Effect of chemical precursors in combustion processing of solution based AlO_x dielectric for GIZO TFTs

E. Carlos*, R. Branquinho, P. Barquinha, R. Martins, E. Fortunato**

CENIMAT/I3N, DCM, FCT-UNL and CEMOP/UNINOVA, Campus da Caparica, 2829-516 Caparica, Portugal

*e.carlos@campus.fct.unl.pt; **emf@fct.unl.pt

Introduction

In the last years, significant efforts have been made in the synthesis of a wide range of inorganic dielectrics using chemical solution routes do to their versatility, low cost and scalability for printed and flexible electronics. Solution synthesis provides a wide range of variables that can be tuned to yield the desired material. In solution combustion of oxide materials the most determinant parameters are the metal source and organic fuel as these influence the oxide formation temperature and properties. [1–2]

In this work the effect of different metal precursors; aluminum chloride and aluminium nitrate, and organic fuels; urea (U) and citric acid (CA), on the properties of solution-processed aluminium oxide thin films was investigated. These films were then applied as dielectric layer in gallium-indium-zinc oxide (GIZO) thin film transistors (TFTs) and the influence of the chemical route on their performance was accessed.

Experimental Section

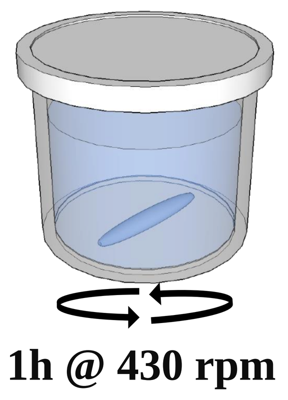
Dielectric precursor solution

Sol-gel

Al(oxidizer)$_x$ $\xrightarrow[\text{Solvent}]{\Delta T}$ $AlO_x + H_2O + CO_2 + N_2 + Cl_2$

- NO_3
- Cl_3

Solvent: 2-ME



Combustion

Al(oxidizer)$_x$ + Fuel $\xrightarrow[\text{Solvent}]{\Delta T}$ $AlO_x + H_2O + CO_2 + N_2 + Cl_2$

Oxidizer:
- NO_3
- Cl_3

Fuel:
- Urea
- Citric acid

Solvent: 2-ME

❑ The synthesis of aluminum oxide with and without combustion using metal precursors and fuels in case of combustion, follow the balance between aluminum nitrate decomposition reactions and the oxidation reaction of the fuels.

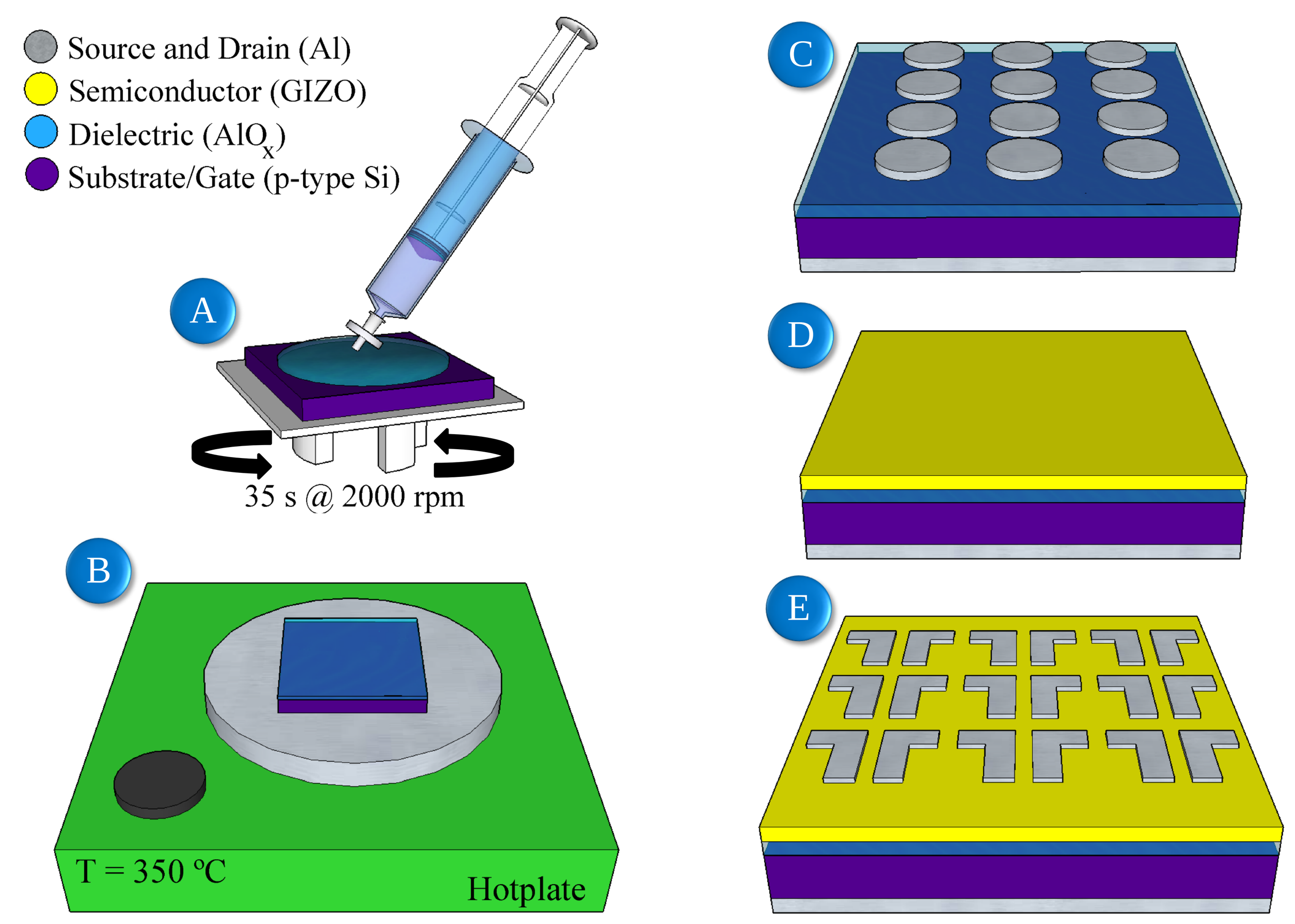
$$\phi = \frac{\text{Reducing reagent}}{\text{Oxidizing reagent}} \cdot \text{number of moles}$$

Variables

:: Metal ion concentration; c = 0.10 M for the films and c = 3 M for TG-DSC

:: Fuel/oxidizer ratio; $\phi = 1$ (stoichiometric redox reaction)

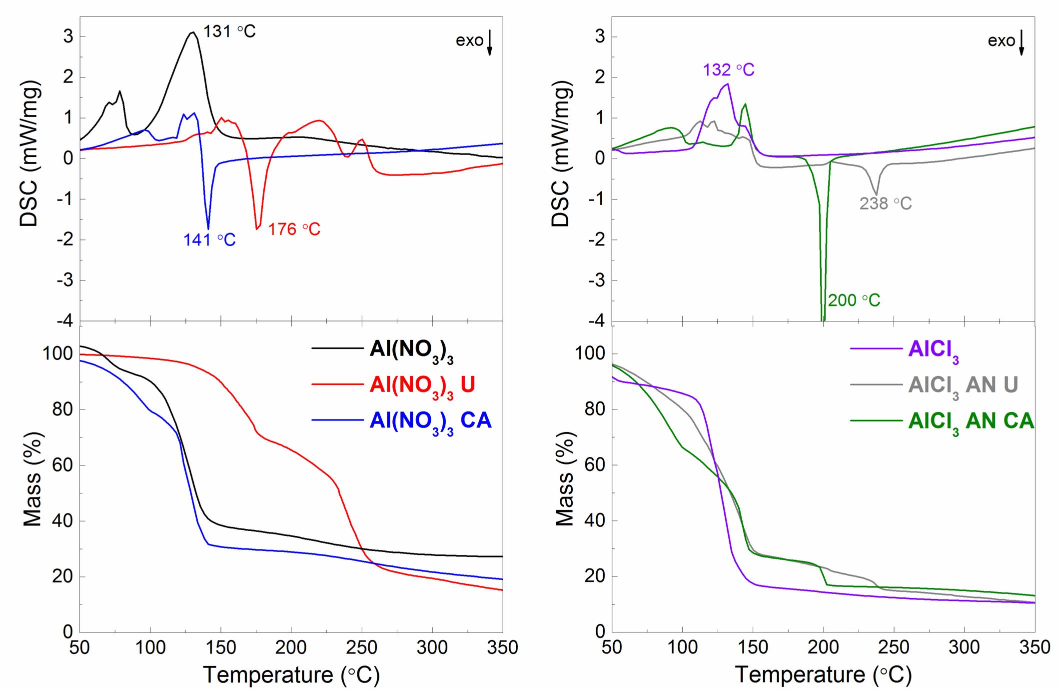
Devices fabrication



Results

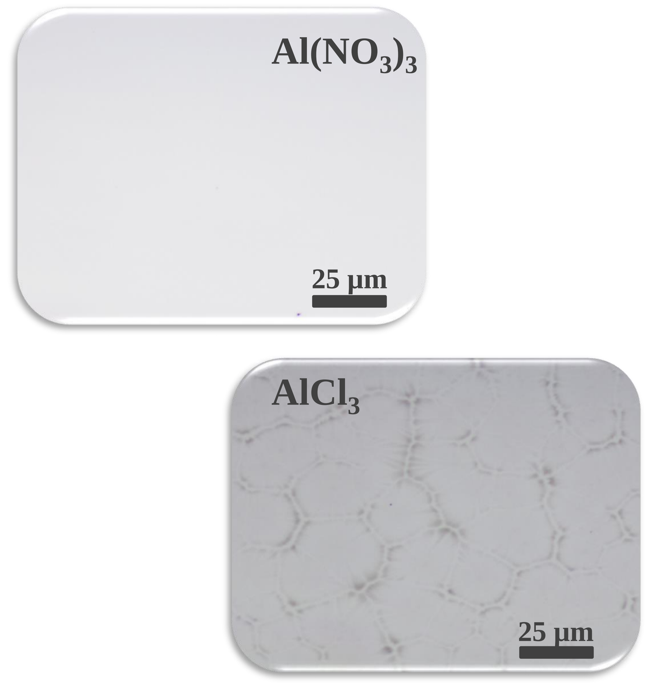
Solution characterization

A Thermogravimetric analysis (DSC-TG)

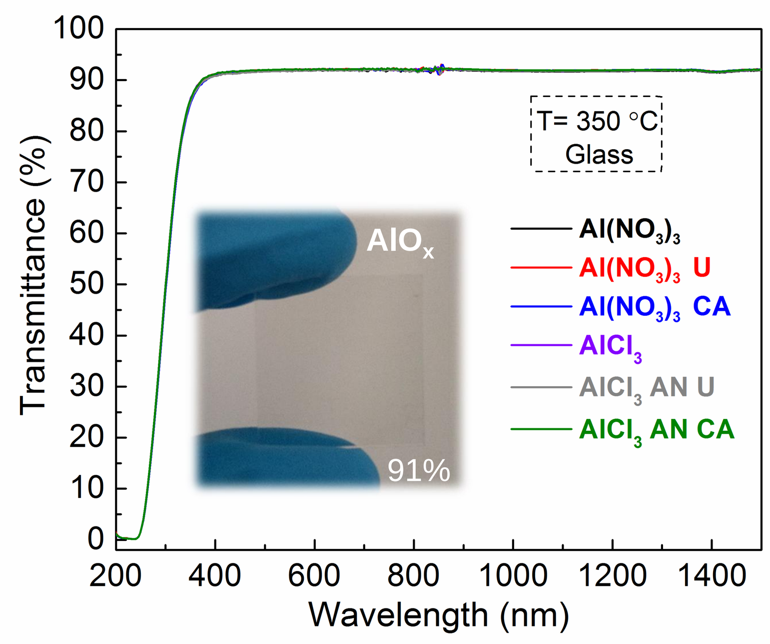


Thin films characterization

B Morphological analysis

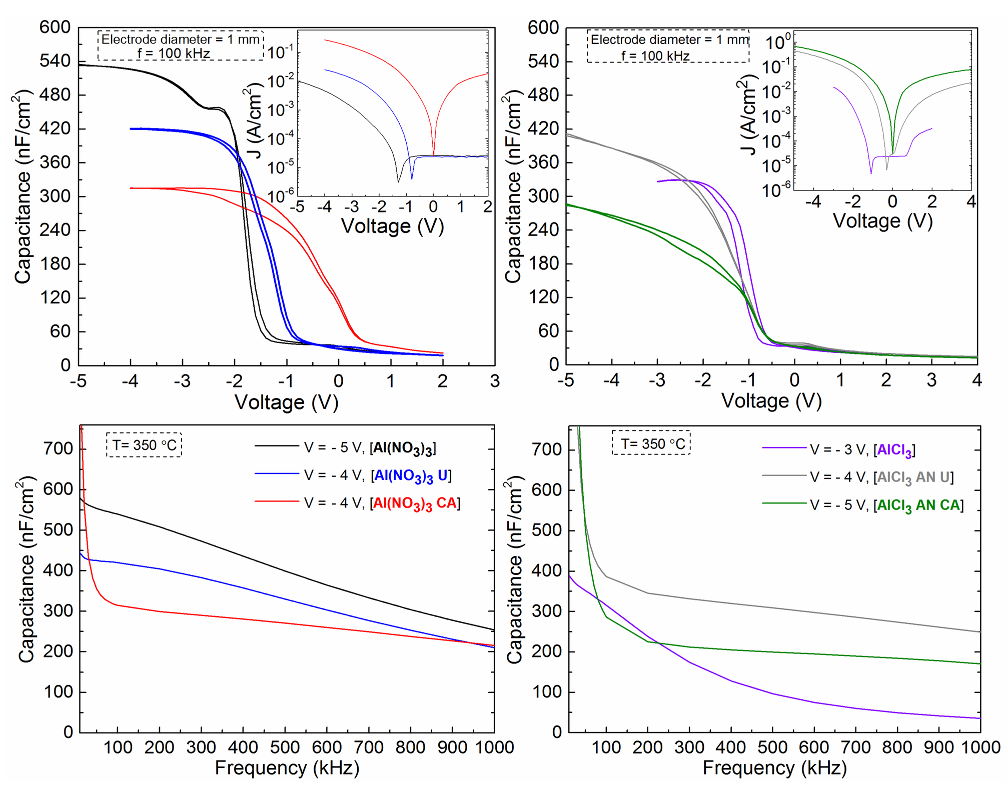


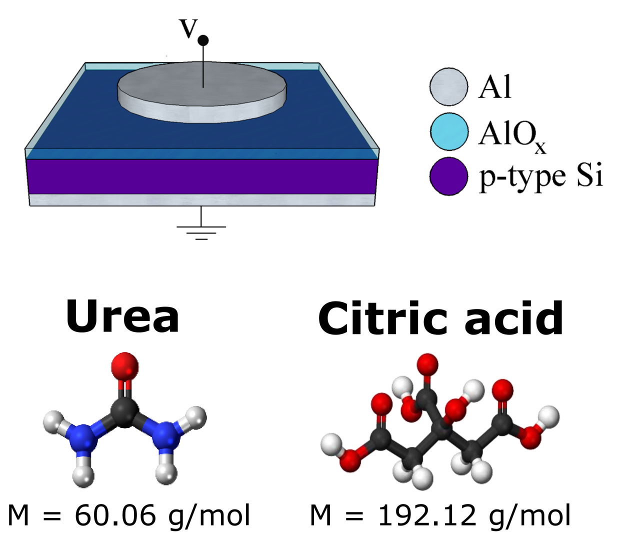
C Optical analysis



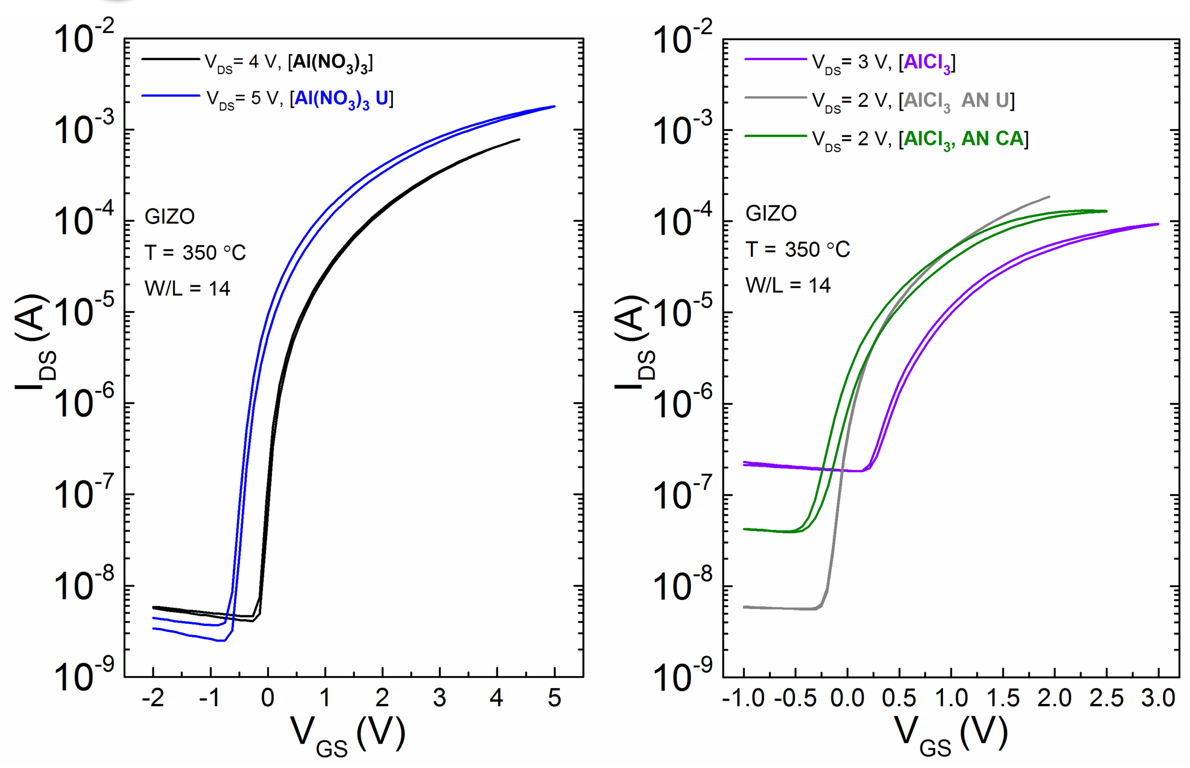
Electrical characterization

A Solution-based AlO_x capacitors





B GIZO/AlO_x thin film transistors



Conclusions

❑ Thermal analysis of precursor solutions reveals that when using aluminium nitrate and citric acid the typical exothermic behaviour occurs at lower temperature leading to film formation at lower temperatures.

❑ The dielectrics with aluminum chloride as precursor solution show a higher hysteresis or a bigger variability of the capacity with frequency.

❑ The capacitors produced with aluminium precursor solutions with citric acid as fuel reveal a higher hysteresis and leakage current density. That is explained by the size of the citric acid organic molecule when compared to urea, causing low agglomeration of particles when occurs the combustion reaction resulting in a porous film.

❑ The optimized GIZO TFTs were prepared from aluminium nitrate precursor solution using urea as fuel shows a saturation mobility of 27.9 $cm^2/V \cdot s$, with an on/off current ratio of 7.2×10^5.

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.

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