# Solution Based Thin Film Transistors: From Lab To Fab

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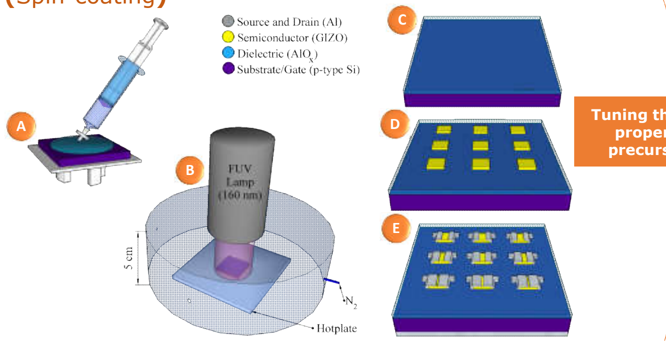
## Introduction

Amorphous metal oxides by solution processes have lately been used as an option to implement in flexible electronics, because it allows a reduction of the production costs. For that a substantial effort has been made to optimize both insulator and semiconductor layers in order to achieve enhanced performance/stability. This condition opens the possibility of moving from LAB to FAB processes.

This work aims to evaluate the progression from the simplest technique, spin-coating (Lab process) to inkjet printing (Fab process). Using spin-coating, great performance was achieved in indium–gallium–zinc-oxide (IGZO) TFTs with solution-based aluminum oxide ($AlO_x$) at low temperatures (150 °C) assisted by UV exposure [1]. In terms of semiconductors IGZO is the most widely used, due to its enhanced and stable electrical performance when compared with indium free metal oxides. Nonetheless, environmental demands require alternatives that rely on abundant and non-toxic elements. Zinc–tin-oxide (ZTO) is a good indium and gallium free alternative and promising results have been obtained with solution-based ZTO TFTs at 250 °C using spin-coating [2]. Precursor materials of $AlO_x$ and ZTO were used to develop a suitable ink for inkjet printing and preliminary results at 350 °C were very promising.

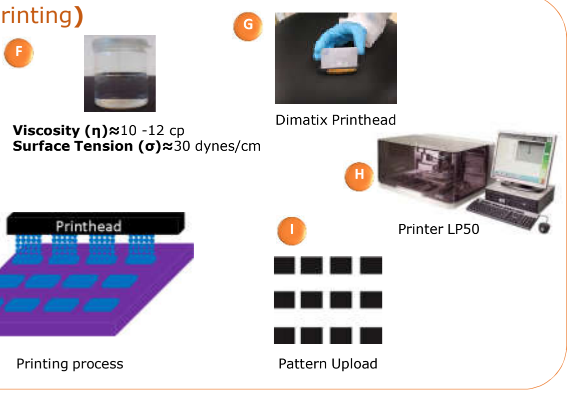
## Experimental Methods

### LAB (Spin-coating)



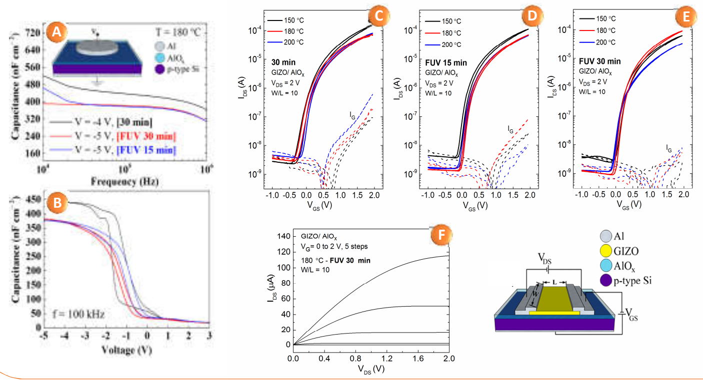

**Tuning the rheological properties of the precursor solution**

### FAB (Inkjet printing)

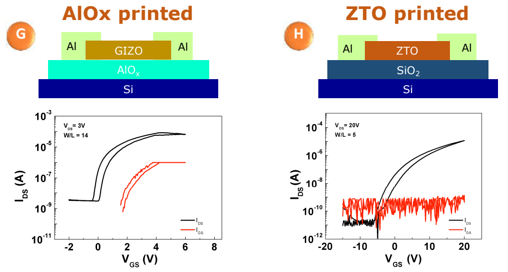



## Results

### Effect of Far Ultraviolet exposure in LAB devices




### AlOx printed / ZTO printed




| | Samples | T (° C) | $V_{ON}$ (V) | $V_{TH}$ (V) | S (V dec$^{-1}$) | $I_{ON}/I_{OFF}$ | Hysteresis (V) | $\mu_{SAT}$ (cm$^2$ V$^{-1}$s$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| LAB | E | 150 | -0.09 | 0.16 | 0.12 | $10^4$ | 0.07 | 14.10 |
| | | 180 | -0.14 | 0.17 | 0.10 | $10^5$ | 0.07 | 18.87 |
| | | 200 | -0.25 | 0.06 | 0.11 | $10^4$ | 0.03 | 10.64 |
| FAB | G | 350 | 0 | 0.16 | 0.16 | $10^4$ | 0.3 | - |
| | H | 350 | -6.25 | -1.66 | - | $10^5$ | 1.56 | 0.02 |

## Conclusions

- ❑ FUV irradiation improved the densification of the films in LAB process.
- ❑ GIZO/$AlO_x$ TFTs fabricated at 180 °C combined with FUV irradiation for 30 min exhibited excellent electrical characteristics with a saturation mobility of 18.87 cm²/V·s, a subthreshold slope of 0.10 V/dec and a turn-on voltage of -0.14 V.
- ❑ Next step will be combine FUV with thermal annealing to decrease the temperature during thin films production in FAB process. In this conditions will be possible apply in flexible electronics.

## References

[1] Carlos E, Branquinho R, Kiazadeh A, Barquinha P, Martins R and Fortunato E 2016 UV-Mediated Photochemical Treatment for Low-Temperature Oxide-Based Thin-Film Transistors *ACS Appl. Mater. Interfaces* **8** 31100–8

[2] Salgueiro D, Kiazadeh A, Branquinho R, Santos L, Barquinha P, Martins R and Fortunato E 2017 Solution based zinc tin oxide TFTs: the dual role of the organic solvent *J. Phys. D. Appl. Phys.* **50** 65106

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