COMBUSTION SYNTHESIS: APPLICATION IN OXIDE ELECTRONICS

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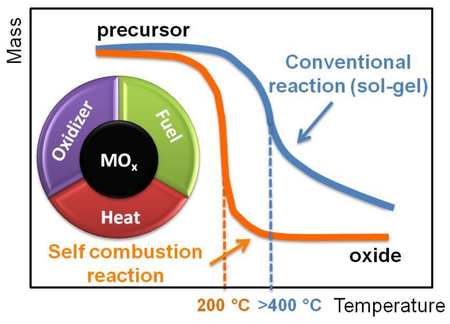
INTRODUCTION

Oxide based electronics have been well established as an alternative to silicon technology. The possibility to deposit the materials by low cost techniques such as inkjet printing has drawn tremendous interest in solution processible materials for electronic applications.

Solution combustion synthesis relies on an exothermic reaction that can convert precursors into oxides at low process temperatures.
It has been applied for semiconductor oxides based on ZnO, In_2O_3, SnO_2 and also for high κ dielectrics (Al_2O_3 and HfO_2).
The properties of produced thin films are highly dependent on the precursor solution.

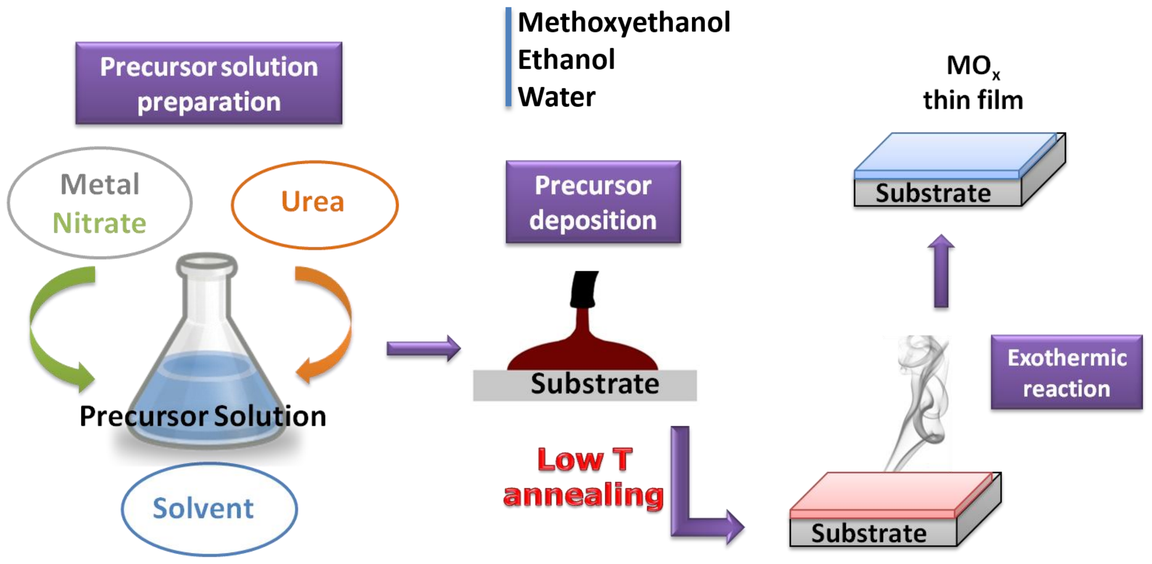


In this work the influence of several processing parameters; organic fuel, solvent and annealing temperature were studied. High performance devices are obtained and the results clearly show that solution combustion synthesis is becoming one of the most promising methods for low temperature flexible electronics. [1–4]

MO_X COMBUSTION SYNTHESIS

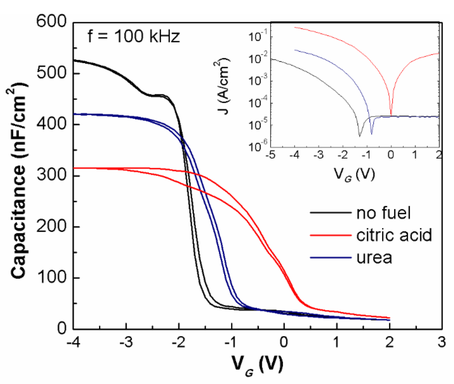
$$M(NO_3)_x + CO(NH_2)_2 \xrightarrow[\text{Solvent}]{\Delta T} MO_x + H_2O + CO_2 + N_2$$

Methoxyethanol
Ethanol
Water

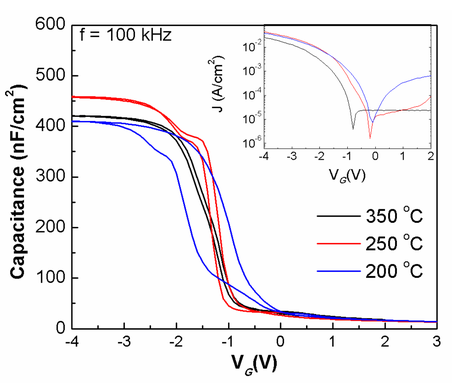


CAPACITORS CHARACTERIZATION

FUEL VARIATION



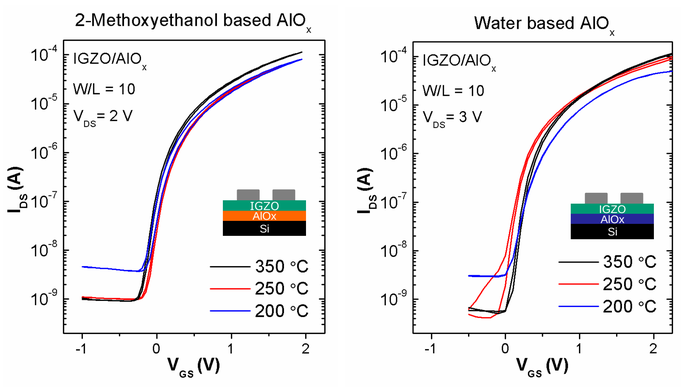
TEMPERATURE VARIATION



- ✓ Urea is the most effective fuel leading to minimized enhanced device performance.
- ✓ Lower temperature leads to non-sufficient organic residue degradation.

TFTs CHARACTERIZATION

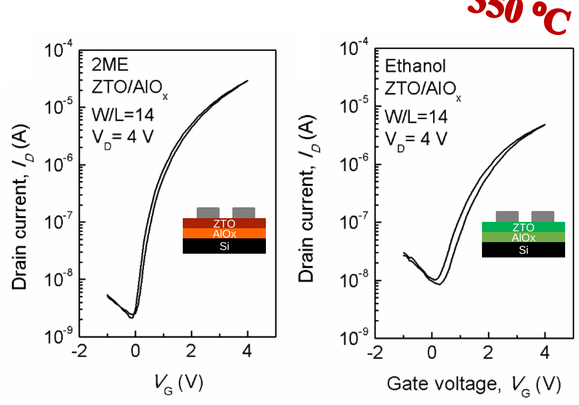
SPUTTERED IGZO / SOLUTION DIELECTRIC TFTs



Solvent	T (ºC)	V_{ON} (V)	I_{ON}/I_{OFF}	μ_{SAT} (cm² V⁻¹ s⁻¹)
2-ME	200	-0.2	8×10^4	9.6
H_2O	200	0	6×10^4	12.9

FULLY SOLUTION BASED TFTs

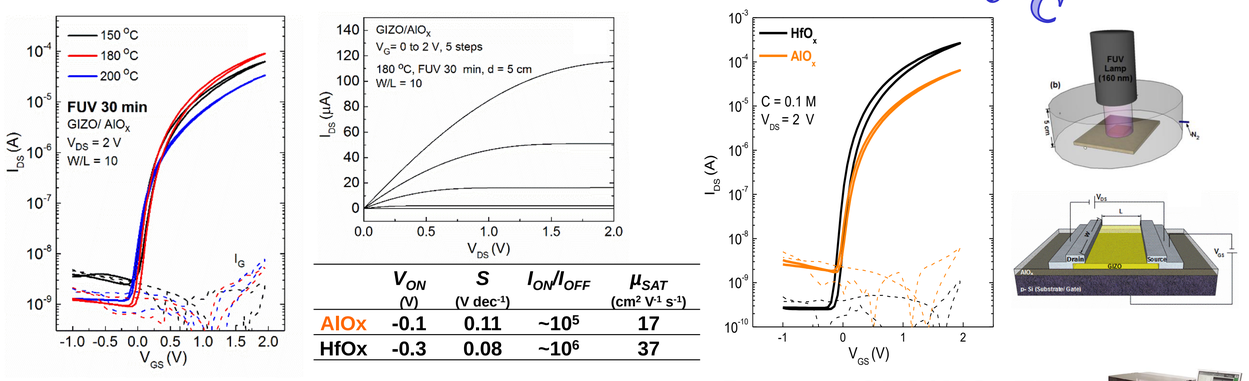
350 °C



Solvent	V_{ON} (V)	S (V dec⁻¹)	I_{ON}/I_{OFF}	μ_{SAT} (cm² V⁻¹ s⁻¹)
2-ME	0	0.3	5×10^4	2.6
Ethanol	0.2	0.6	9×10^3	0.8

UV ANNEALED TFTs CHARACTERIZATION

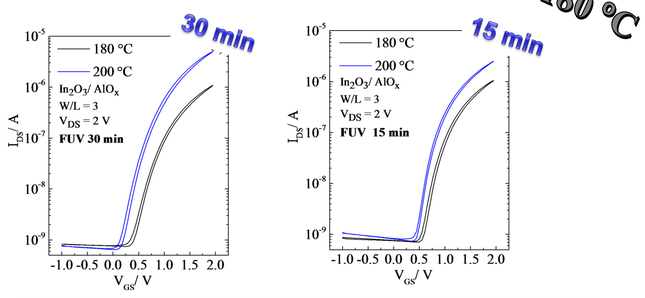
150 °C



	V_{ON} (V)	S (V dec⁻¹)	I_{ON}/I_{OFF}	μ_{SAT} (cm² V⁻¹ s⁻¹)
AlOx	-0.1	0.11	~10^5	17
HfOx	-0.3	0.08	~10^6	37

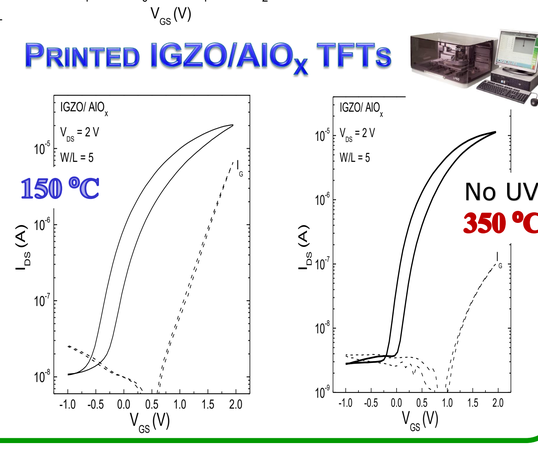
FULLY SOLUTION UV ANNEALED TFTs

180 °C

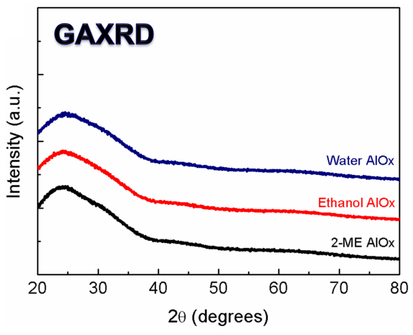


T (ºC)	V_{ON} (V)	S (V dec⁻¹)	I_{ON}/I_{OFF}	μ_{SAT} (cm² V⁻¹ s⁻¹)
180	~0.5	~0.3	~10^4	5

PRINTED IGZO/AlO_X TFTs

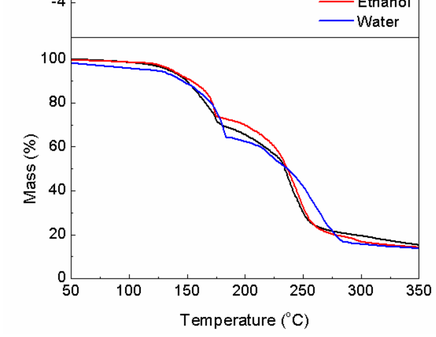


THIN FILMS CHARACTERIZATION



- ✓ Smooth amorphous films are obtained regardless of solvent.

PRECURSOR SOLUTIONS TG-DSC



- ✓ DSC-TG shows low temperature synthesis regardless of solvent.

CONCLUSIONS

- ♦ Urea is the optimal fuel allowing Water and Ethanol based AlO_x thin films with good properties and high stability at low temperature; 200 °C.
- ♦ UV annealing allows lower T (150-180 °C) without performance compromise for solution-based AlO_x and HfO_x TFTs.
- ♦ Printed AlO_x based IGZO TFTs produced at very low T of 150 °C are demonstrated, although performance is still far from required.
- ♦ Solution combustion synthesis is a promising method for low-cost processing of semiconductor and dielectric oxides resulting in TFTs with a good performance.

References

[1] R. Branquinho et al, *ACS Appl. Mater. Interf.*, vol. 60, no. 22, pp. *19592*, 2014. http://dx.doi.org/10.1021/am503872t
[2] M. Lorenz et al. *J Phys D Appl Phys*., vol. 49, no. 43, pp. 433001, 2016. http://dx.doi.org/10.1088/0022-3727/49/43/433001
[3] R. Branquinho et al, *InTech,* Ch. 15, Oct. 2016. http://dx.doi.org/10.5772/64761
[4] E. Carlos et al, *ACS Appl. Mater. Interfaces*, vol. 8, no. 45, pp. 31100, 2016. http://dx.doi.org/10.1021/acsami.6b06321

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Acknowledgments

This work is funded by FEDER funds through the COMPETE 2020 Programme and National Funds through FCT - Portuguese Foundation for Science and Technology under POCI-01-0145-FEDER-007688, Reference UID/CTM/50025, and EXCL/CTM-NAN/0201/2012. European Community FP7 i-FLEXIS (GA 611070). H2020 NMP-22-2015 project 1D-NEON Grant Agreement 685758. E. Carlos acknowledges FCT-MEC for a doctoral grant (SFRH/BD/116047/2016) and IDS-FunMat-INNO project FPA2016/EIT/EIT RawMaterials GA 15015.