



Optical characterization of nanocrystallized AlN:Er films prepared by magnetron sputtering



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Why AlN ?

Facing matrices already studied ...

1/ Physical properties

- Piezo electrical : acousto-optical devices?
- Resistivity to caustic attacks and to corrosion
- Important thermal conductivity
- Wide gap (6,2 eV) : visible LED

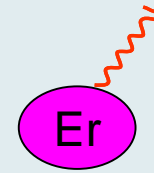
2/ Synthesis possible* with variable morphology
with PVD magnetron (transfer to industry)

*

Brien et al. J.Crystal growth 2007 and 2008



Why AlN+Er ?



$\lambda = 1,54 \mu\text{m}$

- Photonic applications

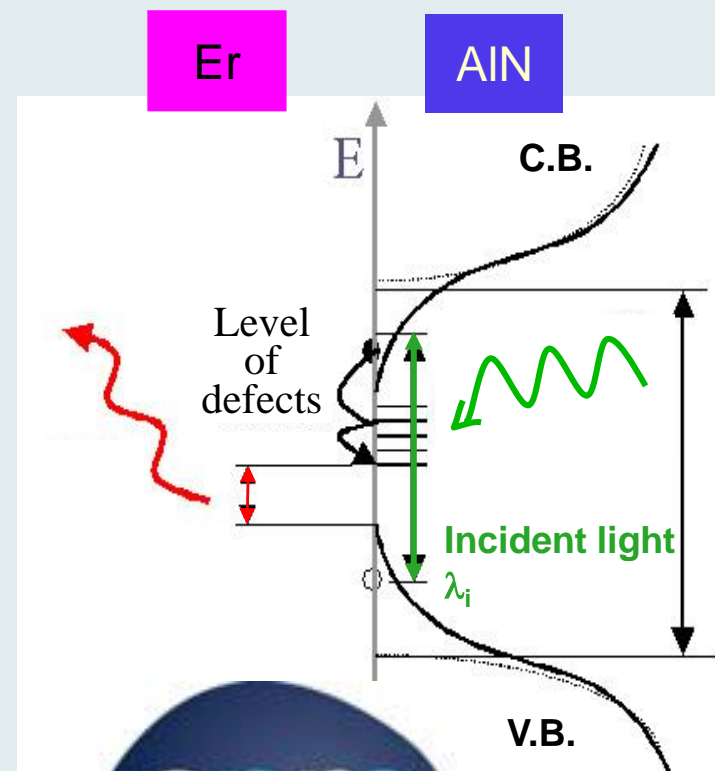
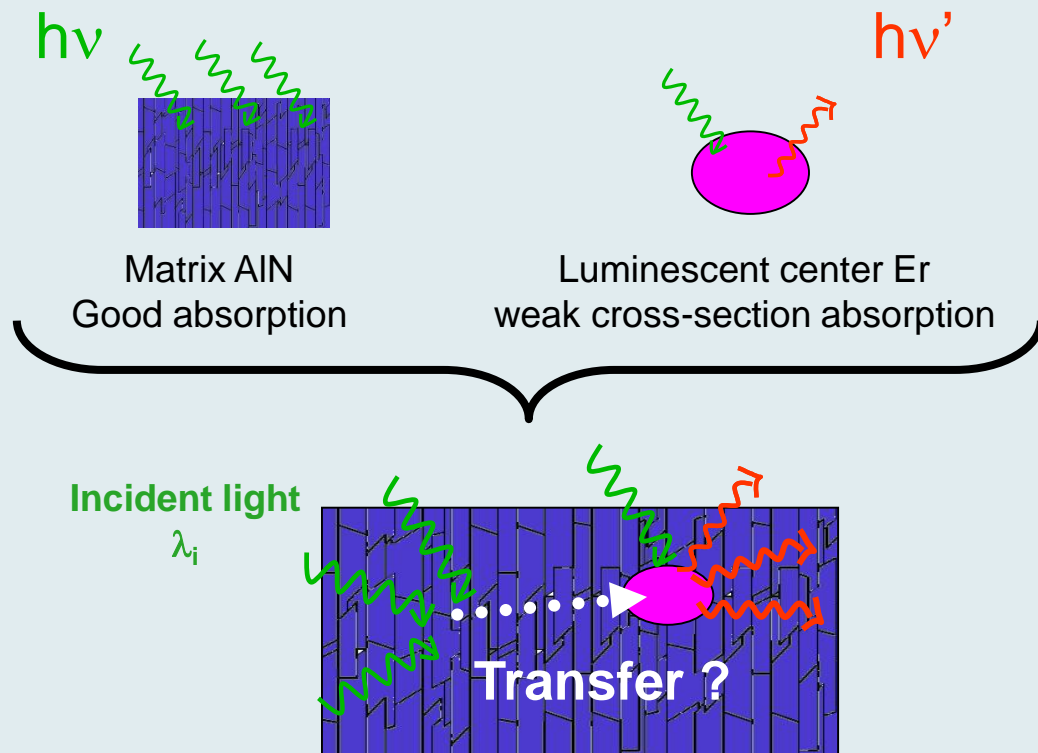
- Telecom domain : Optical interconnection instead of electrical ones
Need of amplifiers and sources at $\lambda = 1,54 \mu\text{m}$

- To benefit from the dispersion throughout a matrix
to circumvent a weak cross-section absorption



Take advantage of indirect process:

Introduction of dopant in a collector matrix of variable morphology



Mechanism not fully understood yet

Optimisation of transfer

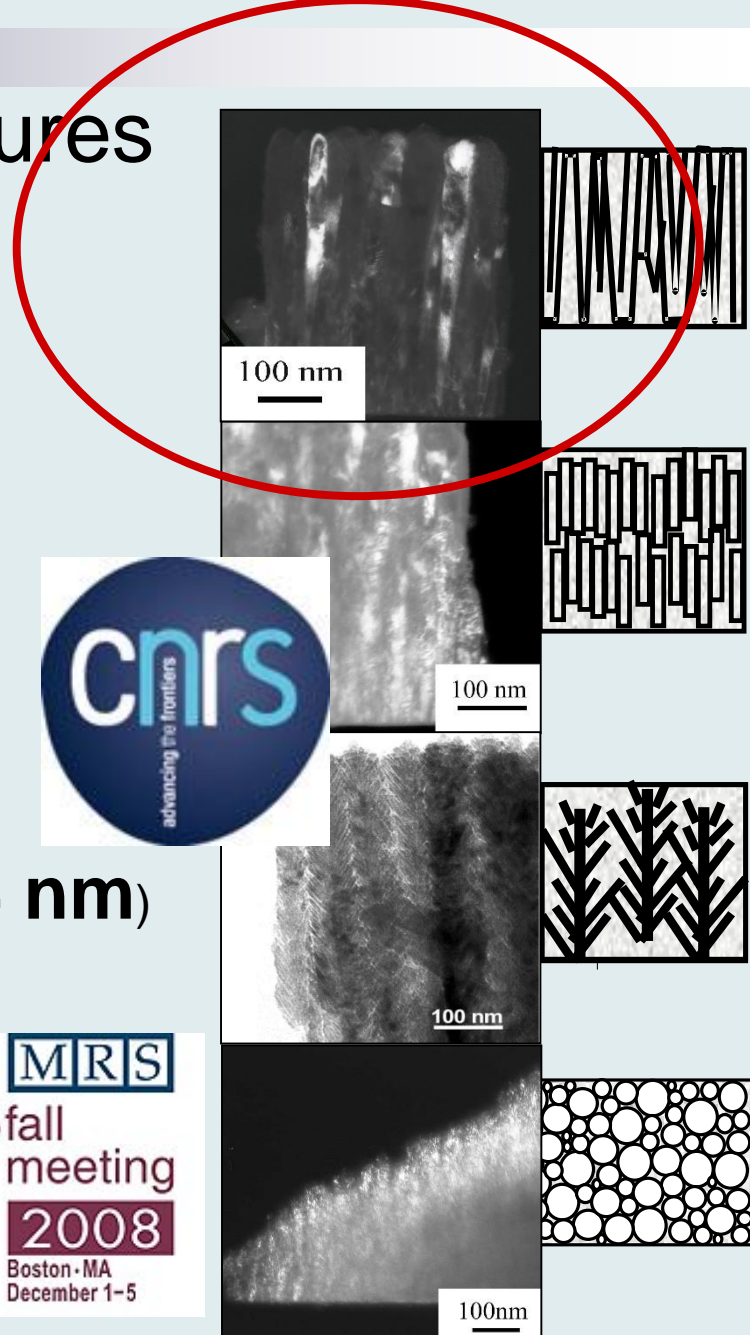
Transfer efficiency \Rightarrow Variable nano-structure

Introduction of levels in matrix thanks to defects ?



4 different AlN:Er nanostructures

- Nano columns (diameter ~ **10-25 nm**)
- Nano rods (diameter ~ **11 nm**)
- Nano columns **feathers** (branch diameter ~ **6-24 nm**)
- Nano **grains** (diameter ~ **3-20 nm**)



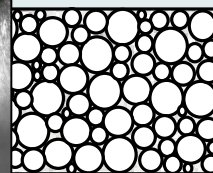
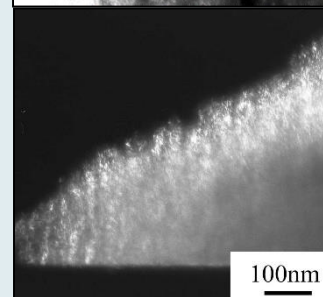
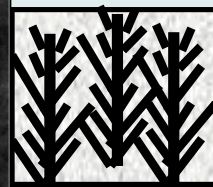
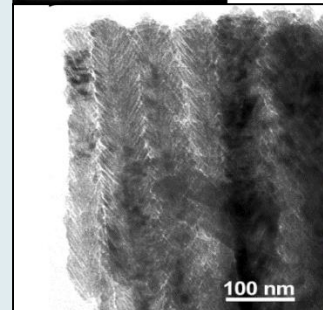
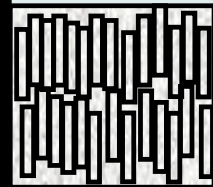
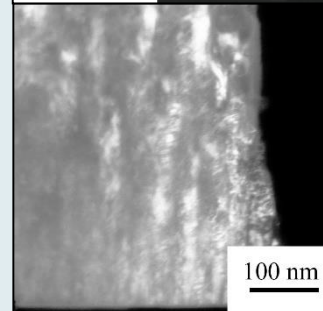
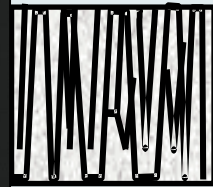
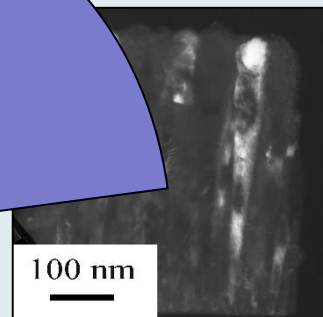
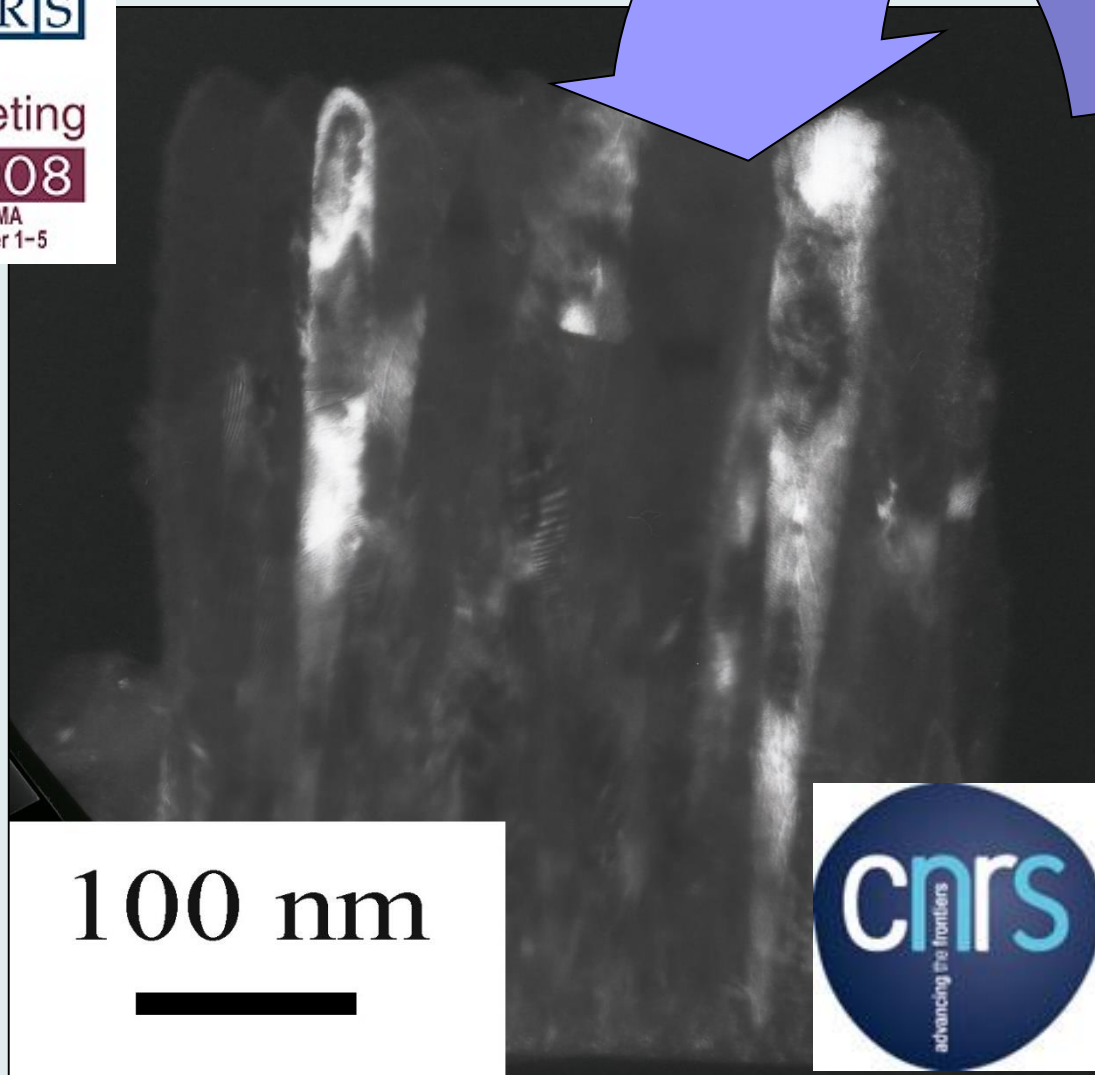
4 different AlN:Er nanostructures



□ Nano

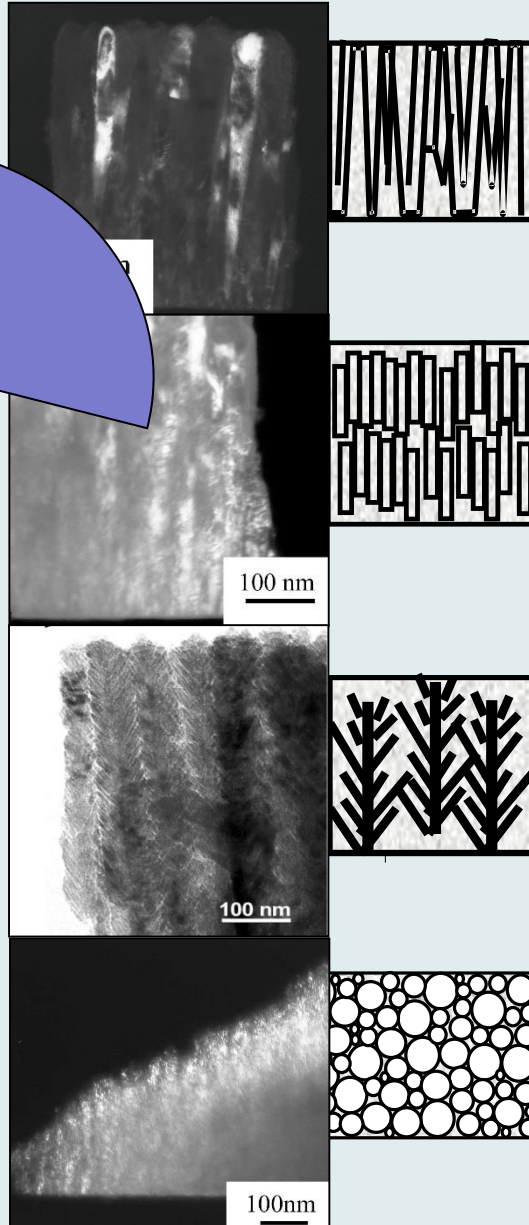
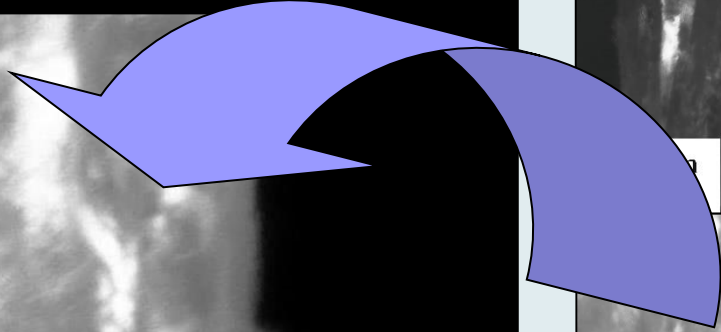
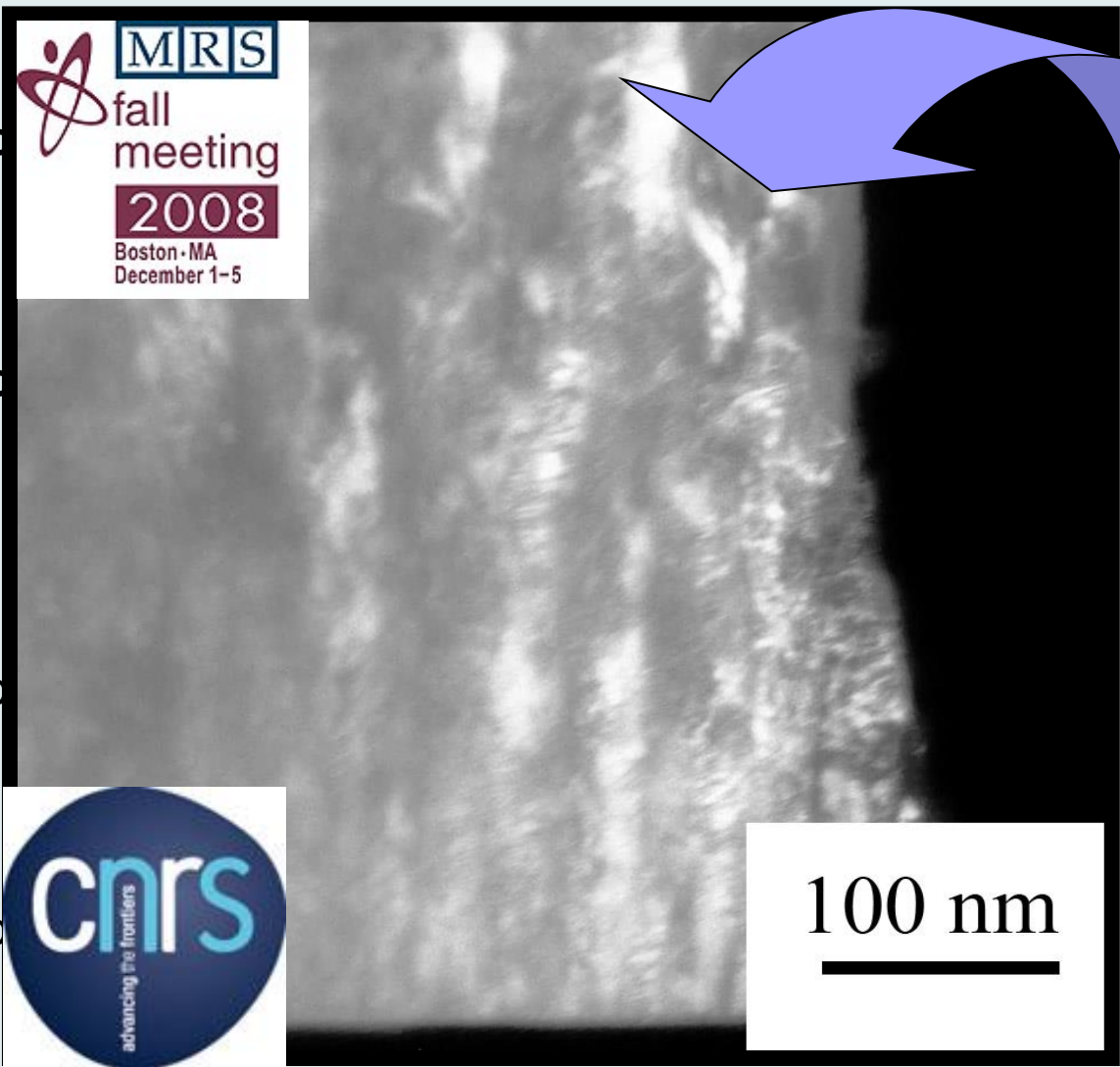
□ Nano

□ Nano



4 different AlN:Er nanostructures

- Nano
- Nano
- Nano
- Nano



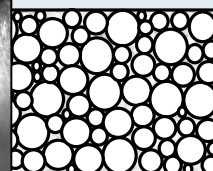
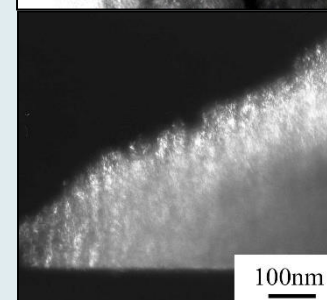
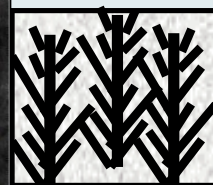
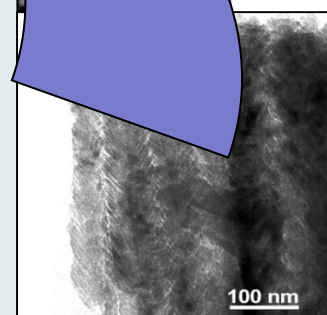
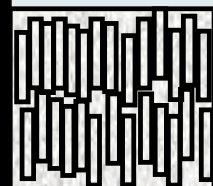
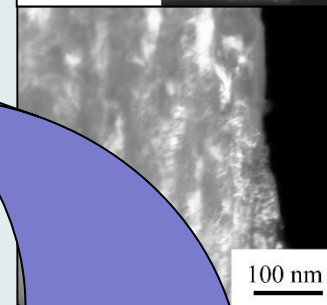
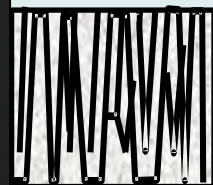
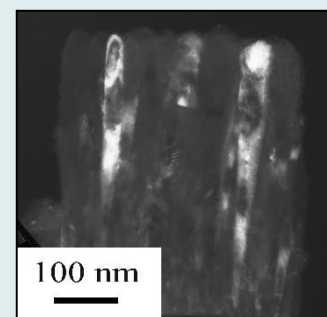
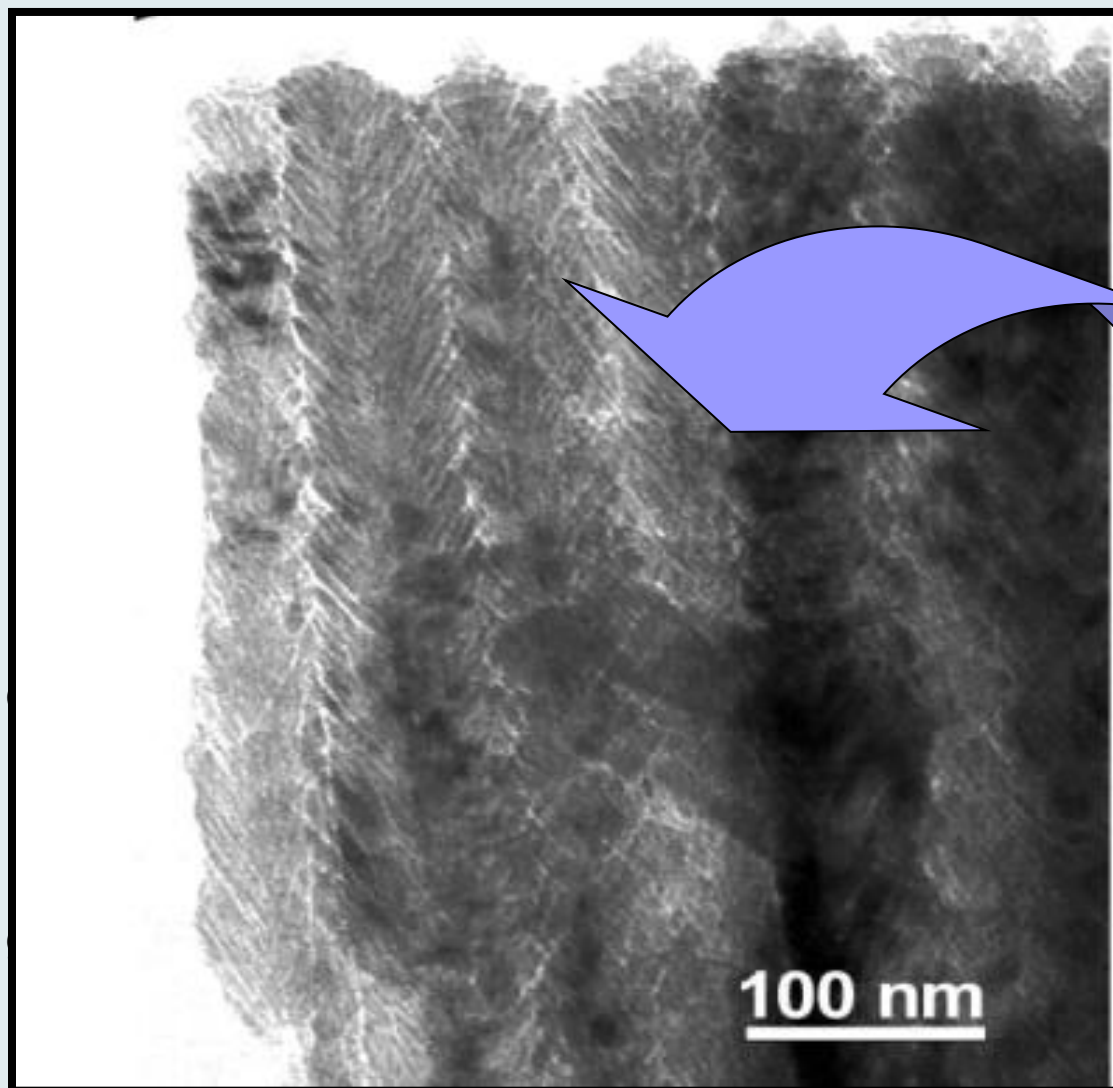
4 different AlN:Er nanostructures

□ Nano

□ Nano

□ Nano

□ Nano



4 different AlN:Er nanostructures

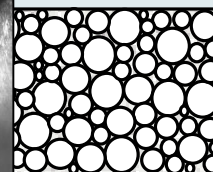
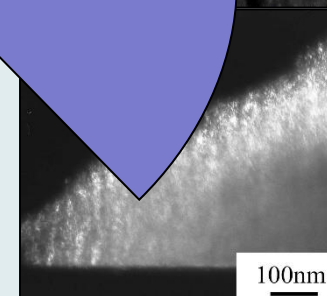
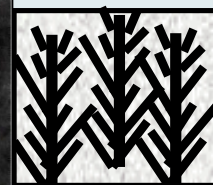
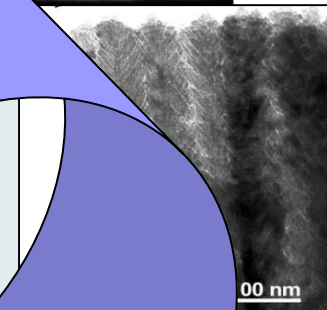
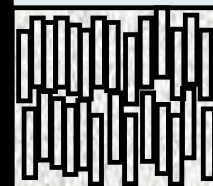
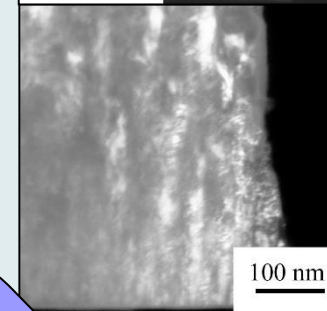
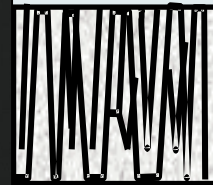
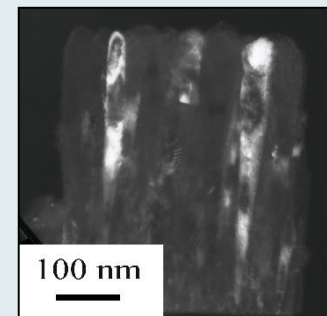
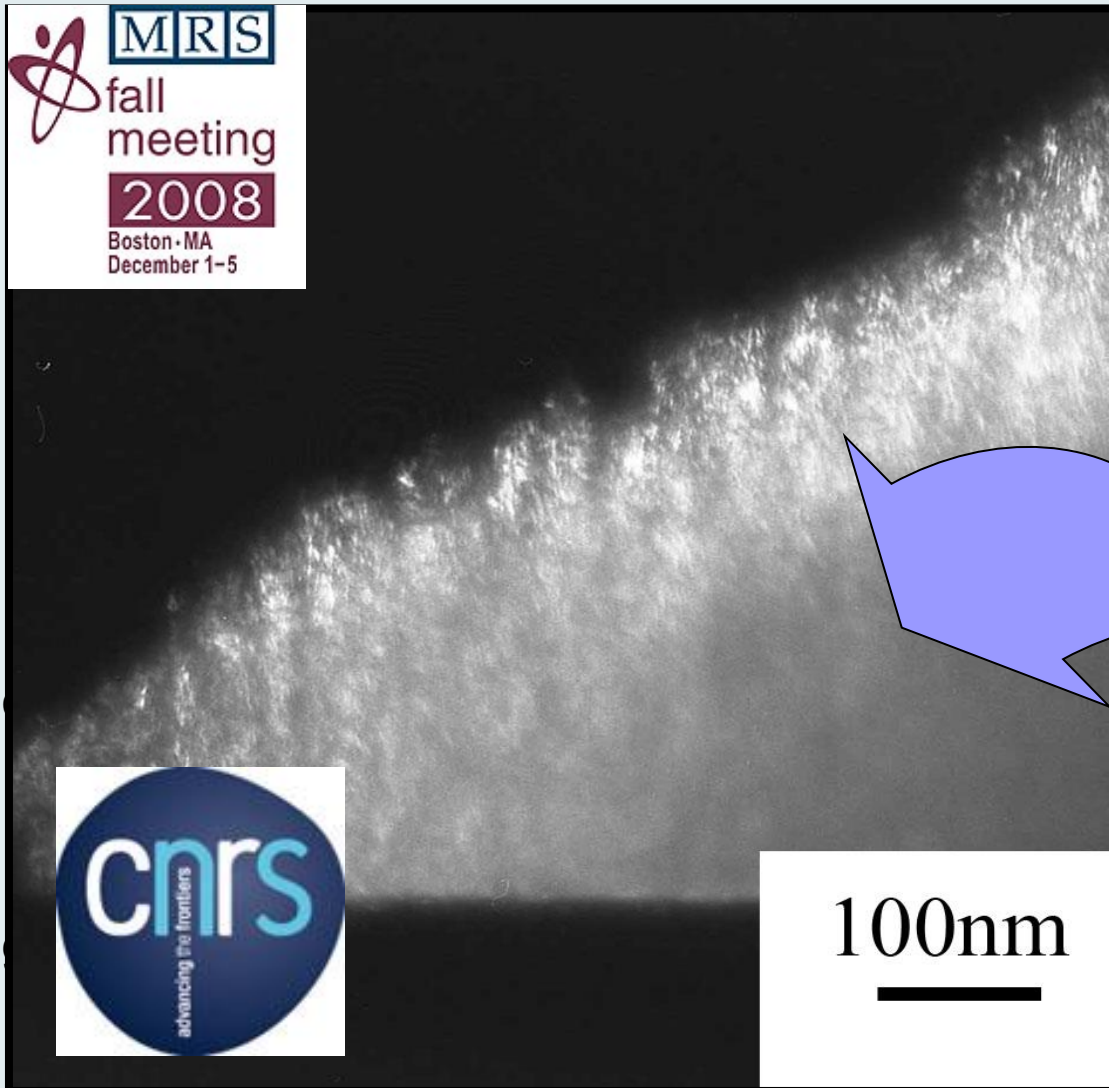
□ Nano



□ Nano

□ Nano

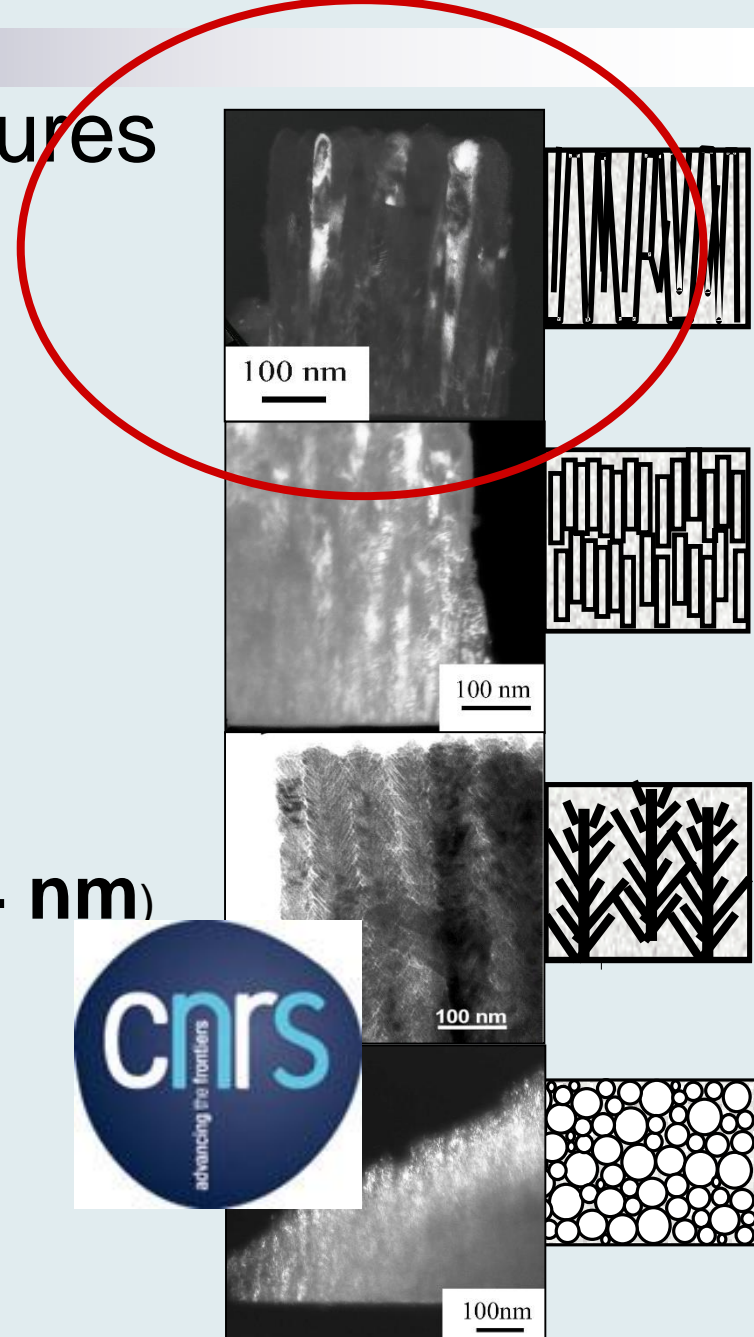
□ Nano



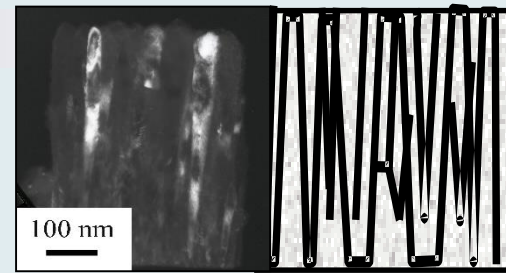
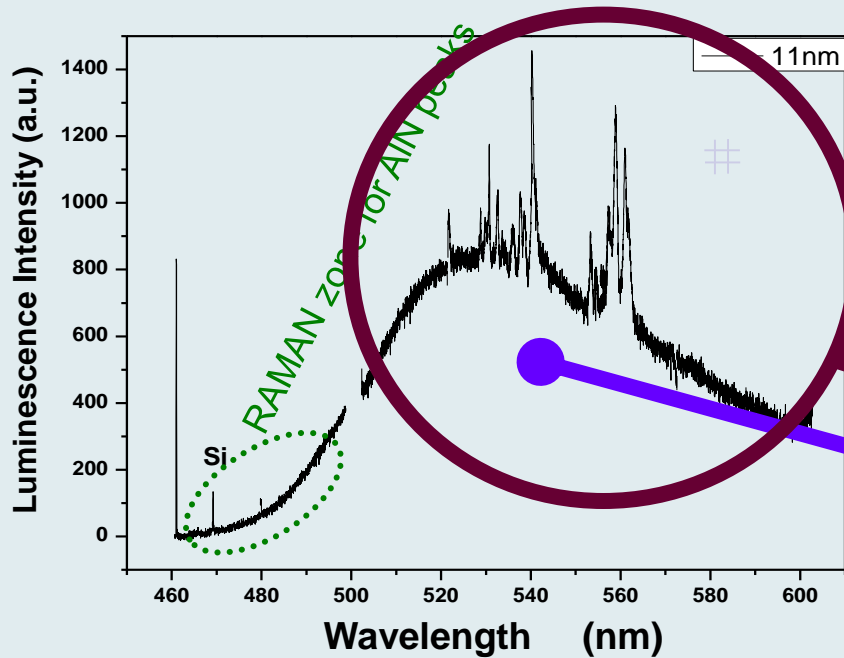
100nm

4 different AlN:Er nanostructures

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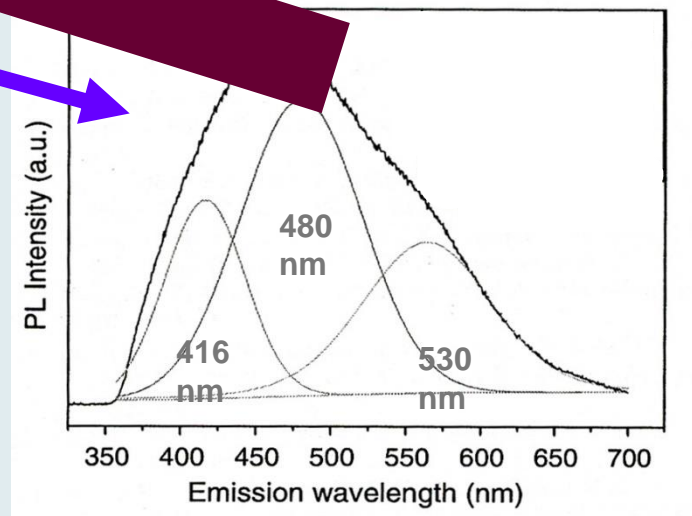


=> VISIBLE high spectral resolution luminescence



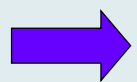
Width of column = 10 - 25 nm
AlN:Er dense film (cross view)

$\lambda_i = 458 \text{ nm (2.7 eV)}$



**** Chen 2008

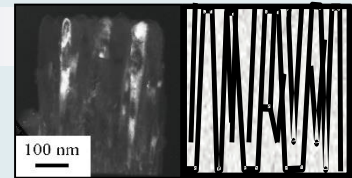
AlN spheres****, whiskers, nanotubes,
crystalline: PL in visible domain same range



Broad band centered
Around 530 nm:
PL of nano AlN

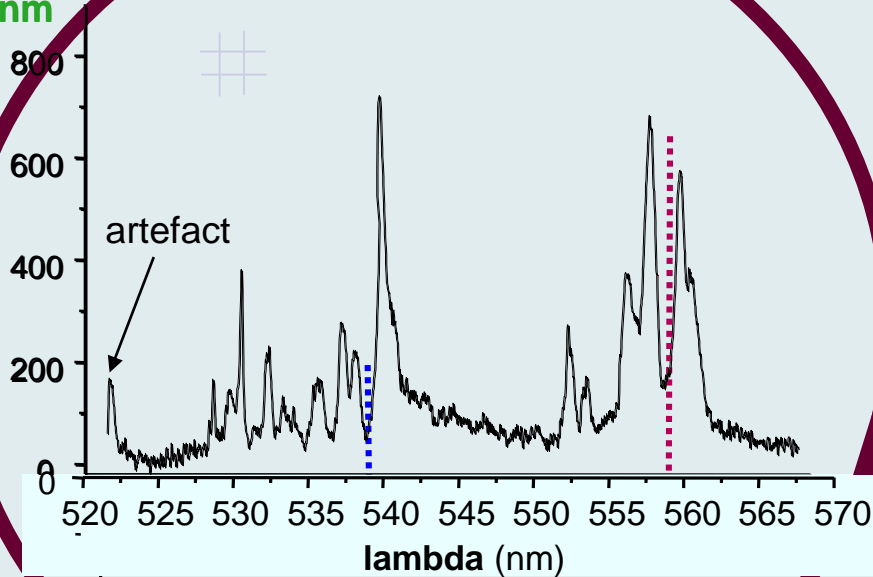


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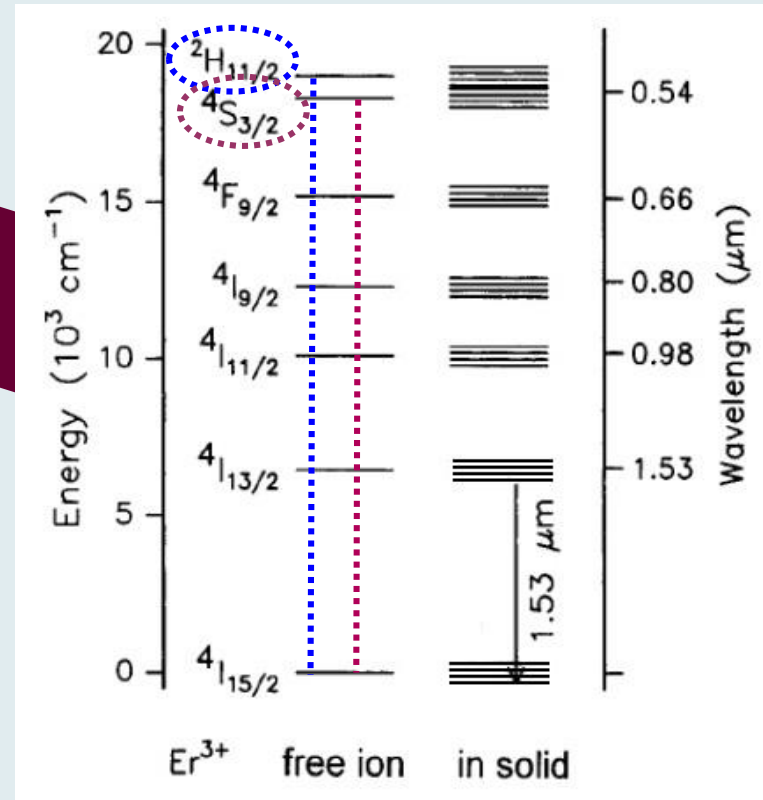
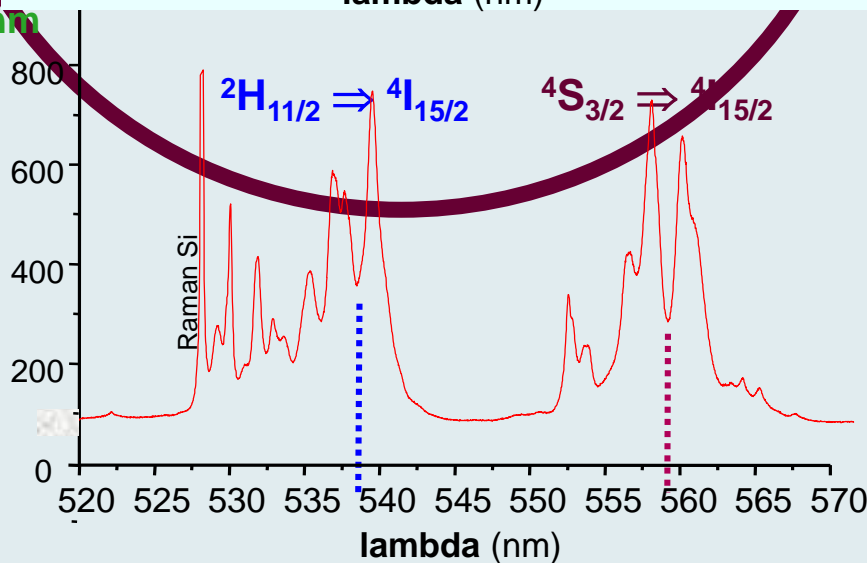


Width of column = 10 - 25 nm
AlN:Er dense film (cross view)

$\lambda_i = 458 \text{ nm}$
(2.7 eV)



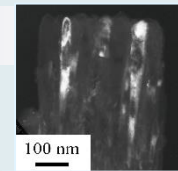
$\lambda_i = 514 \text{ nm}$
(2.4 eV)



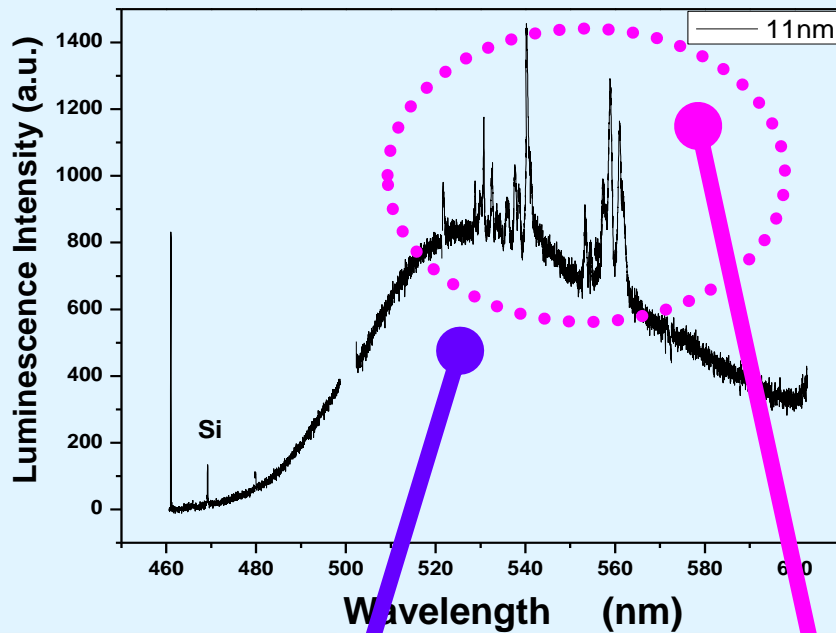
PL of Erbium



=> VISIBLE high spectral resolution luminescence



Width of column = 10 - 25 nm
AlN:Er dense film (cross view)



$\lambda_i = 458 \text{ nm } (2.7 \text{ eV})$

Broad band at
530 nm

Nano AlN

+

Fine structure

Er

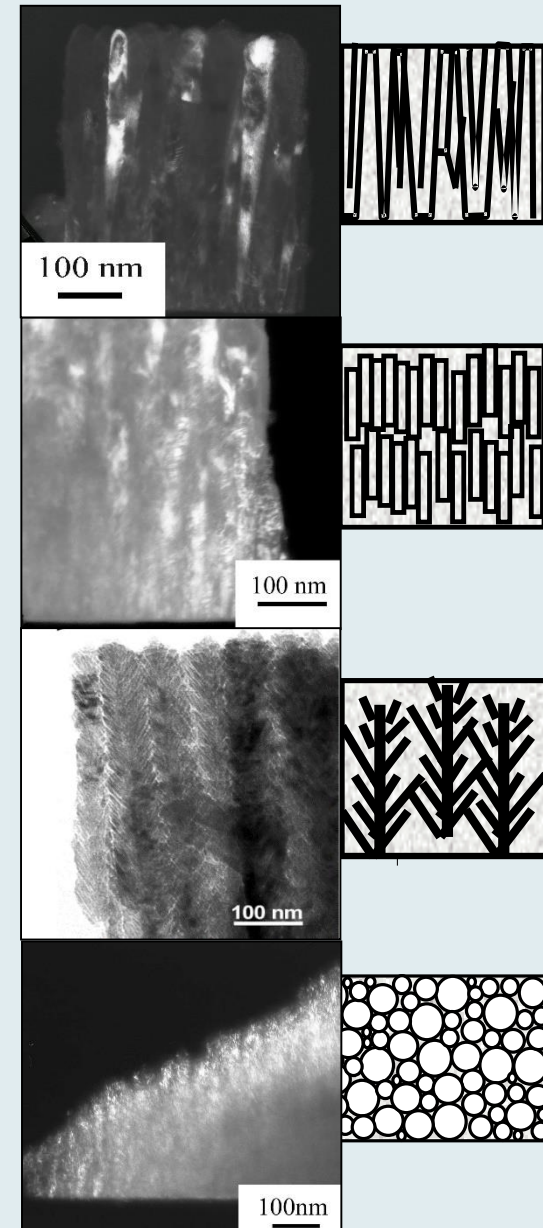


**Correspondance :
Transfer ?**

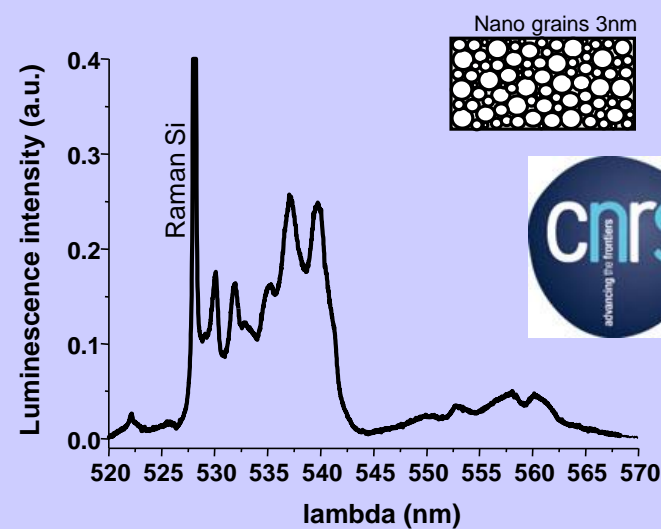
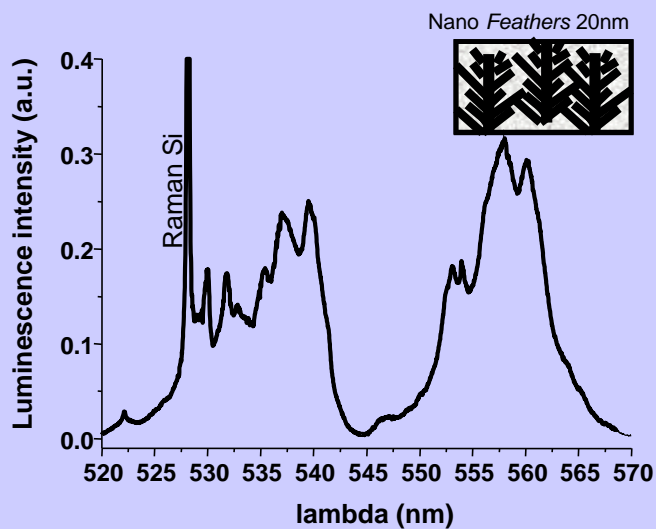
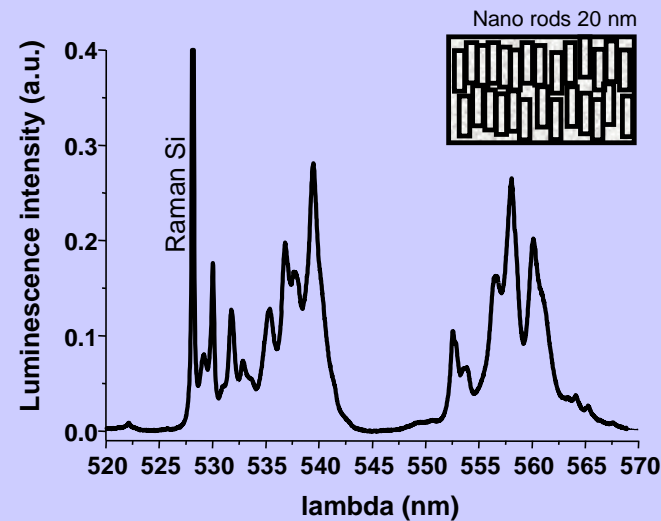
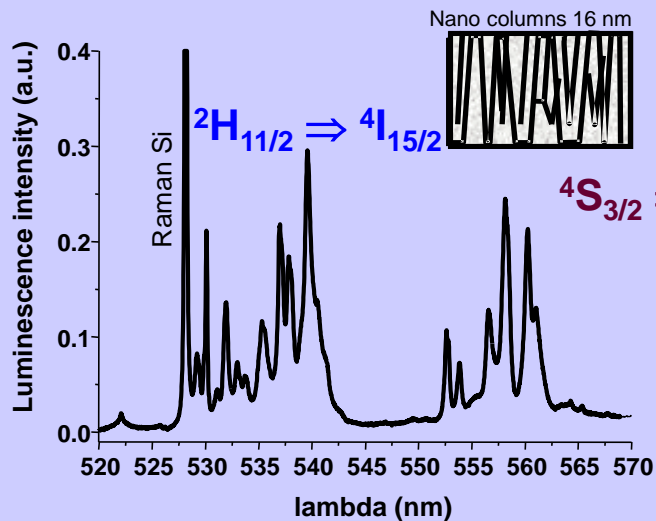


4 different AlN:Er nanostructures

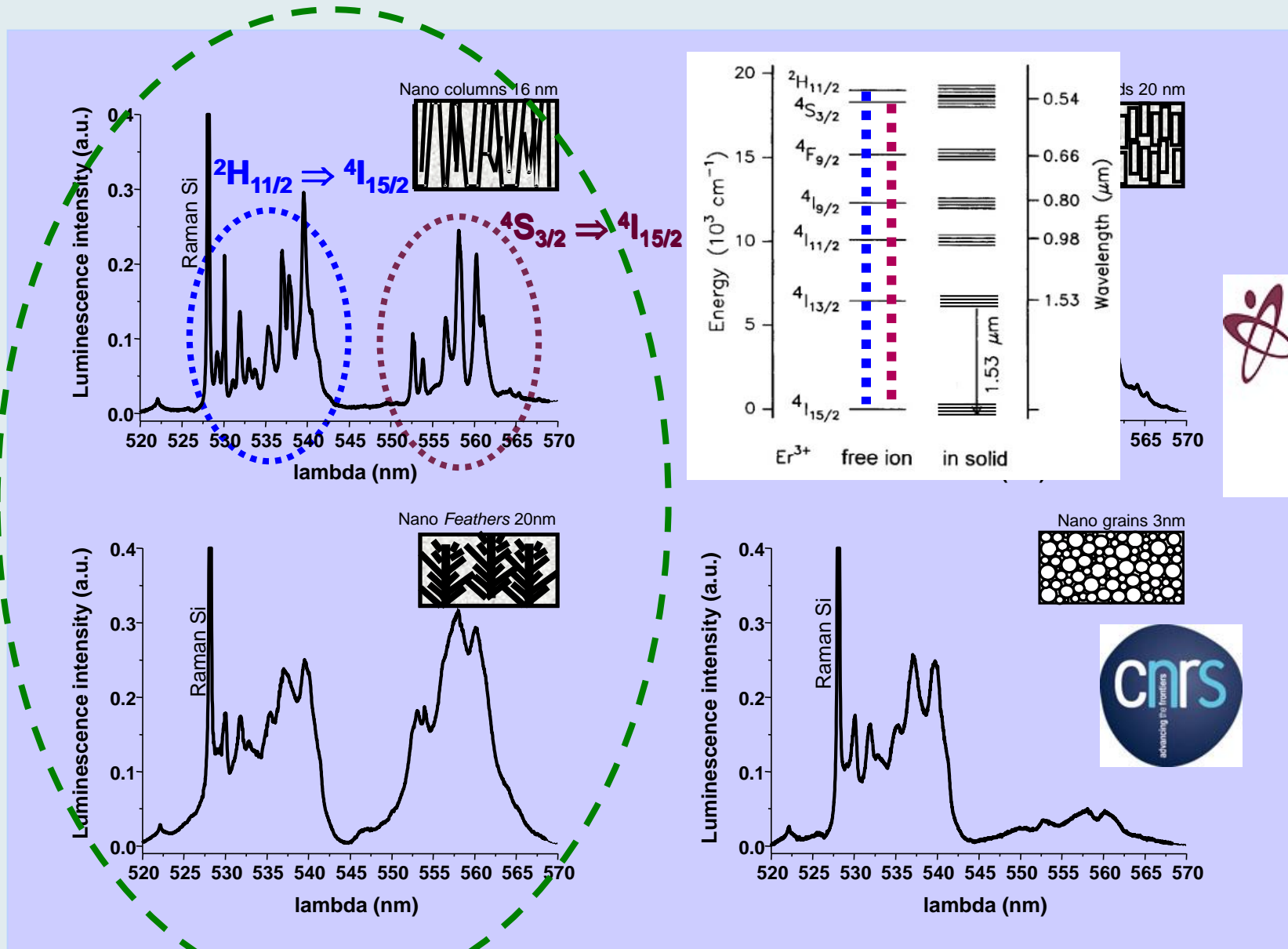
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Evolution of Er visible luminescence as a function of AlN structure

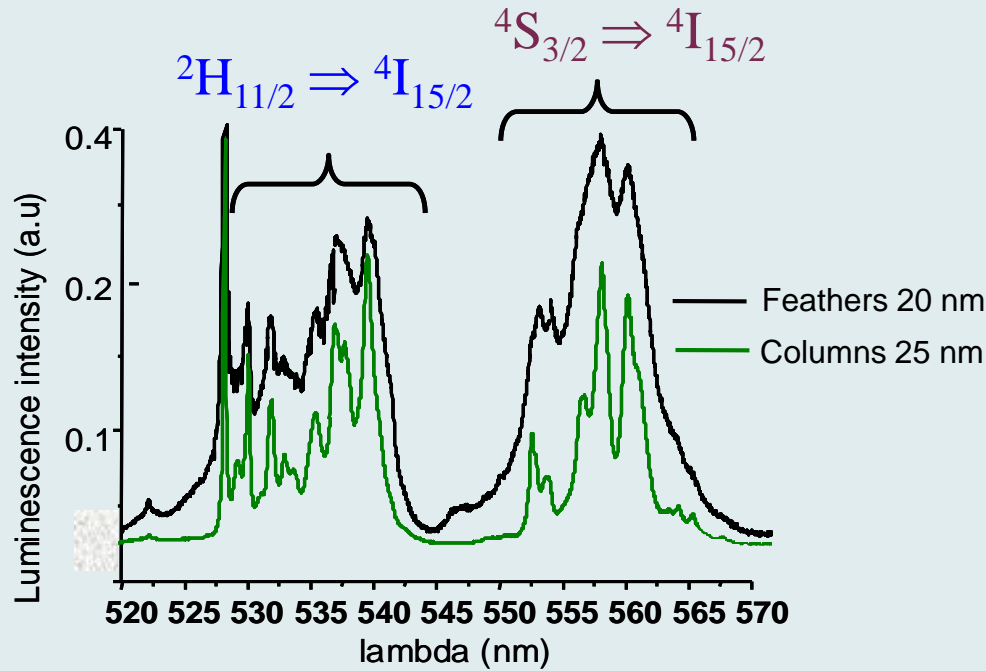


Evolution of Er visible luminescence as a function of AlN structure

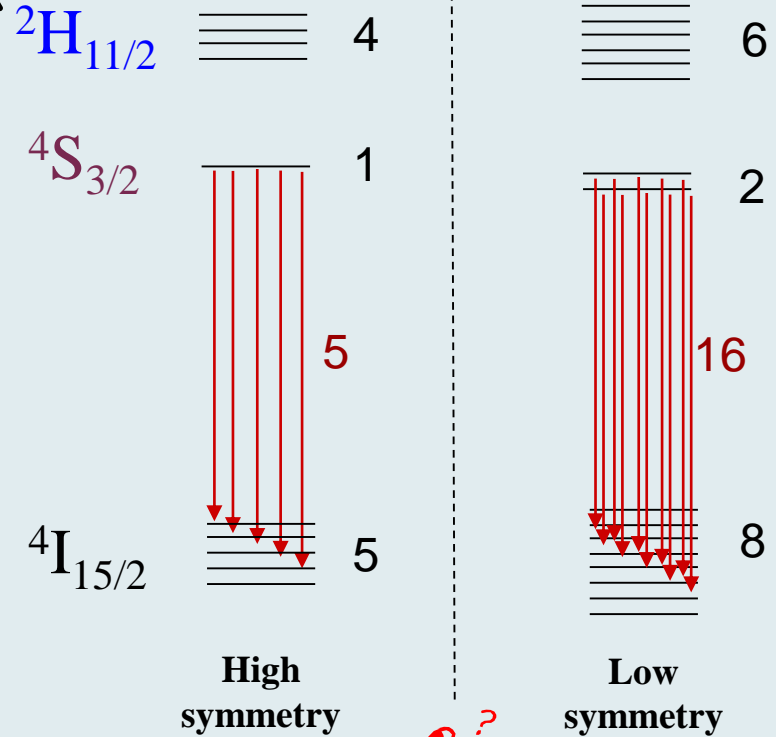


$\lambda_i = 514 \text{ nm} (2.4 \text{ eV})$

Contributions > 5 !



Energy



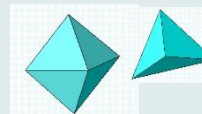
Er shells

Er cations are on:

1 low symmetry site (all contributions not resolved)

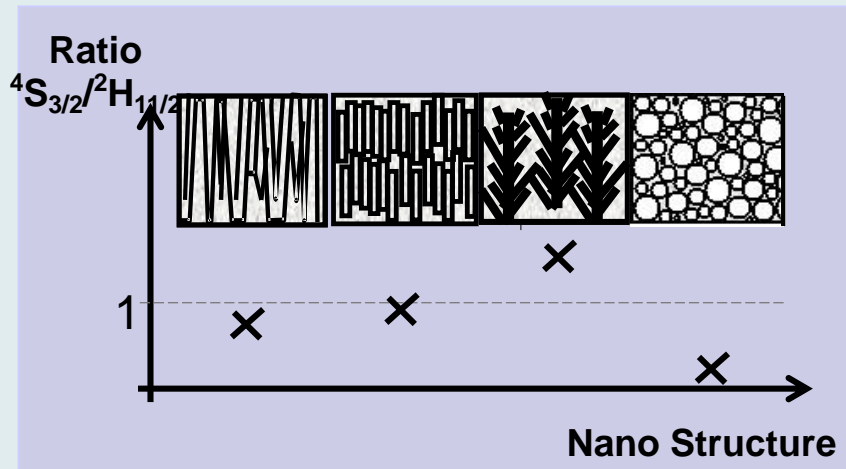
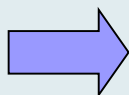
or 2 high symmetry sites (superimposed contributions)

=> Further experiments to conclude



Integrated areas

Sample	${}^2H_{11/2} \Rightarrow {}^4I_{15/2}$ (528-545nm)	${}^4S_{3/2} \Rightarrow {}^4I_{15/2}$ (545-570nm)	ratio ${}^4S_{3/2}/{}^2H_{11/2}$
Nano columns 16 nm	1,28	1,09	0,85
Nano rods 20 nm	1,41	1,37	0,97
Nano "feathers" 20 nm	2,22	2,90	1,31
Nano grains 3nm	2,07	0,56	0,27



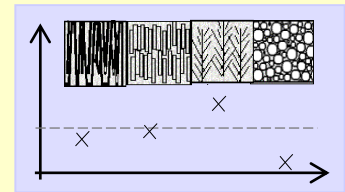
Er can trace the nano-structure, as Eu in glasses *

* G. Vicentini, et al. Coord. Chem. Rev. (2000)

To summarize:

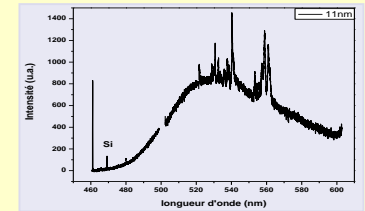
Er Tracer of the nano-structure : Probe of disorder

Need of further experiment to identify the Er site:
- Site selective photoluminescence



Coïncidence of visible PL of nano AlN and Er:

- AlN matrix : **broad** band centered around 530 nm
- Er : 520 - 570 nm



Possibility of energy transfer for IR 1.54 μm Er PL ? Nano AlN may become a RE sensitizer

Need of further experiment to confirm

- Low temperature PL measurement ?
- Life time measurement : which kind of decay ?

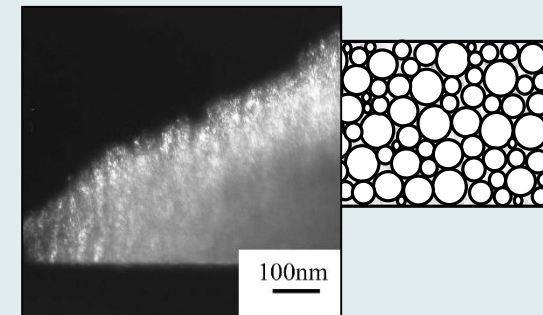
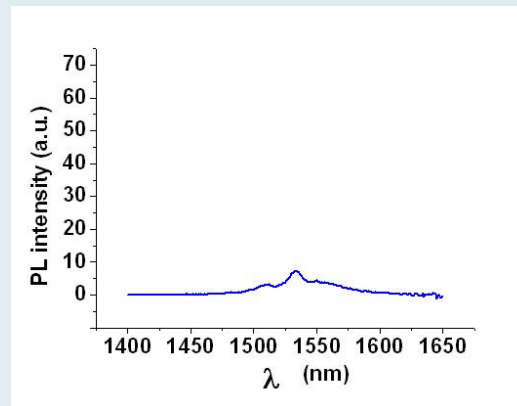
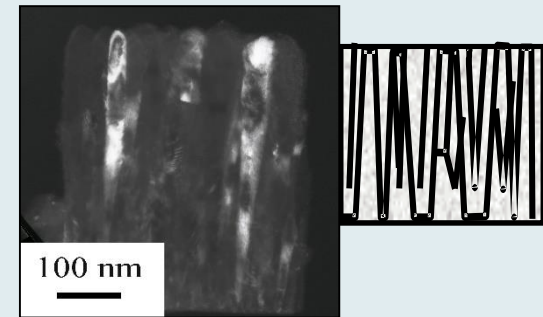
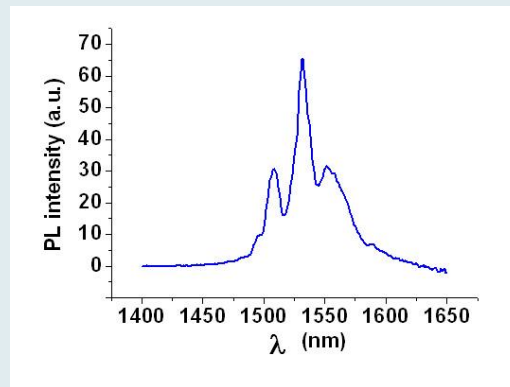


Recent result:

INFRA RED 1.54 μm luminescence measurement versus 2 structures



$\lambda_i = 325 \text{ nm (3.8 eV)}$



*Thank you
for your attention*



Place Stanislas, Nancy, France