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Growth and fabrication of GaN-based structures using AlInN insertion layers

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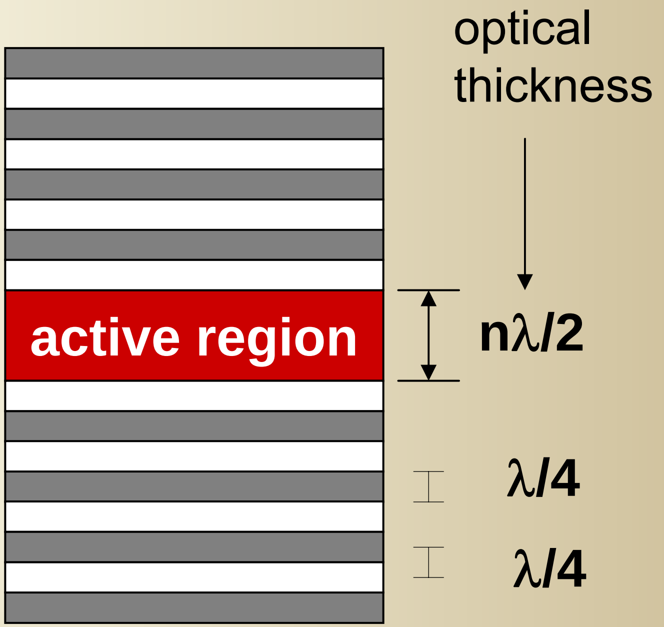
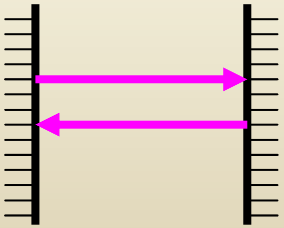
Outline:

- Introduction and motivation
- Design and growth of microcavities
  - Role of AlInN in in-situ monitoring
- Roles of AlInN layer in post-growth processing
  - End point detection in plasma etching
  - Etch selectivity in alkaline solutions
- Summary

Introduction – What is a MicroCavity?

- Used for improvement of efficiency of light emission and to obtain a narrower and more directed emission from light emitting devices
- Our MCs will employ two parallel mirrors between which light can be reflected with little loss

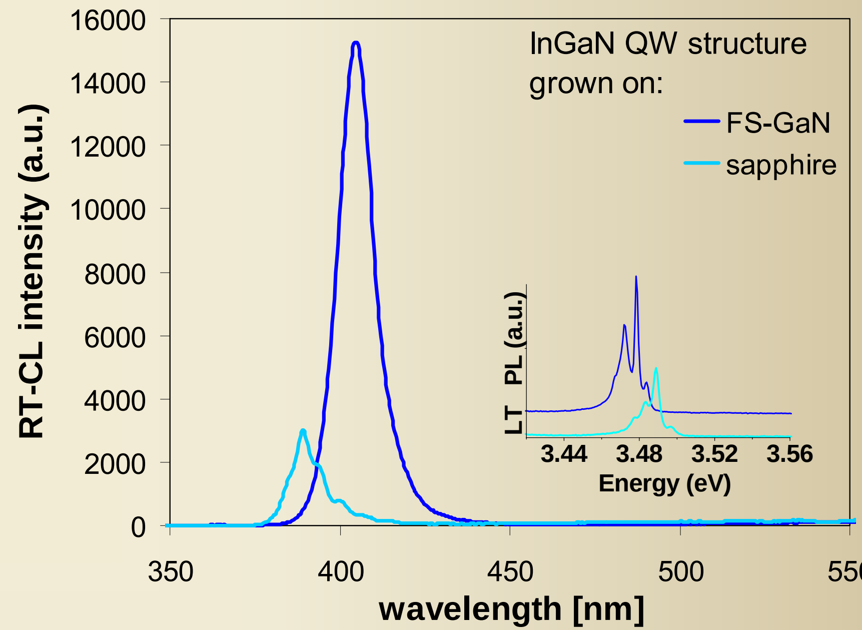




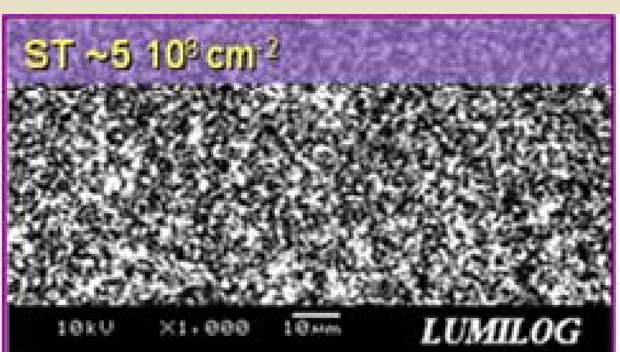
MC confine light → MC store light at certain resonant frequencies → Quality of mirrors very important

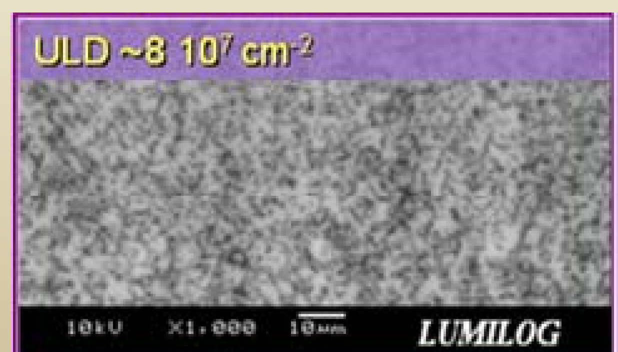
Free Standing-GaN: motivation

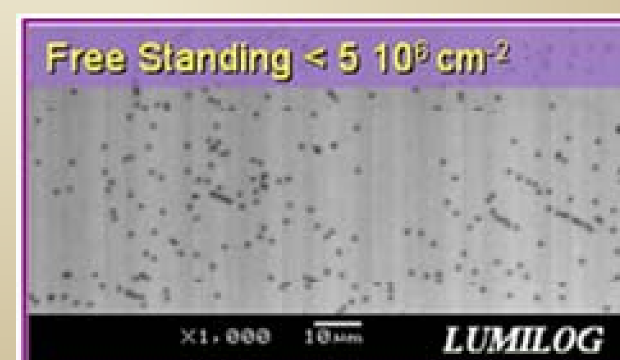
Increasing availability of free-standing GaN (e.g. Lumilog)



Improvement in emission properties with comparison to sapphire

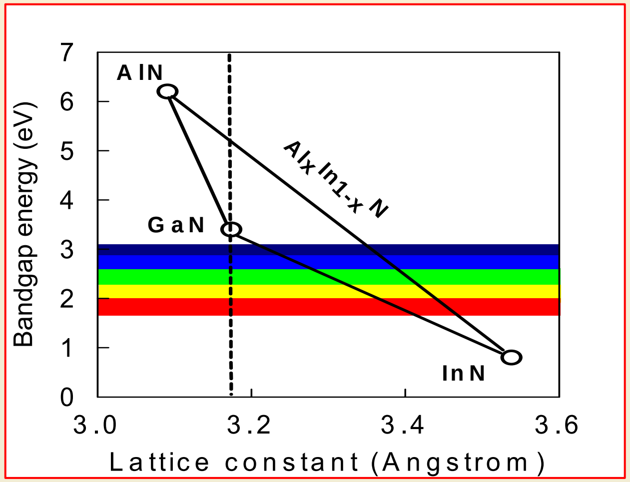




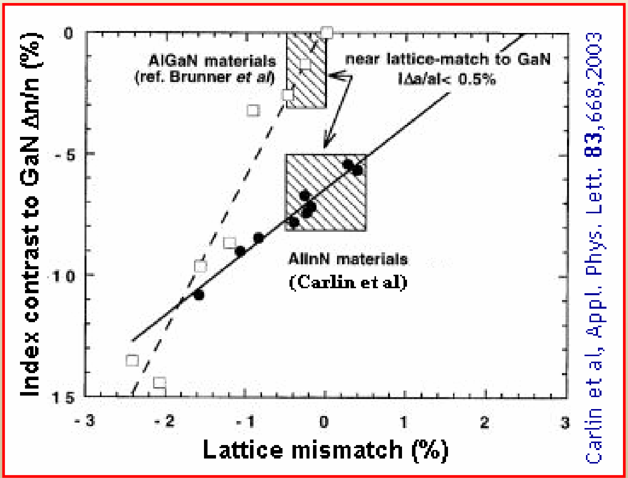


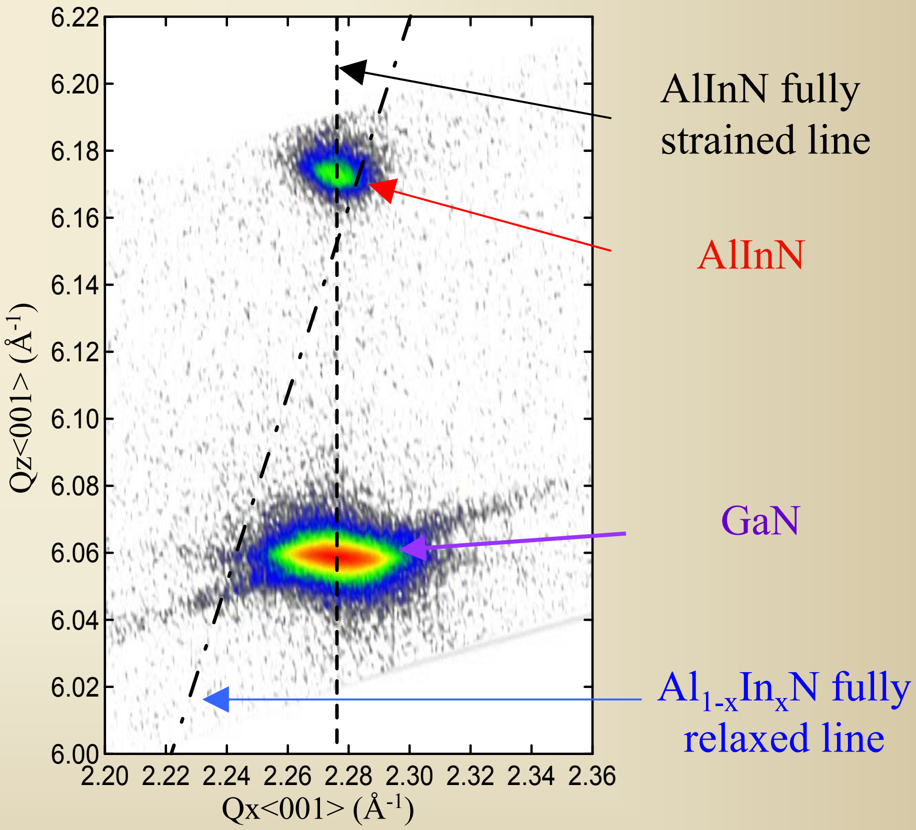
AlInN layers

- **AlInN: lattice matched to GaN**



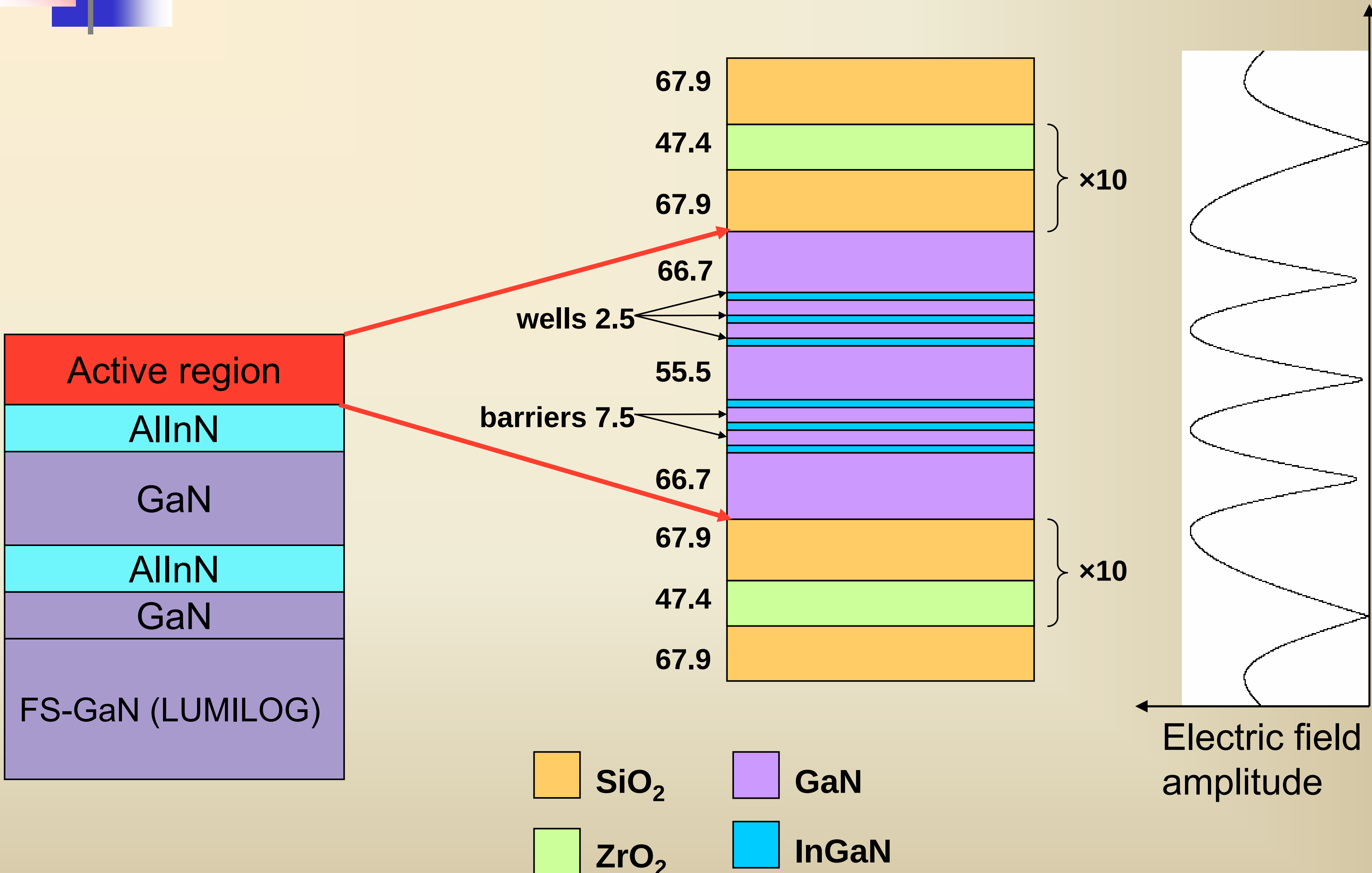
- **AlInN/GaN: high refractive index contrast**





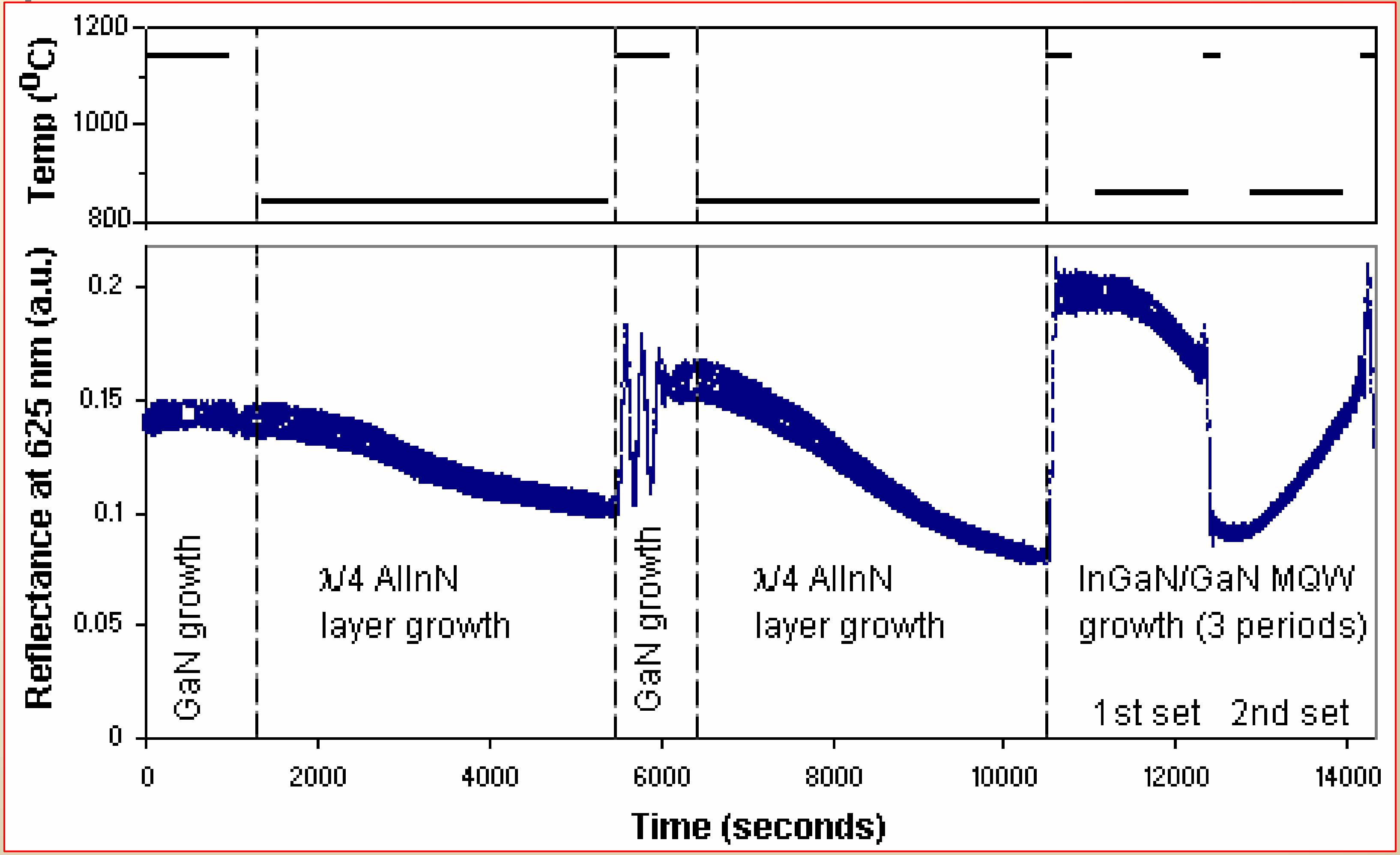
X-ray reciprocal space mapping performed by N. Franco at ITN, Sacavém, Portugal using Cu $K_{\alpha}1$ X-rays

MC structure



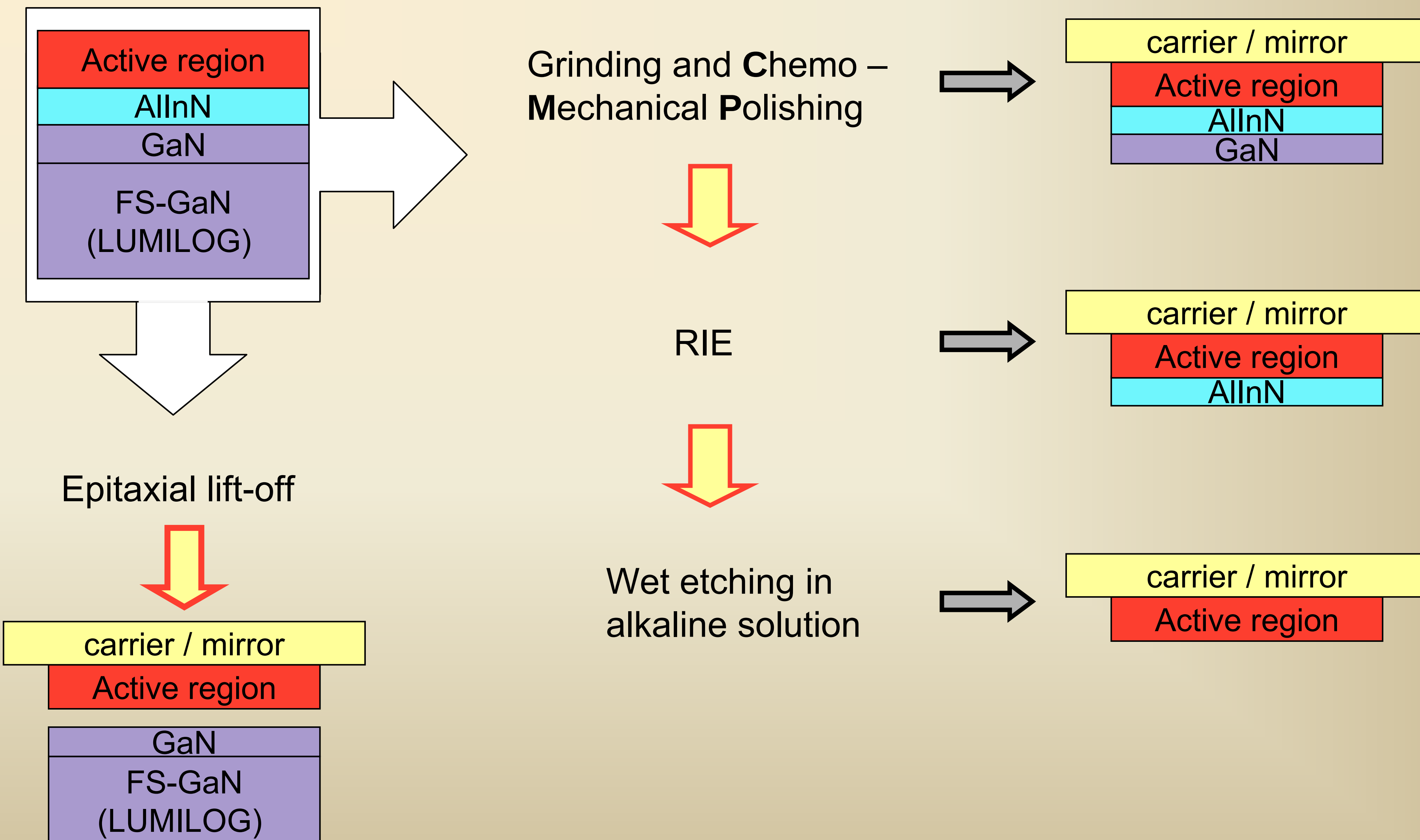
All dimensions in nm

In-situ growth monitoring

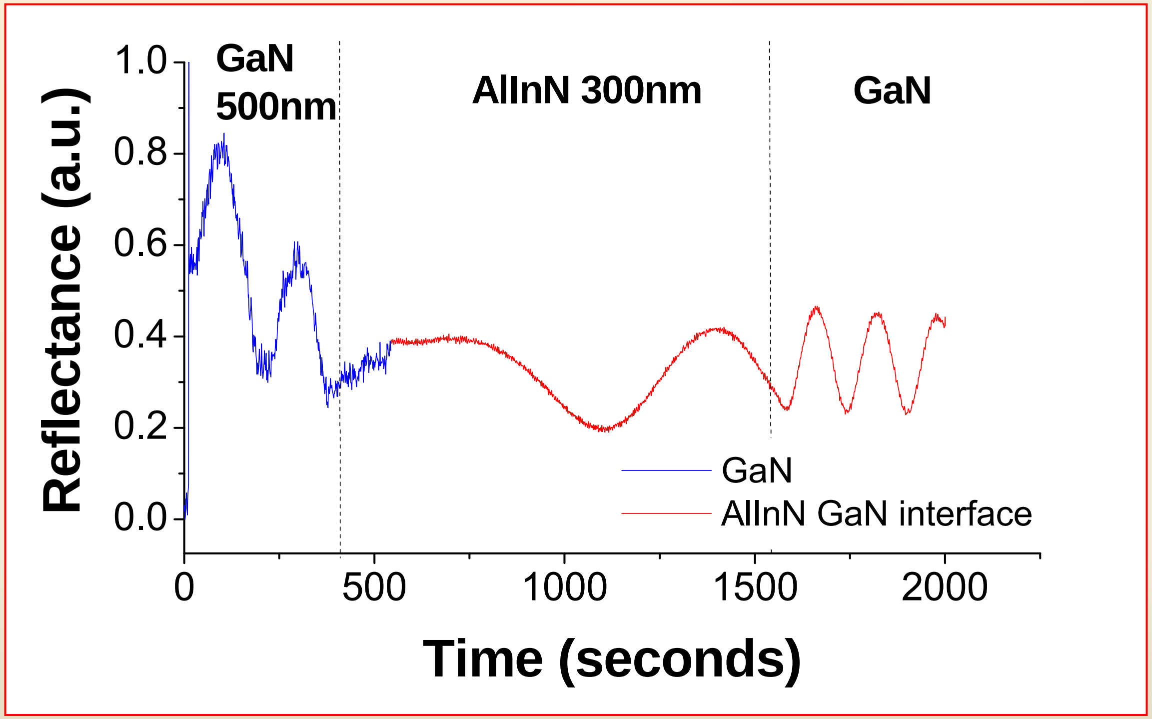


Refractive index contrast between AlInN and GaN! → **Measurement of growth rate (in real time) allows to optimize thickness of MC active region**

From grown structure to microcavity



Reactive Ion Etching – in-situ monitoring



Cl_2+CH_4+Ar:

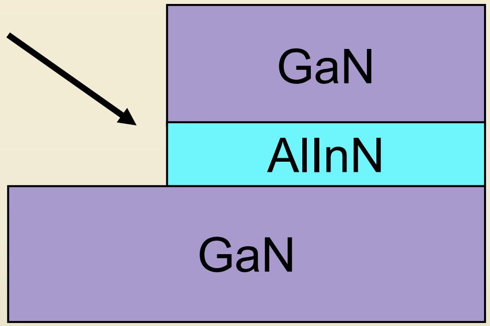
Etch rate:

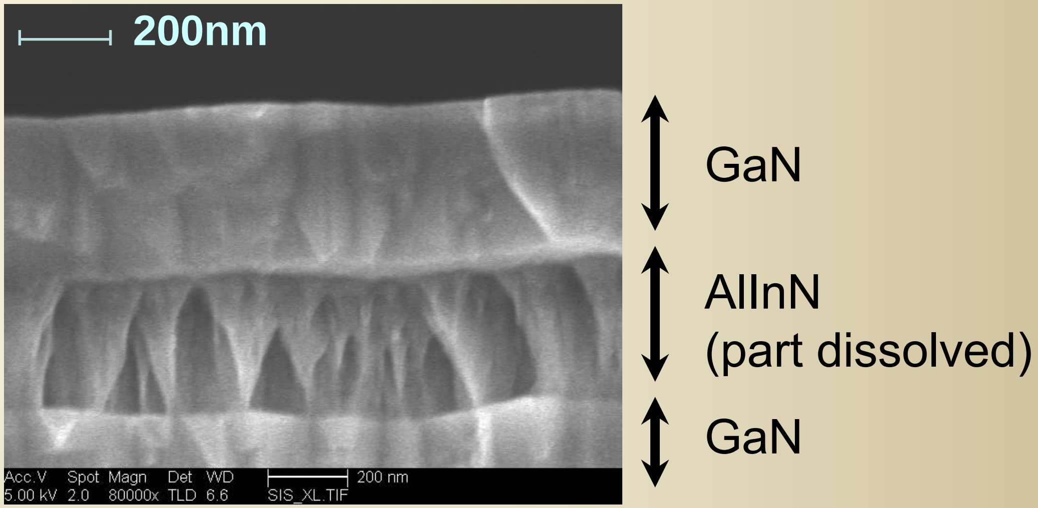
GaN/AlInN ~ 5/1

layer	on	Etch rate [Å/min]
GaN	AlInN	463
AlInN	GaN	105
GaN	Al_2O_3	550

Etching in alkaline solution

Secondary electron image of the edge of a mesa produced by initial plasma etching of a GaN/AlInN/GaN trilayer after etching in 1,2-diaminoethane.





The 300nm AlInN layer has been undercut and etched into conical forms

➡ this demonstrates selectivity which can be exploited in lift-off processing

Summary

- Insertion of $\lambda/4$ AlInN layers allows measurement of growth rates by a standard method which allows accurate control of layer thicknesses
- Selectivity demonstrated between AlInN and GaN layers in RIE
- Etching in alkaline solutions also shows strong selectivity