

Properties of high-performance solution-processed transparent thin film transistors

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ABSTRACT

Thin film transistors (TFTs) based on metal oxide semiconductor hold great promise for the future in the field of electronics, optics and sensors. Manufacturing of TFTs can be conducted at low temperatures onto flexible substrates from solution based precursors. The various precursors are either soluble or dispersible in water or organic solvents and a variety of deposition techniques can be deployed such as by spin-coating or aerosol deposition.

Herein, the manufacturing of TFTs onto an aluminum oxide (Al_2O_3) ultrathin dielectric is reported. The active layer semiconducting material (ZnO) was deposited by spray-pyrolysis technique, using an organic precursor solution of zinc acetate di-hydrate in methanol.

EXPERIMENTAL DETAILS

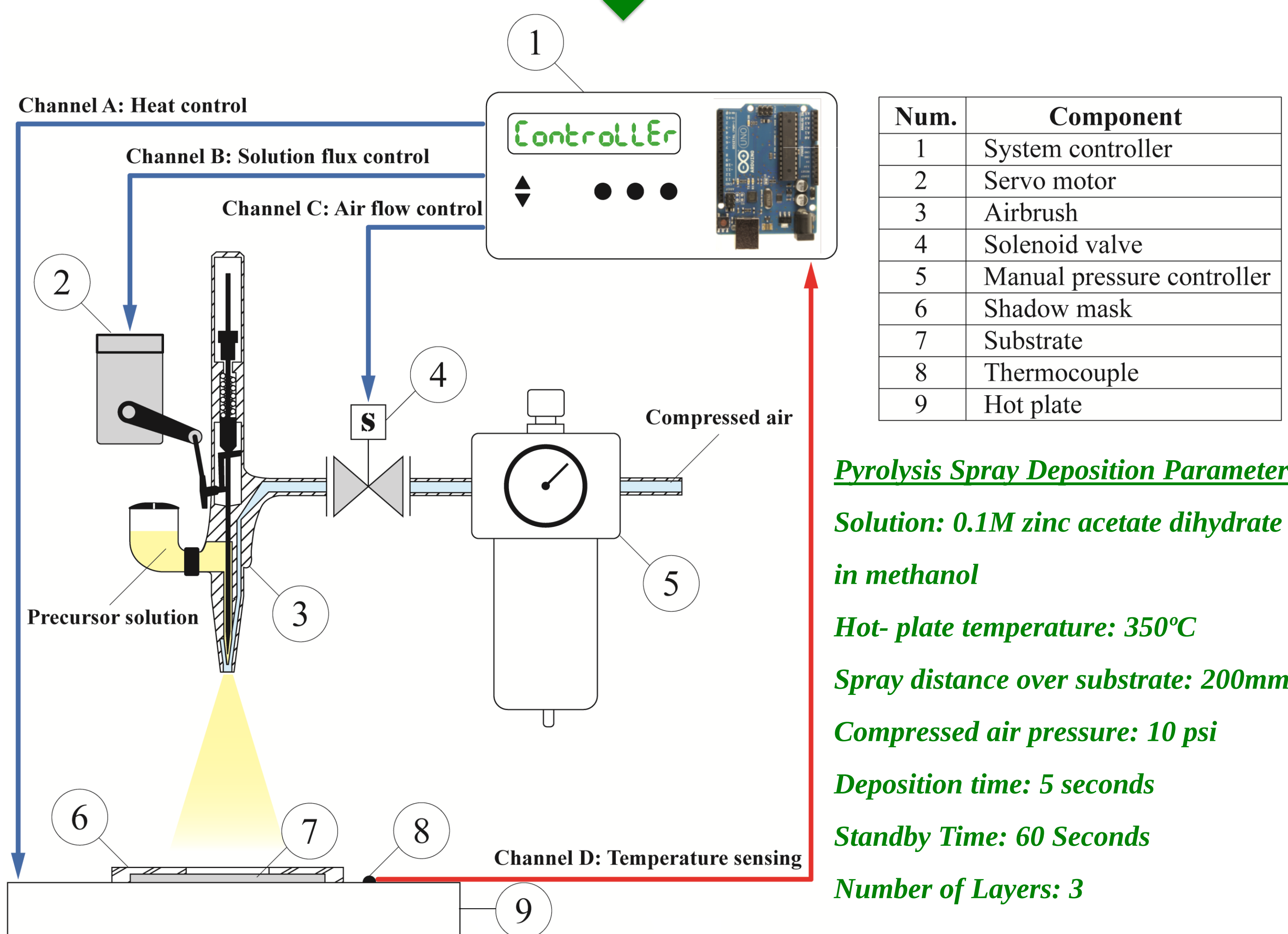
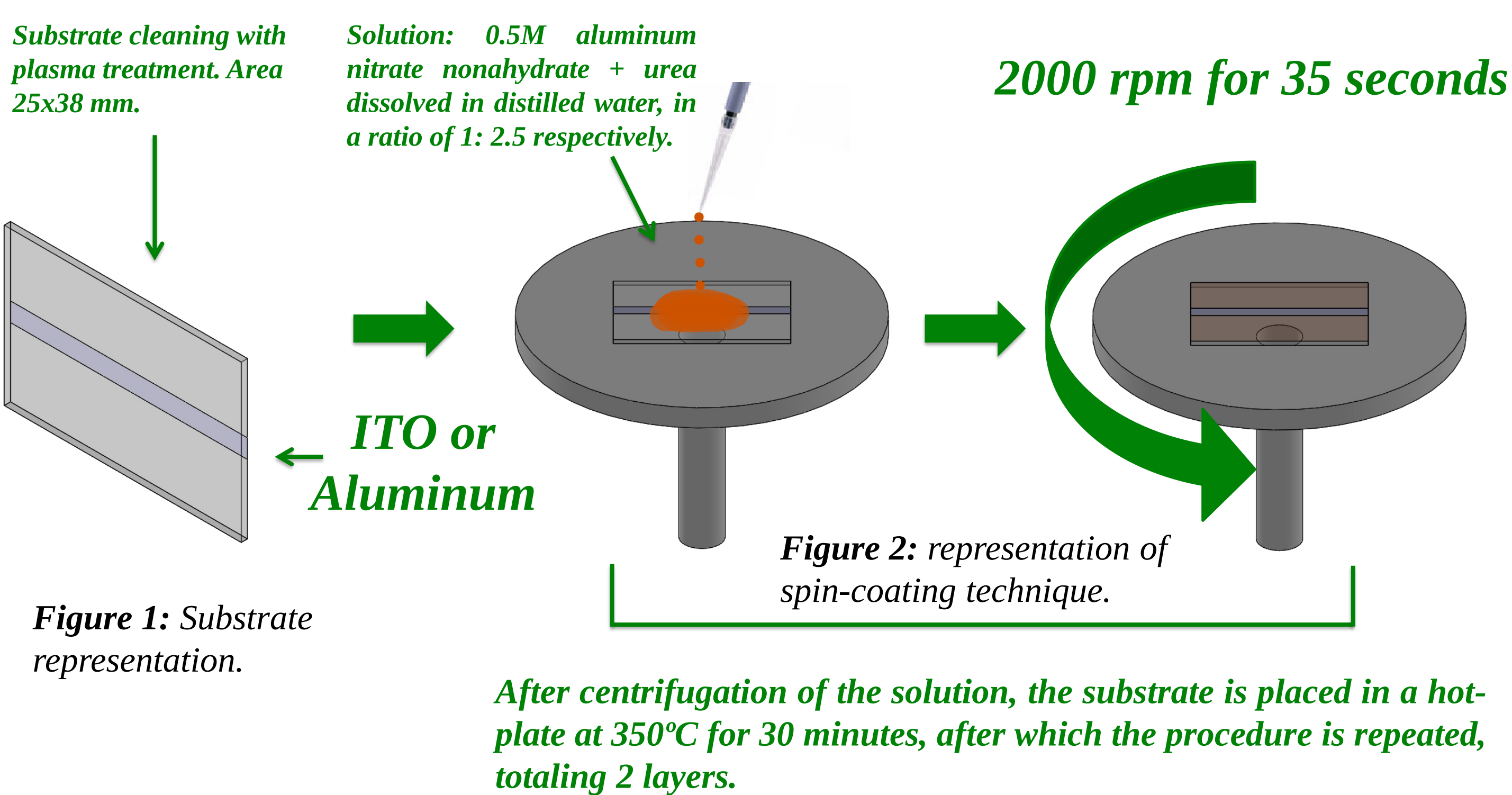


Figure 3: Schematic of the thin film spray deposition method.

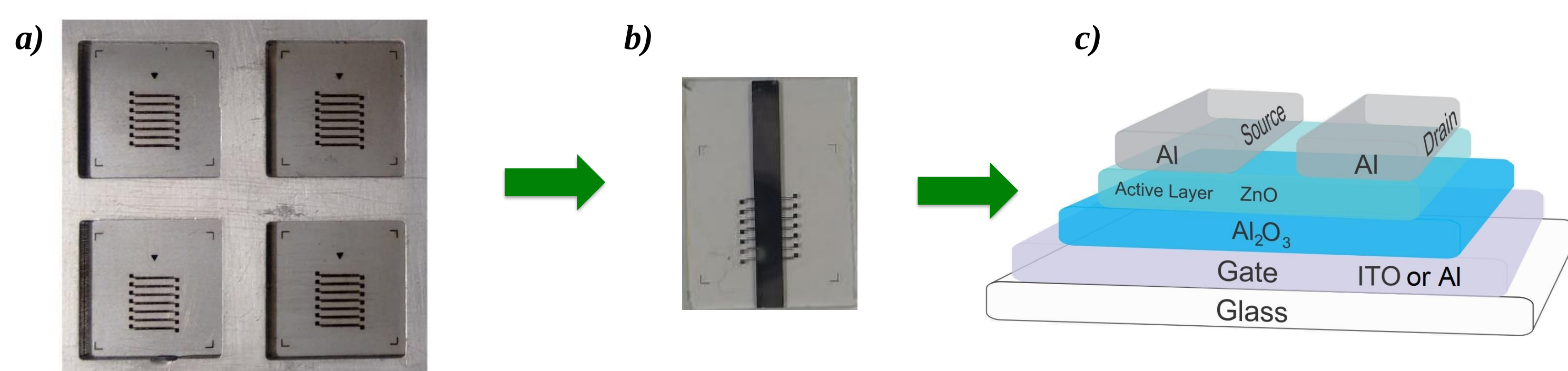


Figure 4: a) Image of the mask used for thermal evaporation of the drain and source aluminum electrodes; b) Photograph of the finished sample, containing seven TFTs; c) The structure (bottom-gate / top-contact) of a single TFT of the sample.

RESULTS AND DISCUSSION

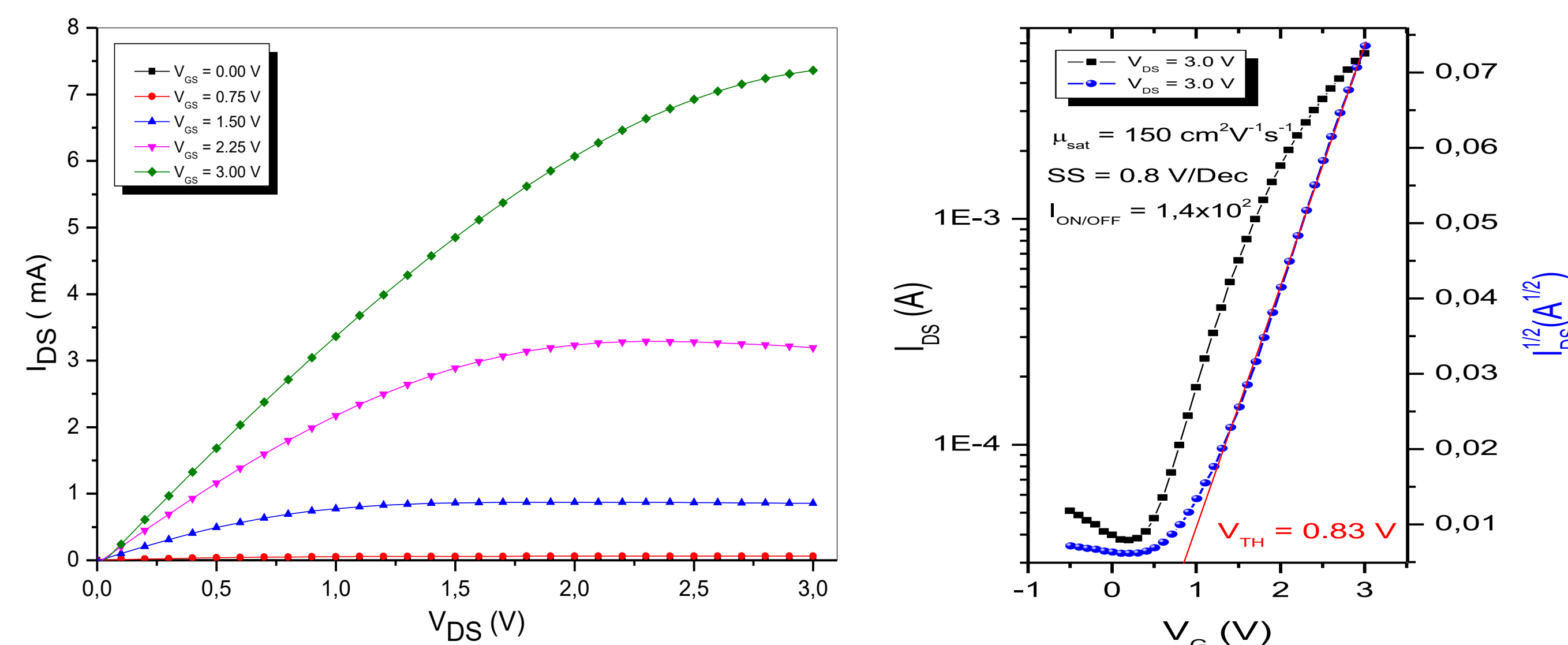


Figure 5: a) Output curve graph; b) Transfer curve graph. TFT with active ZnO layer and Al_2O_3 dielectric on ITO/glass substrate.

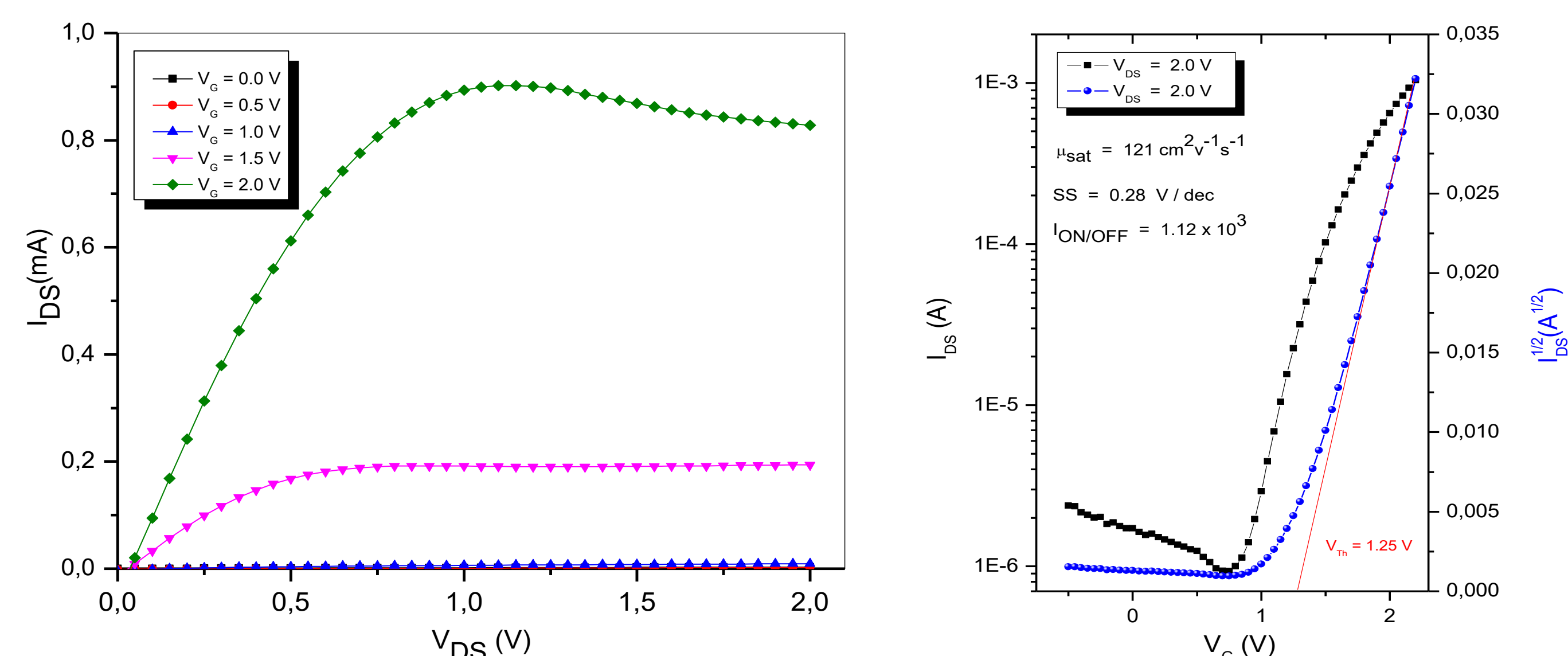


Figure 6: a) Output curve graph; b) Transfer curve graph. TFT with active ZnO layer and Al_2O_3 dielectric on Al/glass substrate.

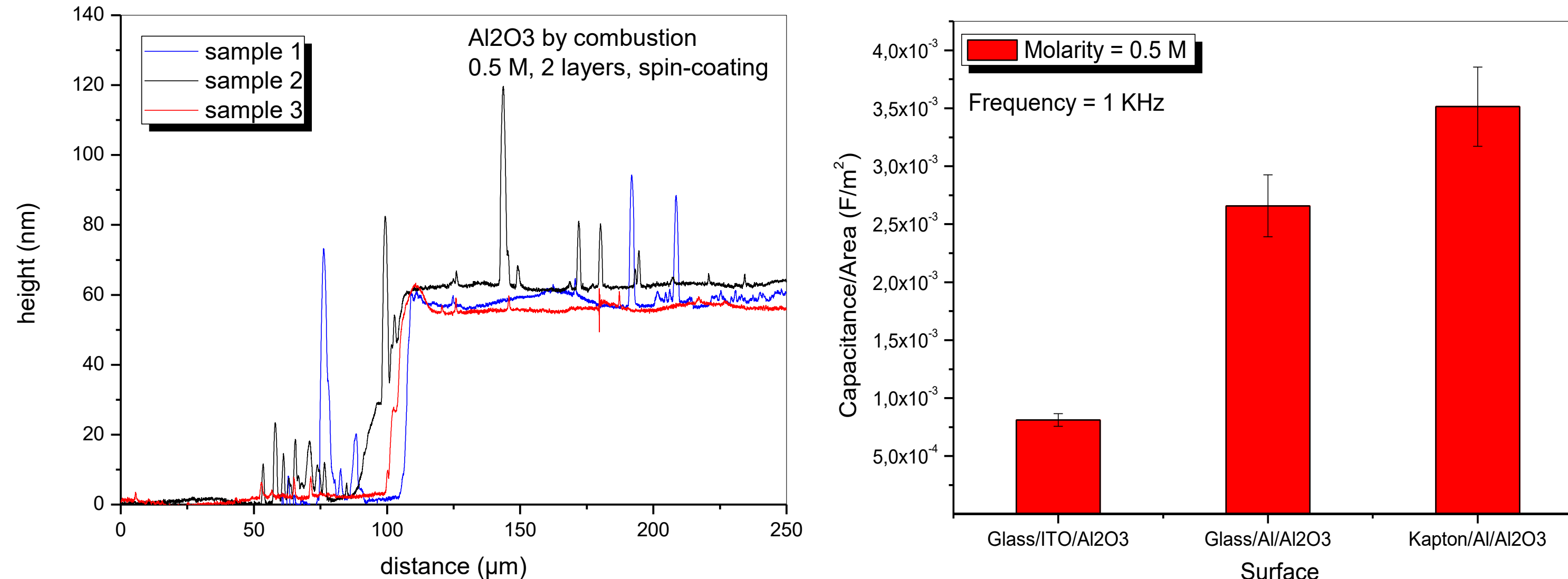


Figure 7: a) Profilometry scan of Al_2O_3 film thickness deposited on glass substrate in different regions, showing an approximate thickness of 60 nm; b) Graph capacitance by area for different substrates.

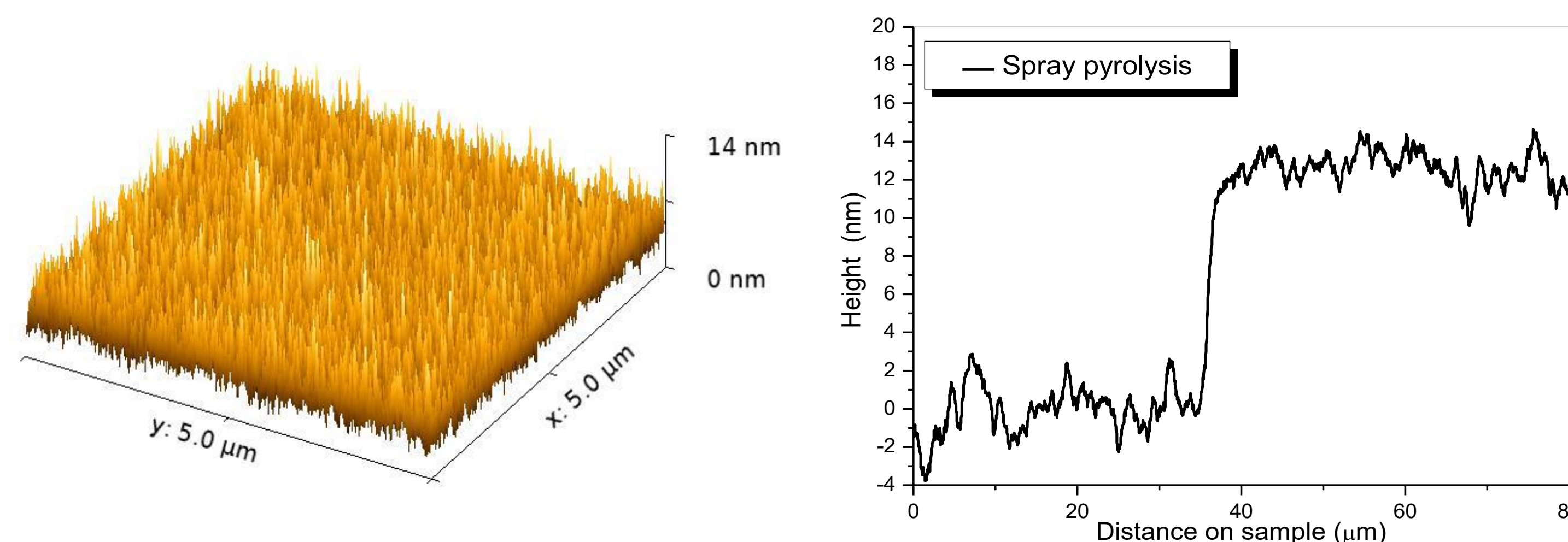


Figure 8: a) AFM image of ZnO thin film prepared via spray pyrolysis deposition; b) Profilometry scan of ZnO film thickness deposited on glass substrate, approximate thickness of 13 nm.

CONCLUSIONS

The present study shows results of μ_{sat} greater than $120 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$, $I_{\text{ON/OFF}}$ around 10^3 , SS around 0.3 V/dec and V_{TH} around 0.8~1.2 V, which can be compared with the best literature results using the ZnO as active layer in TFT. The work shows that the performance of the TFTs (μ_{sat} , $I_{\text{ON/OFF}}$, SS and V_{TH}) depends a lot on the deposition surface, in this work ITO/glass and Al/glass were used. Importantly, the devices operate at low voltage (below 3 V), being an ideal voltage for applications in transparent digital circuits. For future work, the TFTs will be applied as a NOT port in a ring oscillator circuit. The ring oscillator is composed of an odd number of NOT ports in a ring whose output fluctuates between two voltage levels (true or false), enabling possible applications in transparent digital logic circuits.

Acknowledgements

