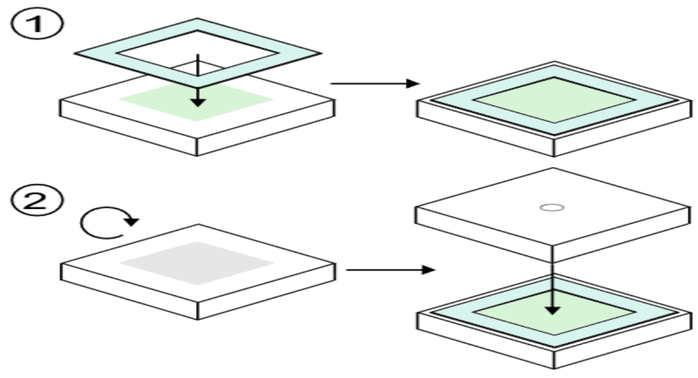

Figure 4: Sandwiching of electrodes, green film represents TiO_2 and grey Pt.

5. Conclusions

- Ink jet printing offers facile method with low waste to deposit patterned thin films of varying thickness by utilising drop-on-demand technique and the ability to print multiple layers sequentially.
- Ink jet printing can further improve the environmental friendliness and low cost of manufacturing DSCs by reducing waste of expensive and rare materials.

Acknowledgements

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