Ga_2O_3 Thin Films for Integrated Photonics through Doping and Ion Implantation

Alexandre Jorge Serra Capricho

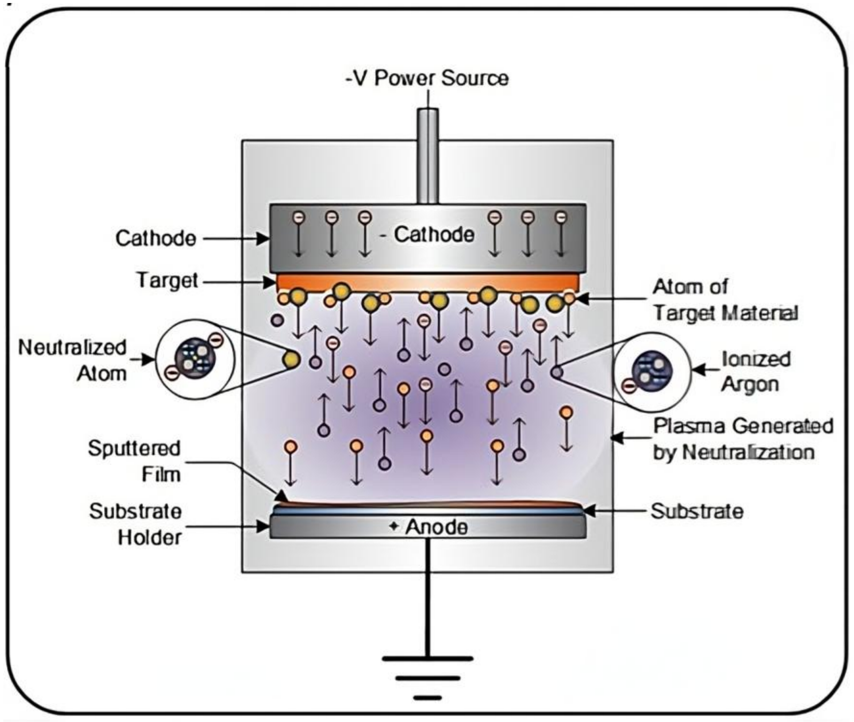
Supervisors:
Dr. Marco Peres and
Dr. Katharina Lorenz

Optimizing Ga_2O_3 Thin films - Deposition

This work focuses on the fabrication of Ga_2O_3 thin films using **radio-frequency magnetron sputtering** (RFMS) deposition.

In RFMS, a plasma that hits a **target** (Ga_2O_3), ejecting material that condenses onto a substrate to form a **thin film**.

The **properties** of RFMS-grown films depend heavily on the **deposition parameters**: RF-power, working pressure and target-substrate distance, and more.

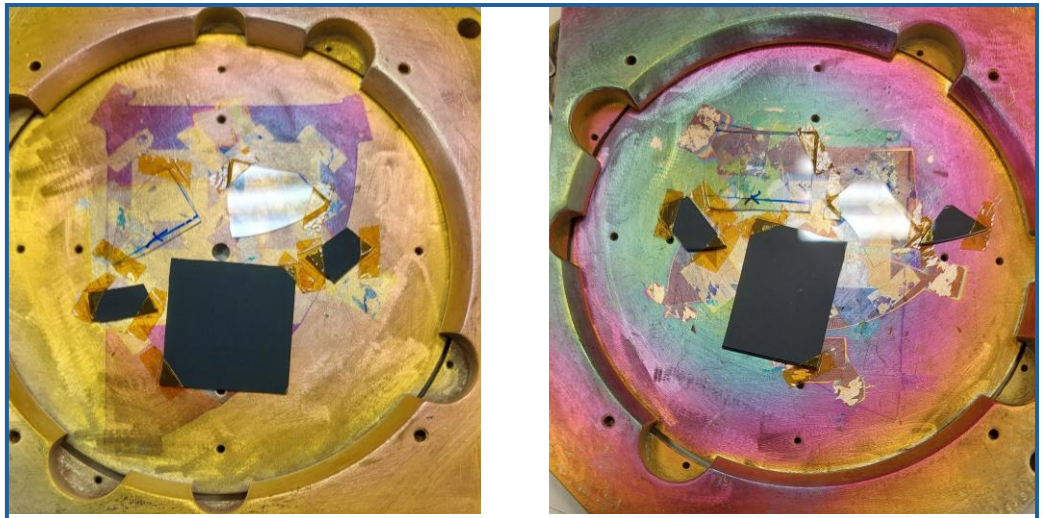


RFMS Deposition

Optimizing Ga_2O_3 Thin films - Samples

Two sets of samples with **different** deposition **conditions** were deposited with an Alcatel SCM 450 magnetron sputtering system at INESC-MN.

In each deposition, **3 different substrates** used: **Silicon** (Si), **Fused Silica** (amorphous SiO_2) and **Quartz** (monocrystalline SiO_2).

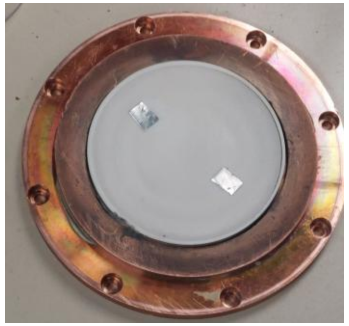


RF-Power: 80W
Argon Gas Flow: 30 sccm

RF-Power: 50 W
Argon Gas Flow: 20 sccm

Sets of samples and Deposition Conditions

Alcatel SCM - 450 at INESC-MN



Ga_2O_3 and Aluminum Target used in deposition

Tubular Furnace at CTN

Optimizing Ga_2O_3Thin films - Characterization

To optimize the **optical properties** of the thin films, we need to **measure** them.

This is done with **characterization techniques**, most importantly:

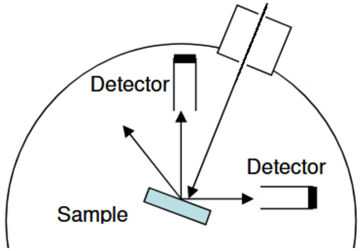
Ellipsometry

n(λ)

Optical Absorption (O.A.)

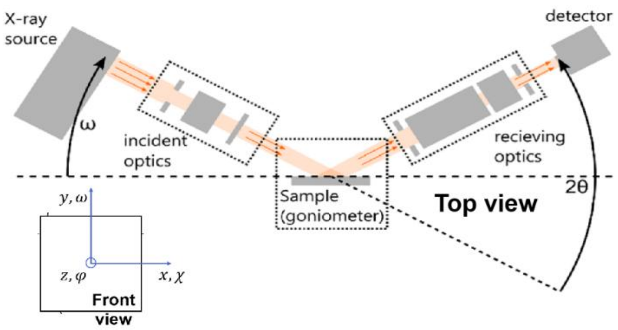
α(λ), E_g

Rutherford Backscattering Spectrometry (RBS)



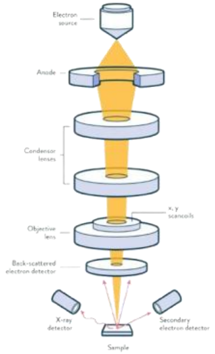
Al%

X-Ray Diffraction (XRD)



Crystal Structure

Microscopy (SEM)

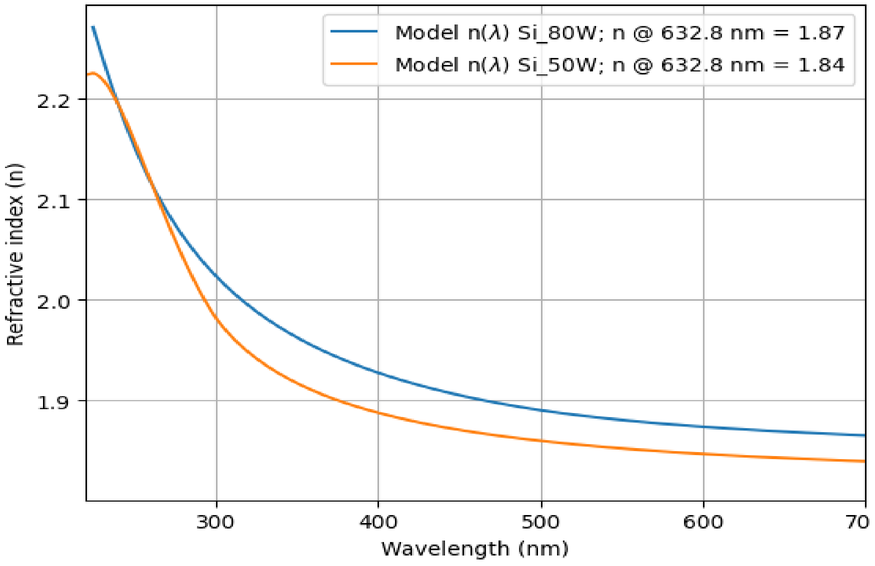


Surface Morphology

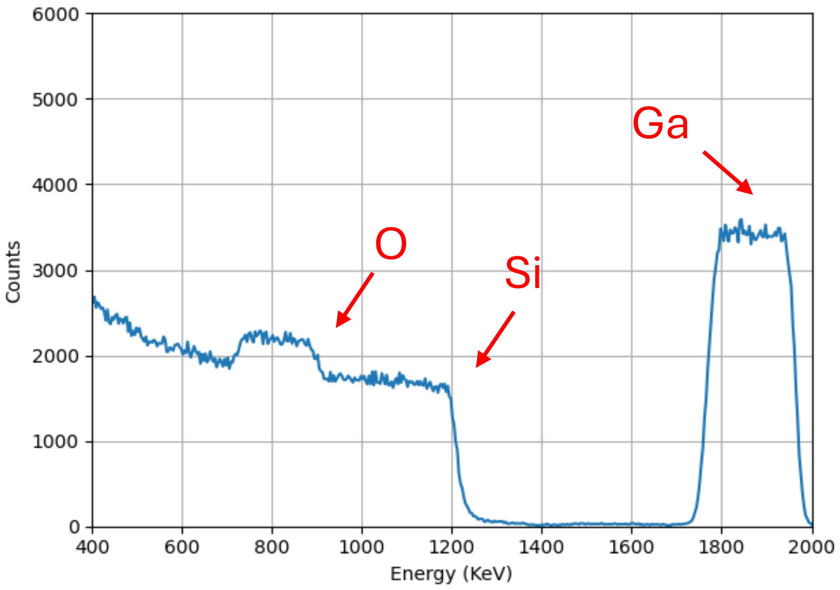
Characterization Methods and Properties Extracted from Them

Optimizing Ga_2O_3Thin films - Preliminary Results

- Ellipsometry model predicts **different n(λ)** for 80W and 50W depositions.
- No **aluminum plateau** seen in RBS spectrum.
- SEM images show **smooth** surfaces **before annealing** and **damage** after 600 ∘C **annealing.**



Model n(λ) for 80W and 50W samples



RBS Spectrum of 50W as-grown Sample

SEM image of 50W sample after annealing

Conclusions and Next Steps

- **Index of refraction** is influenced by **deposition conditions.**
- **Cannot detect** aluminum with **current** RBS **setup**.
- **Thermal effects** seem to cause more **surface damage** on some substrates.

- Optimize **Deposition** and **Annealing** Conditions: Deposit More Samples to know exactly how n(λ) changes and prevent surface damage.
- **Tune** Aluminum doping or use other characterization method (eg. PIXE) to measure aluminum content.
- After Fabrication Optimization: **Ion implantation** and **irradiation** for the **development of waveguides** in Ga_2O_3.