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ELECTRICAL AND OPTICAL PROPERTIES OF ALN_XO_Y THIN FILMS PREPARED BY REACTIVE DC MAGNETRON SPUTTERING

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The addition of oxygen and nitrogen to a growing Al film can give rise to an oxynitride (AlN_xO_y) film with a wide range of different properties, that can be tailored between those of the pure Al and those of AlN_x and AlO_y. In this work, a set of films of AlN_xO_y and two sets of the binary systems, AlN_x and AlO_y, were produced using reactive DC magnetron sputtering. The discharge characteristics, composition, structure, electrical and optical properties were studied, in order to test whether the oxynitride films have an unique behaviour or are simply a transition between AlN_x and AlO_y.

Electrical and Optical properties of AlN_xO_y thin films prepared by reactive DC magnetron sputtering

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GRF (Functional Coatings Group) – http://online.uminho.pt/projectos/grf/

Motivation

Aluminium nitride (AlN)
Semiconductor (~6.2 eV)

AlN is used in:
- **Electronic packaging;**
- **Optoelectronic devices;**
- **Microelectronics;**
- **Surface/bulk acoustic wave devices; etc.**

Aluminium (Al)
Metal

Al is used in:
- **Food packaging;**
- **Electrode in many devices;**
- **Polymeric and silicon solar cells;**
- **PLEDs; etc.**

Aluminium oxide (Al_2O_3)
Insulator

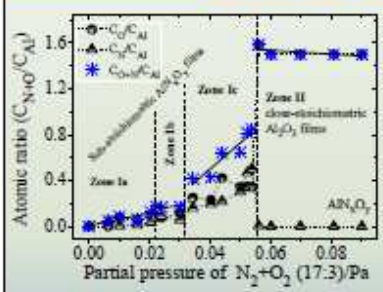
Al_2O_3 is used in:
- **Corrosion protection;**
- **OTFT;**
- **Solar cells;**
- **Flash memory circuits;**
- **MOS devices; etc.**

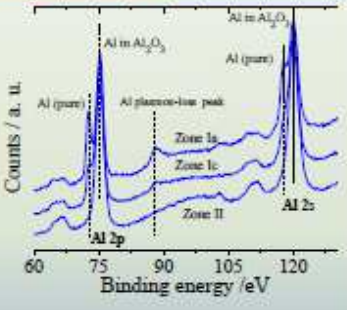
ALUMINIUM OXYNITRIDE (AlN_xO_y)

> AlN_xO_y may have some interesting applications due to a wide difference in the properties of Al, AlN and Al_2O_3.

> The main idea is to tailor the properties of AlN_xO_y films between pure aluminium and those of aluminium oxide and nitride films.

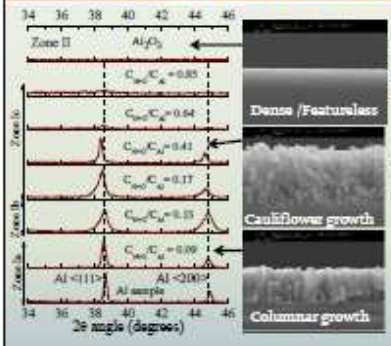
Chemical Composition



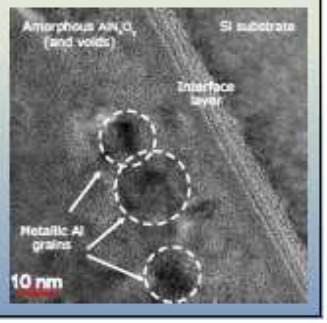


- **RBS** results shows a wide range of **chemical compositions.**
- **XPS** suggests the existence of pure Al in the films ascribed to **zones Ia, Ib** and **Ic**.
- The films indexed to **zone II** are composed of close-stoichiometric Al_2O_3 without pure Al.

Structure and Morphology

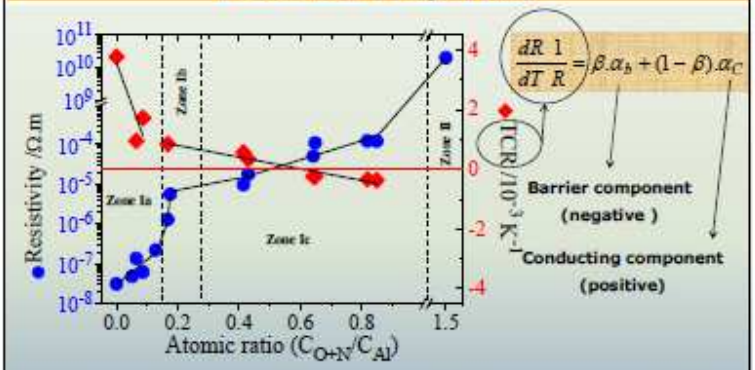


- **XRD** revealed Al-type **structure** (**fcc**) with a gradual amorphization as the atomic ratio increases.
- **SEM** cross-section micrographs shows different **types of growth** in each zone.



- **TEM** confirms the XRD Al-type nanocrystals.
- **EELS** suggests that Al nanocrystals are surrounded by an amorphous AlN_xO_y matrix.

Electrical Properties

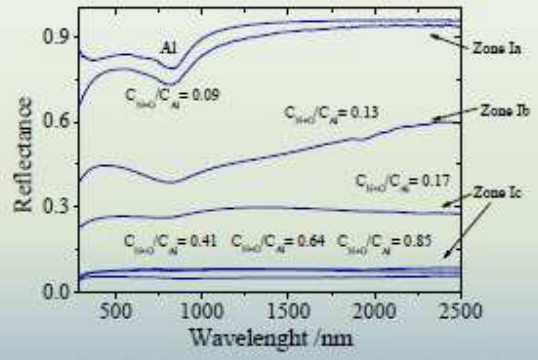


$$\frac{dR}{dT}\frac{1}{R} = \beta.\alpha_b + (1-\beta).\alpha_C$$

•**Electrical resistivity** gradually increases, up to 4 orders of magnitude, in the films with Al-type structure.

•**TCR** decrease and can even be negative.

Optical Reflectance



•The **reflectance** drops from the typical Al profile towards very low values as the atomic ratio increases.

•A flat reflectance, as low as 5%, between 250 and 2500 nm, can be observed in the films indexed to **zone Ic**.

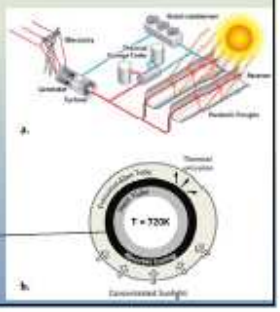
Conclusions and possible applications

•Films of AlN_xO_y were prepared by reactive DC magnetron sputtering, using an aluminium target and an $Ar/(N_2+O_2)$ gas mixture.

•The composition, morphology and structure of the films induced a wide variation in the electrical and optical responses, which was directly correlated with a nanocomposite-like material where aluminium nanoparticles are embedded in an insulator matrix.

•The films may have some potential applications in different technological fields, such as in **concentrated solar power (CSP) systems**.

AlN_xO_y can be the absorber coating?



Published work

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[2] J. Borges, E. Alves, F. Vaz, L. Marques, in: M.F. Costa (Ed.), International Conference on Applications of Optics and Photonics, Spie-Int Soc Optical Engineering, Braga, 8001 (2011) 80010F
[3] J. Borges, N. Martin, N.P. Barradas, E. Alves, D. Eyidi, M.F. Beaufort, J.P. Riviere, F. Vaz, L. Marques, Thin Solid Films 520/21 6709 (2012)
[4] E-book chapter, 2013 (accepted)
[5] Article submitted to Journal of Physics D: "Influence of stoichiometry and structure on the optical properties of AlN_xO_y films"

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