FUV-assisted low temperature AlO_x solution based dielectric for oxide TFTs

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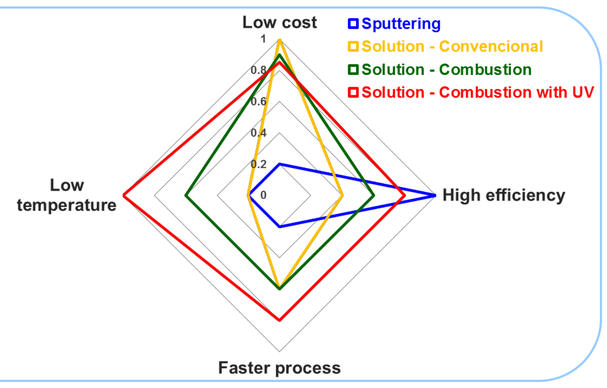
Introduction

Solution processing of amorphous metal oxides has been lately used as an option to implement in flexible electronics allowing a reduction of the associated costs and increased performance. However the research has focused more on semiconductor layer rather than on the insulator layer that is related to the stability and performance of the devices.

This work aims to evaluate amorphous aluminum oxide thin films produced by combustion synthesis and the influence of far ultraviolet (FUV) irradiation on properties of the insulator on thin film transistors (TFTs) using different semiconductors, in order to have compatibility with flexible substrates. [1–3] Optimized dielectric layer was obtained for an annealing of 30 minutes assisted by FUV exposure.



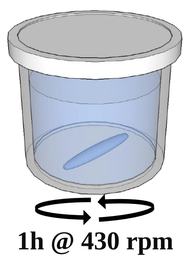
Experimental Section

Dielectric precursor solution

- The synthesis of aluminum oxide with combustion using metal precursors and fuel (urea), follow the balance between aluminum nitrate decomposition reactions and the oxidation reaction of urea.

$$Al(oxidizer)_x + Fuel \xrightarrow[Solvent]{\Delta T} AlO_x + H_2O + CO_2 + N_2$$

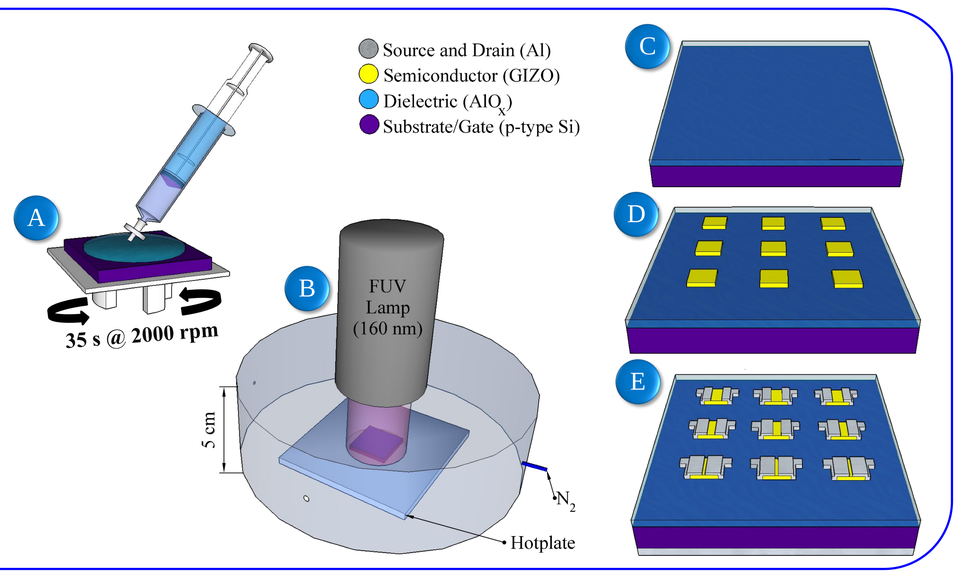
($Al(oxidizer)_x$: NO_3; Fuel: Urea; Solvent: 2-ME)



Variables

:: Metal ion concentration; c = 0.1 M for the films and c = 3 M for TG-DSC
:: Fuel/oxidizer ratio; ϕ = 1 (stoichiometric redox reaction)

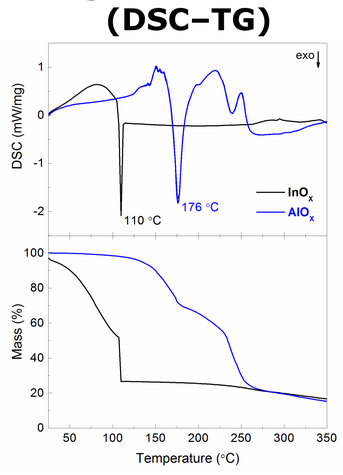
Devices fabrication



Results

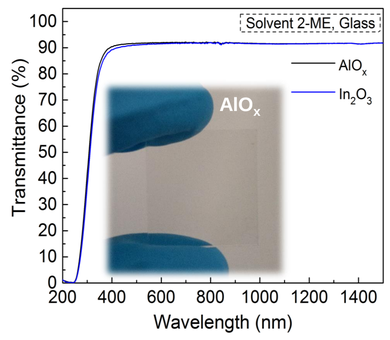
Solution characterization

Thermogravimetric analysis (DSC–TG)



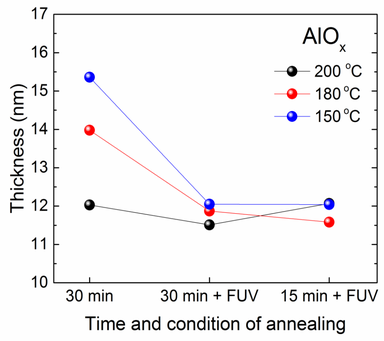
Thin films characterization

A Optical analysis



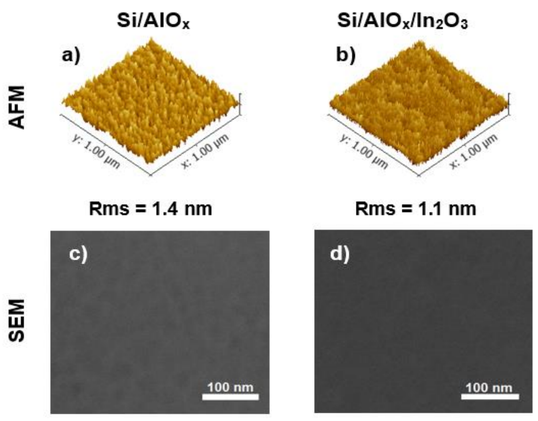
91% 90%

B Thickness influence



➢ FUV more effective for lower temperatures.

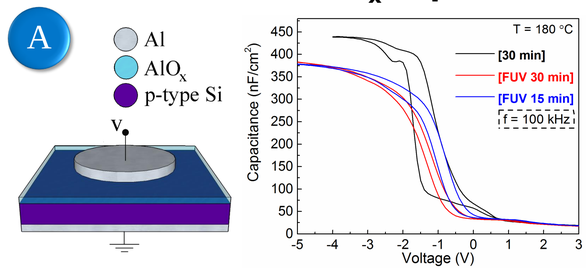
C Surface morphology (180 ºC with FUV for 30 min)



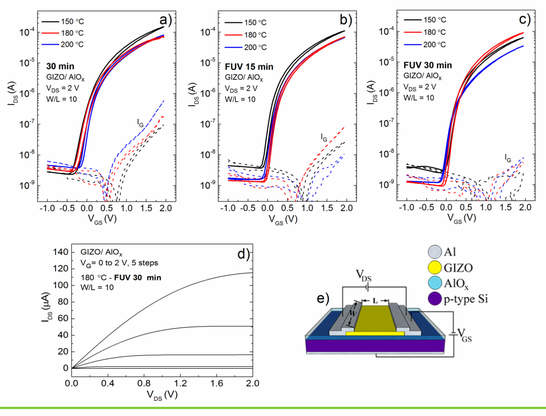
Electrical characterization

Solution-based AlO_x capacitors

A



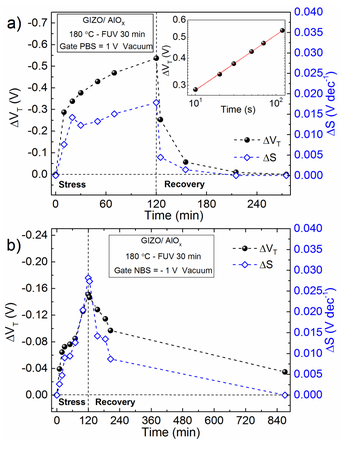
B Effect of FUV exposure in GIZO/AlO_x TFTs



C Stress measurements of optimized GIZO/AlO_x TFTs in vacuum

PBS

NBS



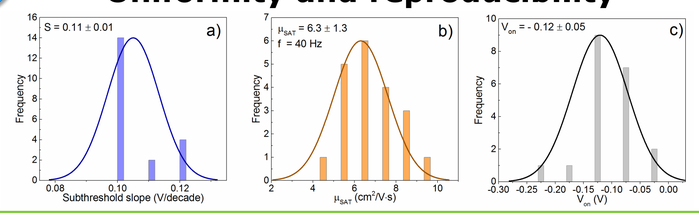
➢ Negative V_T shift

- Ion migration
- Release of hydrogen
- Charge detrapping

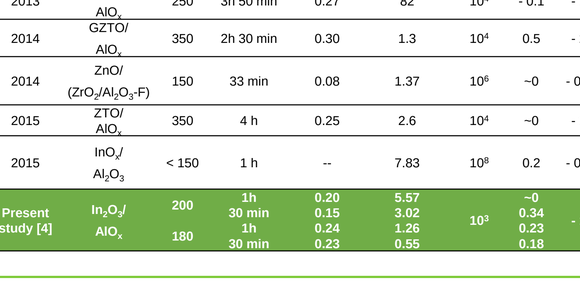
➢ Slow recovery

- Passivation

D Uniformity and reproducibility



E Fully solution-based In_2O_3/AlO_x TFTs



Year	TFT	T (ºC)	Time of annealing	S (V/dec)	Mobility ($cm^2/V \cdot s$)	$I_{ON/OFF}$	V_{ON} (V)	V_G range (V)
2011	In_2O_3/ AlO_x	200	1h 30 min	0.14	12.6	10^4	0.1	- 0.6 – 2
2013	In_2O_3/ AlO_x	250	3h 50 min	0.27	82	10^4	- 0.1	- 1 – 3
2014	GZTO/ AlO_x	350	2h 30 min	0.30	1.3	10^4	0.5	- 2 – 5
2014	ZnO/ (ZrO_2/Al_2O_3-F)	150	33 min	0.08	1.37	10^6	~0	- 0.1 – 3
2015	ZTO/ AlO_x	350	4 h	0.25	2.6	10^4	~0	- 1 – 4
2015	InO_x/ Al_2O_3	< 150	1 h	--	7.83	10^8	0.2	- 0.5 – 4
Present study [4]	In_2O_3/ AlO_x	200	1h 30 min	0.20 0.15	5.57 3.02	10^3	~0 0.34	- 1 – 2
		180	1h 30 min	0.24 0.23	1.26 0.55		0.23 0.18	

Conclusions

- The FUV irradiation aids on densification of the films resulting in a low hysteresis and leakage current.
- GIZO/AlO_x TFTs fabricated at 180 ºC combined with FUV irradiation for 30 min exhibited excellent electrical characteristics with an average saturation mobility of 6.3 ± 1.3 $cm^2/V \cdot s$ at 40 Hz, a subthreshold slope of 0.11 ± 0.01 V/dec and a turn-on voltage of -0.12 ± 0.06 V, and a good stability over time.
- Fully solution based In_2O_3/AlO_x TFTs were produced in a short processing time of 30 min.

References

[1] M.-G. Kim et al, *Nat. Mater.*, vol. 10, no. 5, pp. 382–8, May 2011.
[2] R. Branquinho et al, *ACS Appl. Mater. Interfaces*, vol. 6, no. 22, pp. 19592–9, Nov. 2014.
[3] J. Leppäniemi et al, *Appl. Phys. Lett.*, vol. 105, no. 11, p. 113514, Sep. 2014.
[4] E. Carlos et al, *Adv. Electron. Mater*, *submitted*, 2016.

Acknowledgments

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