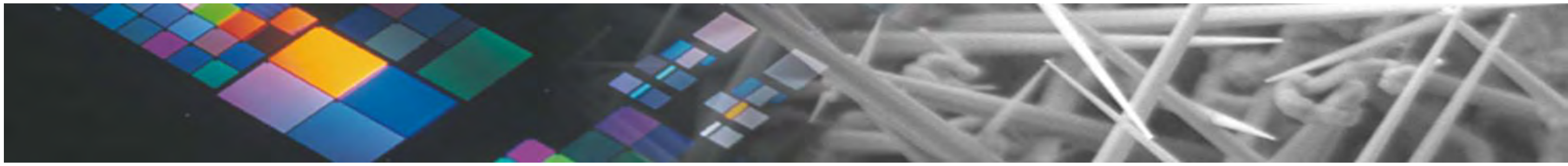
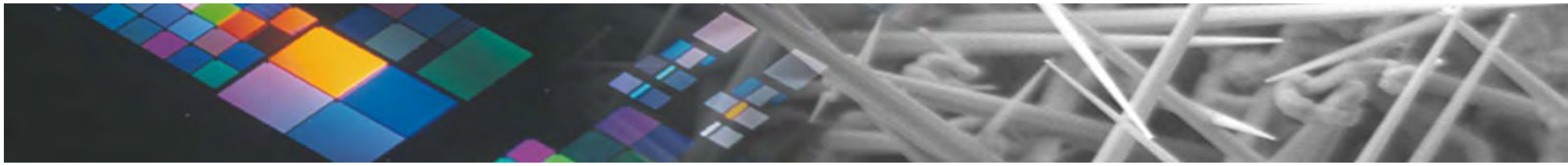


Impression de réseaux de piliers déformables pour pendéo-épitaxie de GaN

C. Gourgon, Mrad Mrad, S. Labau, M. Panabière, C. Petit-Etienne

Laboratoire des Technologies de la Microélectronique
Grenoble

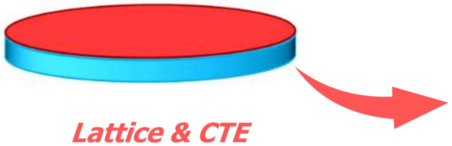


Projet ANR PEGADIS (Pendeo-Epitaxy of GAN for DISplays) 2021-2023

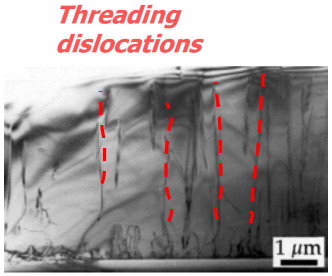
Objectif : optimisation de µleds à base de GaN sur substrat SOI par pendeo epitaxy

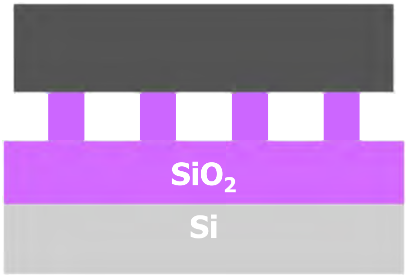
- **CEA-LETI-DPFT**
- LTM
- CHREA
- CEMEF

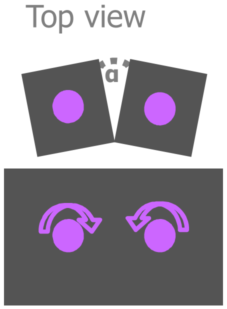
GaN on Si : limitations



Lattice & CTE mismatch
+ Nuclei misorientation





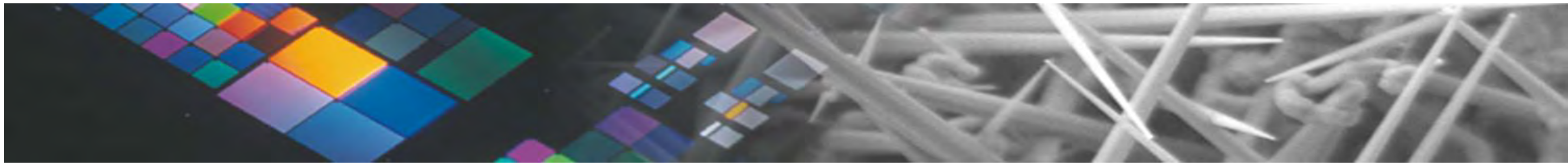


2 mis-oriented crystallites on <u>deformable pedestals</u> (tilt + twist)

(SiO_2 easily deformable at GaN growth temperature)

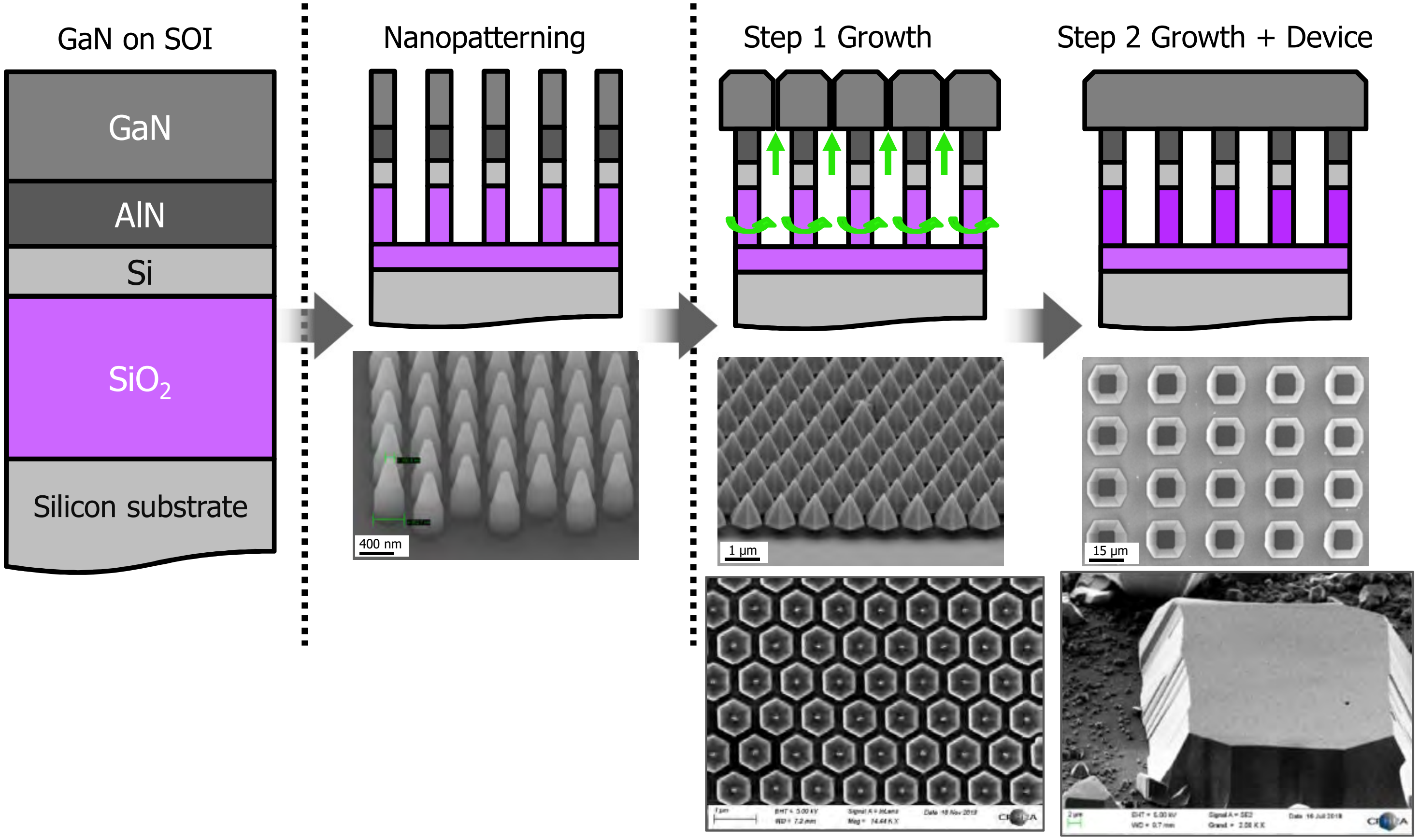
→ No grain boundary defects are generated

Patent CEA/CNRS patent WO2019122461



Process technologique

CRHEA | LTM | CRHEA

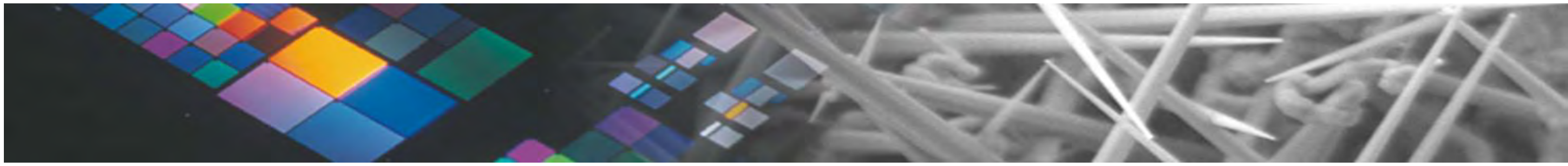


GaN on SOI

Nanopatterning

Step 1 Growth

Step 2 Growth + Device

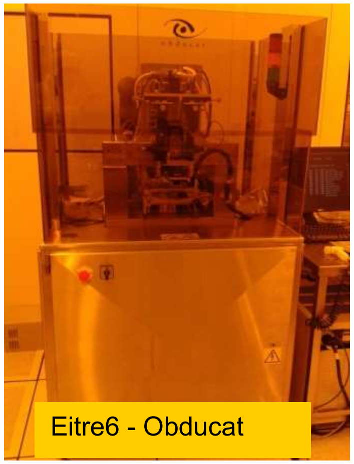


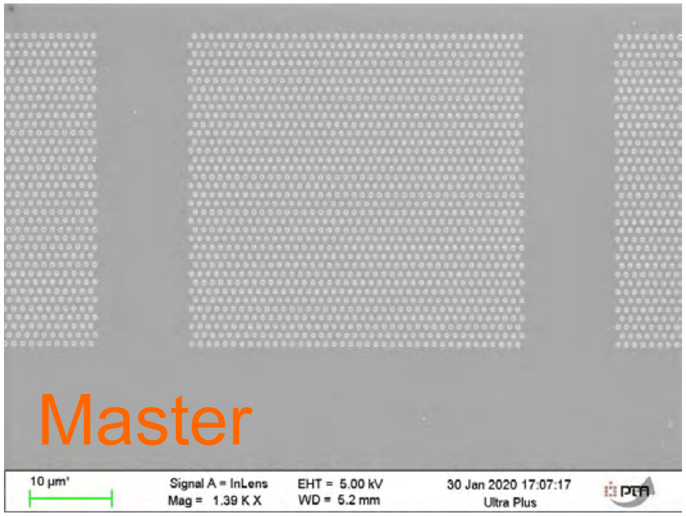
Patterning des nanopiliers

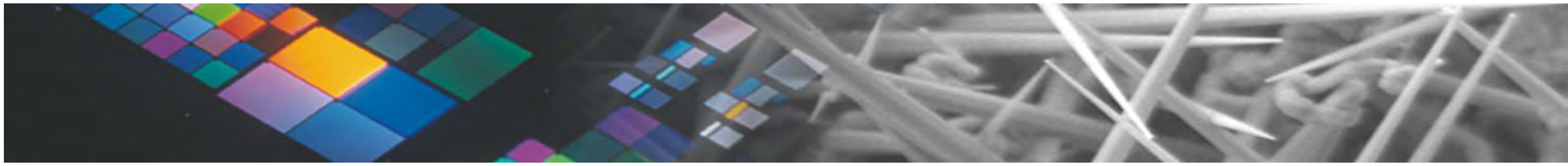
- NIL : Equipement Eitre 6 – Obducat
- UV-NIL thermique
- Résolution 100 nm
- Objectif : aucun pilier manquant pour optimiser la recroissance
- Master : lithographie E-beam / Plasma etching / FDTS

(LAAS – réseau Renatech)

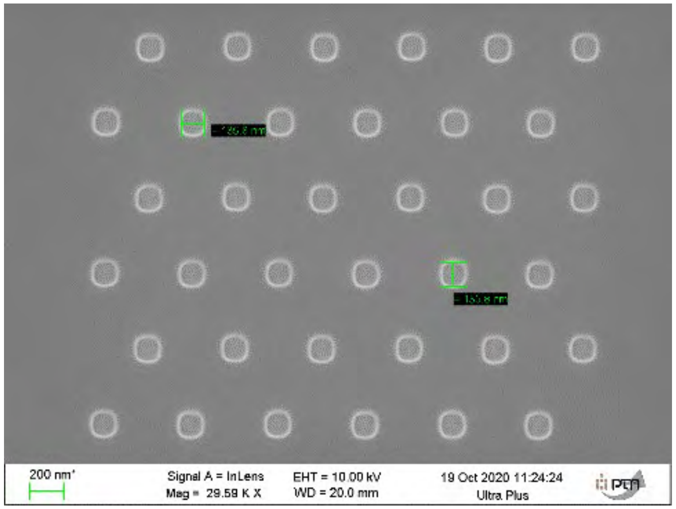
- Réseaux de 200x200 µm² à 3x3 µm² pour µleds


Eitre6 - Obducat

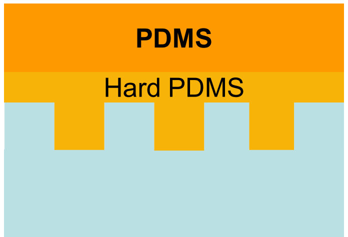

Master

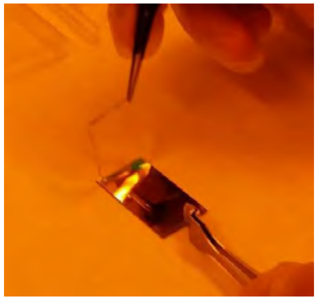


NanoImprint

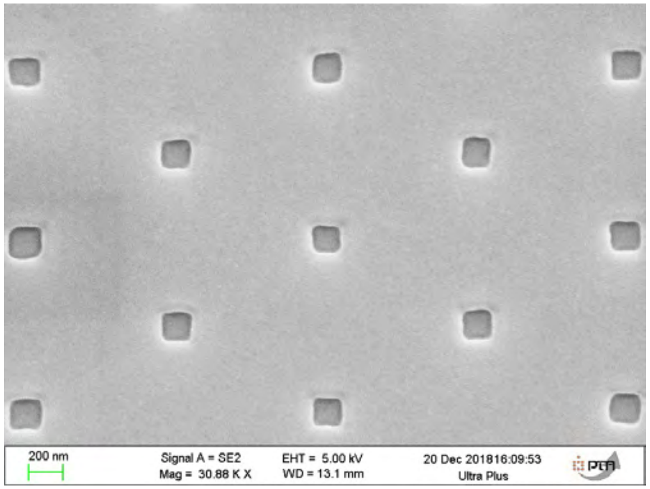


Master Si

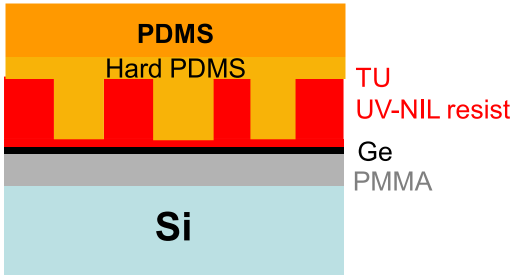


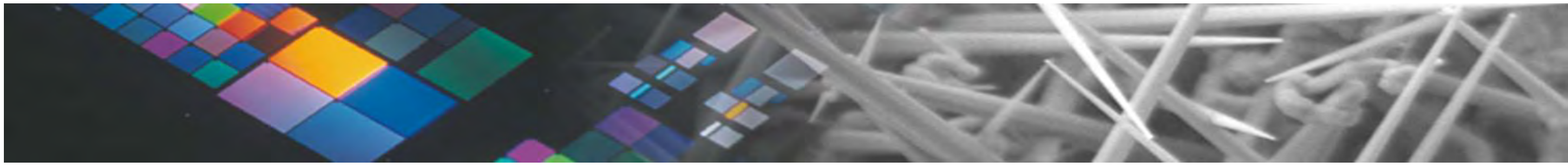


Moule



NIL



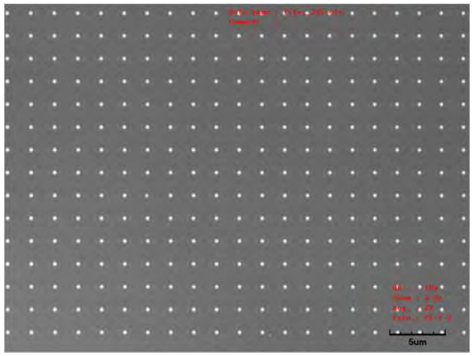


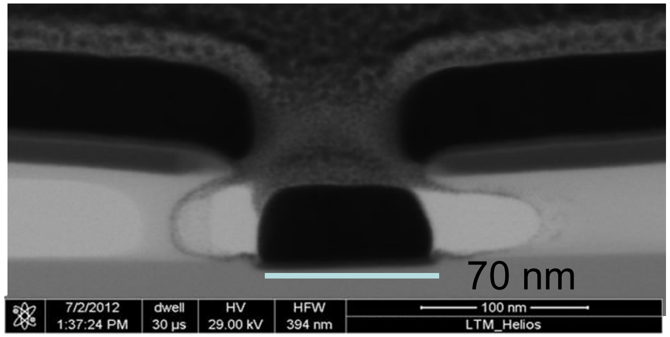
Plots Ni

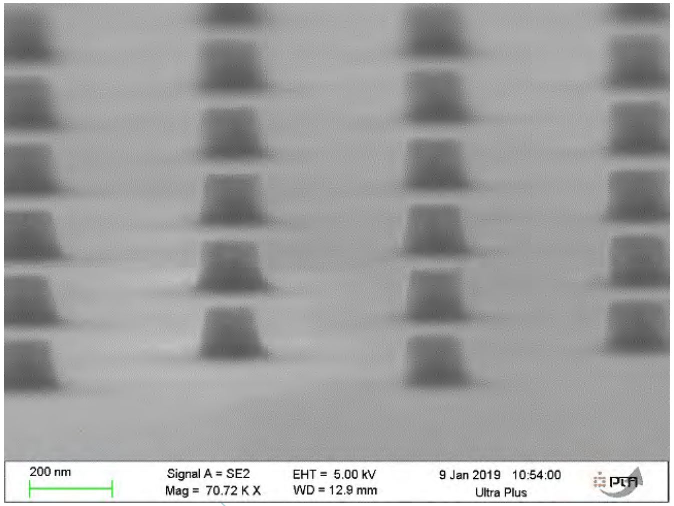
- Plasma etching pour graver la tri-couche avec profil rentrant

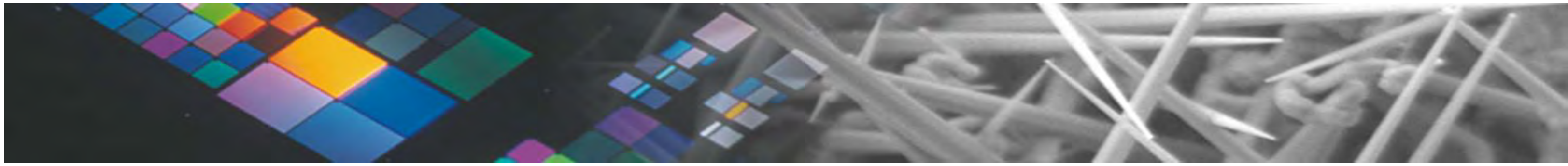
- Dépôt 75 nm masque Ni

- Lift off



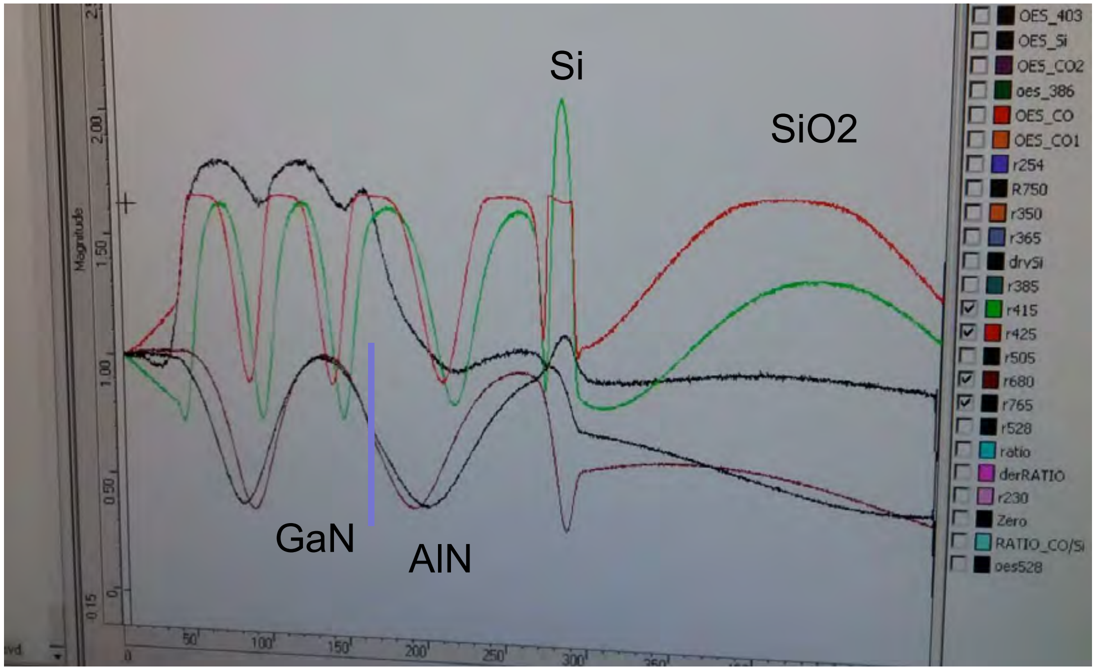


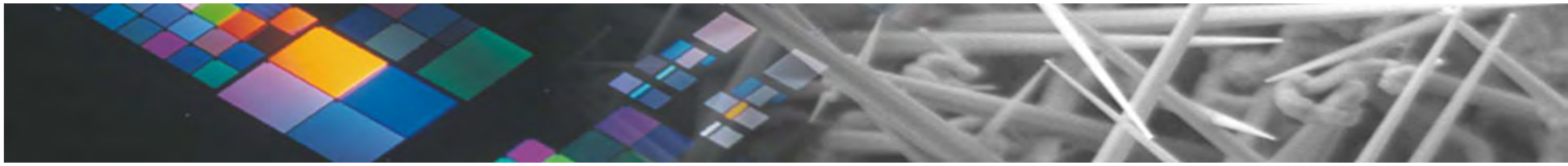


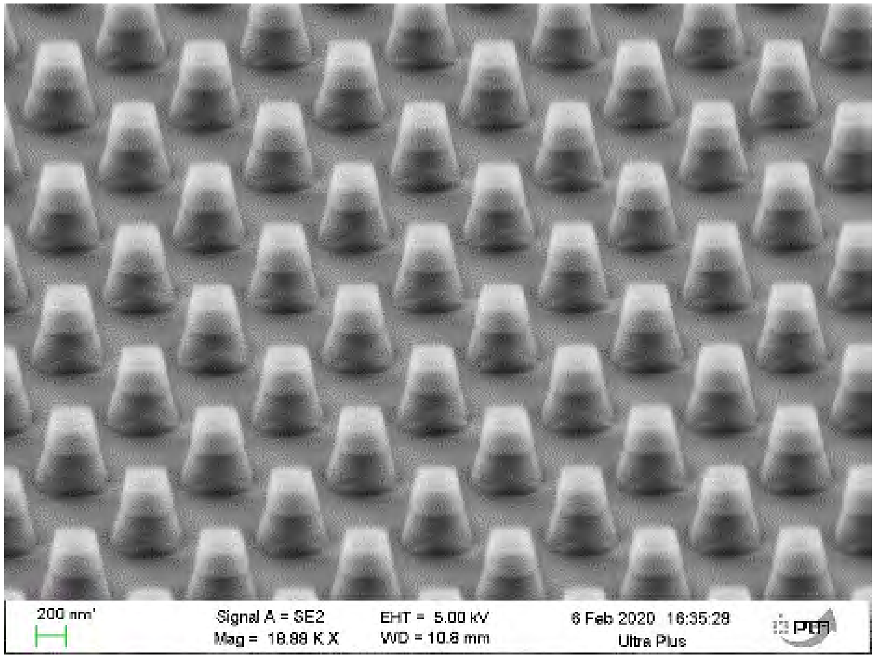


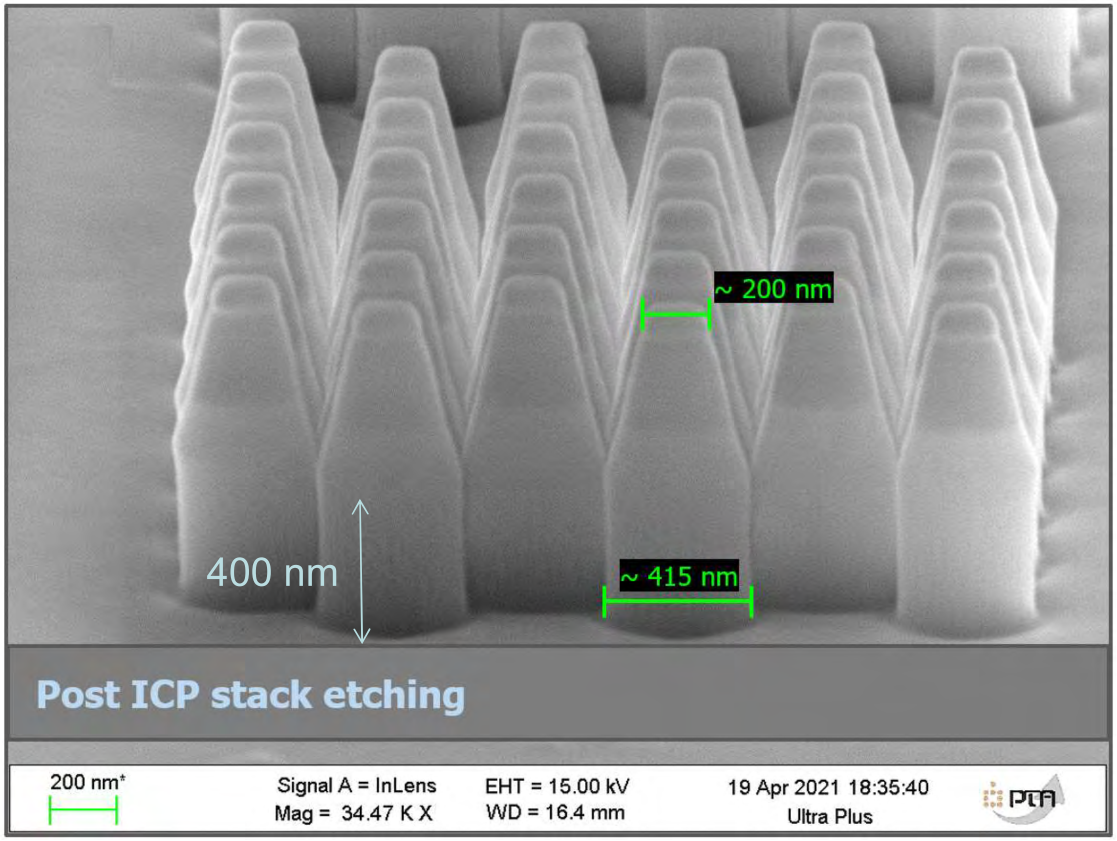
Plasma etching empilement GaN/AlN/SOI

- ICP DPS chamber – Applied Materials
- Contôle interférométrique
- Possibilité de contrôler la profondeur gravée dans SiO2

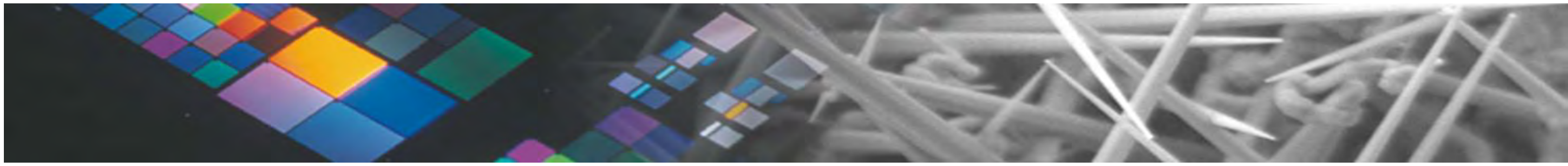


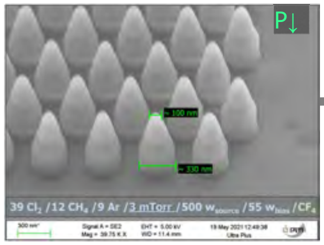


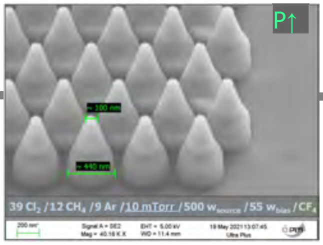


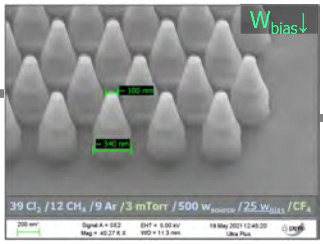


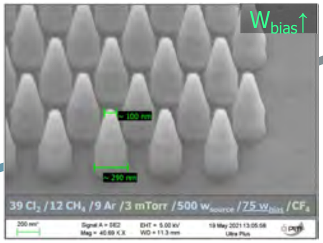
→ Optimisation du contrôle de la pente pour réduire D_{bottom}

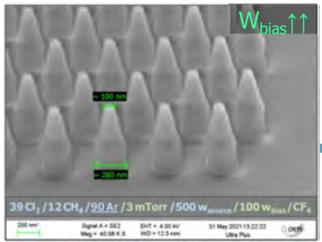


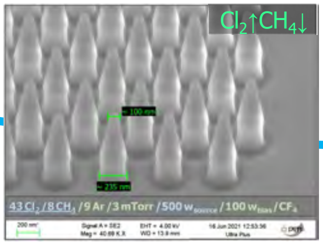

P↓
~ 100 nm
~ 330 nm
39 Cl$_2$ /12 CH$_4$ /9 Ar /3 mTorr /500 w$_{source}$ /55 w$_{bias}$ /CF$_4$
300 nm
Signal A = SE2
Mag = 39.75 K X
EHT = 5.00 kV
WD = 11.4 mm
19 May 2021 12:49:38
Ultra Plus

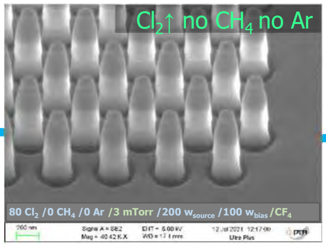

P↑
~ 100 nm
~ 440 nm
39 Cl$_2$ /12 CH$_4$ /9 Ar /10 mTorr /500 w$_{source}$ /55 w$_{bias}$ /CF$_4$
200 nm
Signal A = SE2
Mag = 40.16 K X
EHT = 5.00 kV
WD = 11.4 mm
19 May 2021 13:07:45
Ultra Plus

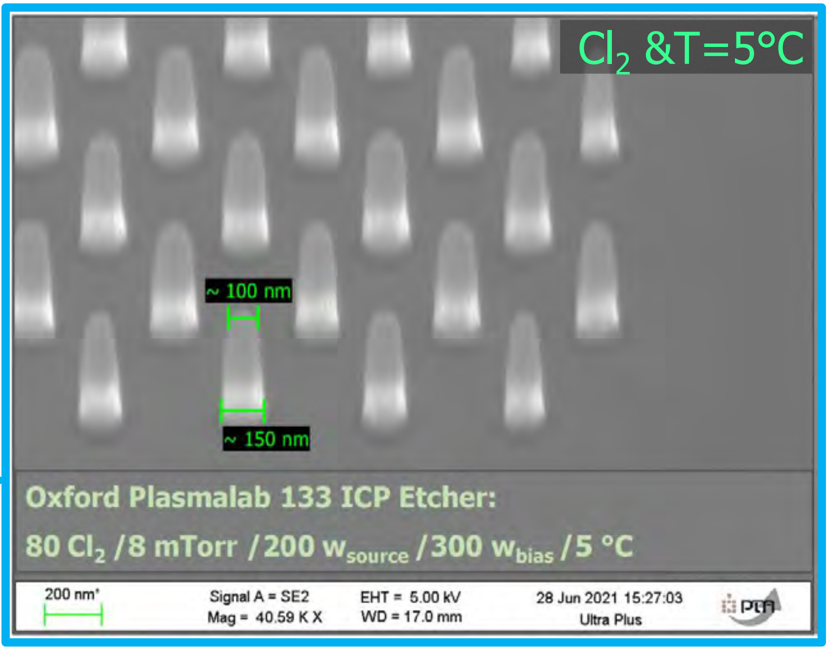

W$_{bias}$↓
~ 100 nm
~ 340 nm
39 Cl$_2$ /12 CH$_4$ /9 Ar /3 mTorr /500 w$_{source}$ /25 w$_{bias}$ /CF$_4$
200 nm
Signal A = SE2
Mag = 40.27 K X
EHT = 5.00 kV
WD = 11.3 mm
19 May 2021 12:45:20
Ultra Plus

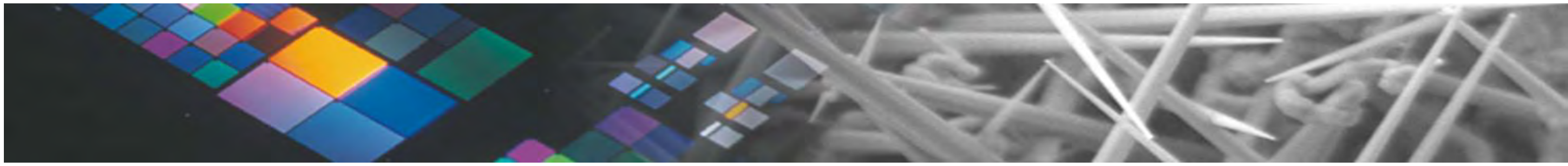

W$_{bias}$↑
~ 100 nm
~ 290 nm
39 Cl$_2$ /12 CH$_4$ /9 Ar /3 mTorr /500 w$_{source}$ /75 w$_{bias}$ /CF$_4$
200 nm
Signal A = SE2
Mag = 40.69 K X
EHT = 5.00 kV
WD = 11.3 mm
19 May 2021 13:05:58
Ultra Plus

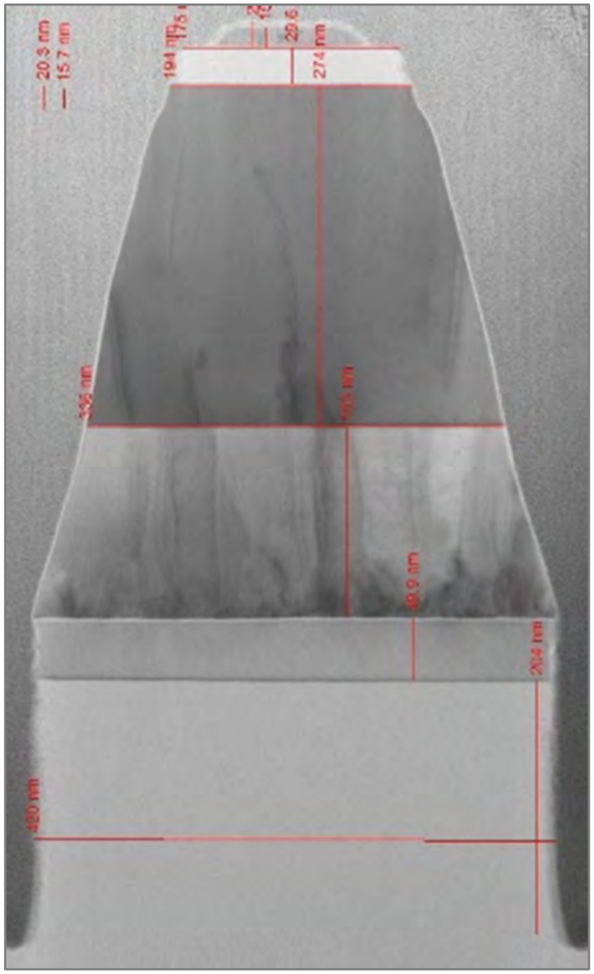

W$_{bias}$↑↑
~ 100 nm
~ 280 nm
39 Cl$_2$ /12 CH$_4$ /90 Ar /3 mTorr /500 w$_{source}$ /100 w$_{bias}$ /CF$_4$
200 nm
Signal A = SE2
Mag = 40.58 K X
EHT = 4.00 kV
WD = 12.5 mm
31 May 2021 13:22:22
Ultra Plus

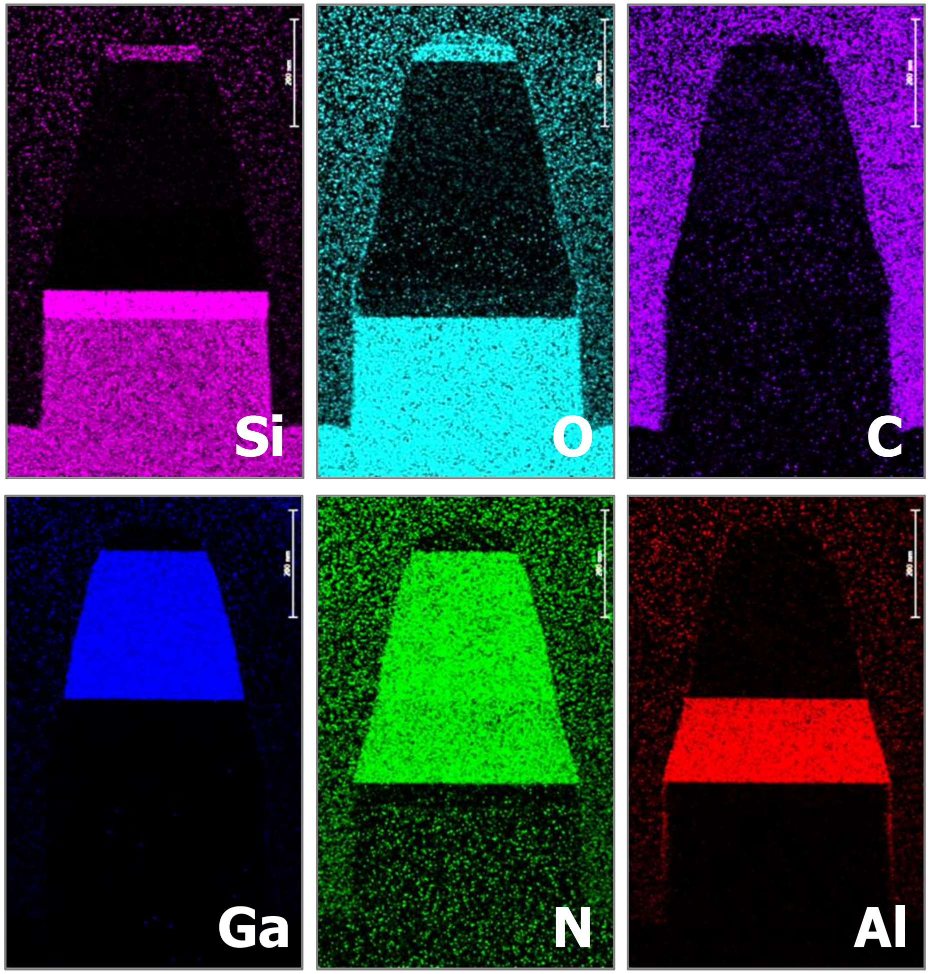

Cl$_2$↑CH$_4$↓
~ 100 nm
~ 235 nm
43 Cl$_2$ /8 CH$_4$ /9 Ar /3 mTorr /500 w$_{source}$ /100 w$_{bias}$ /CF$_4$
200 nm
Signal A = SE2
Mag = 40.69 K X
EHT = 4.00 kV
WD = 13.8 mm
16 Jun 2021 12:53:56
Ultra Plus


Cl$_2$↑ no CH$_4$ no Ar
80 Cl$_2$ /0 CH$_4$ /0 Ar /3 mTorr /200 w$_{source}$ /100 w$_{bias}$ /CF$_4$
200 nm
Signal A = SE2
Mag = 40.42 K X
EHT = 5.00 kV
WD = 17.1 mm
12 Jul 2021 12:17:00
Ultra Plus

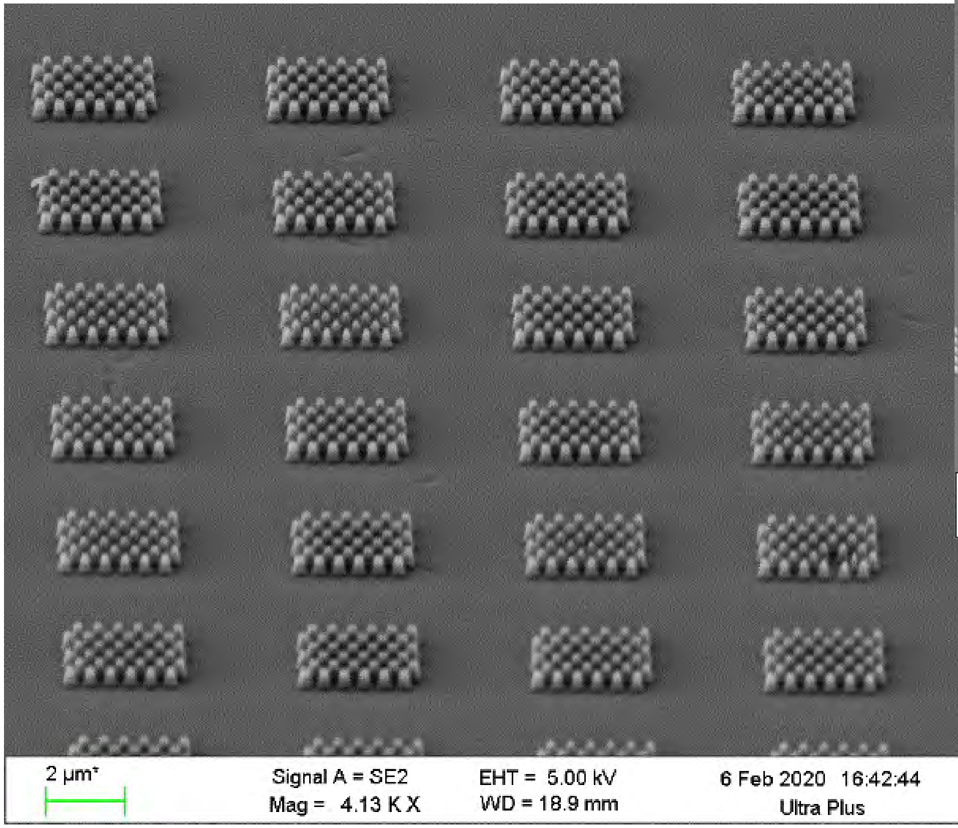

Cl$_2$ &T=5°C
~ 100 nm
~ 150 nm
Oxford Plasmalab 133 ICP Etcher:
80 Cl$_2$ /8 mTorr /200 w$_{source}$ /300 w$_{bias}$ /5 °C
200 nm
Signal A = SE2
Mag = 40.59 K X
EHT = 5.00 kV
WD = 17.0 mm
28 Jun 2021 15:27:03
Ultra Plus

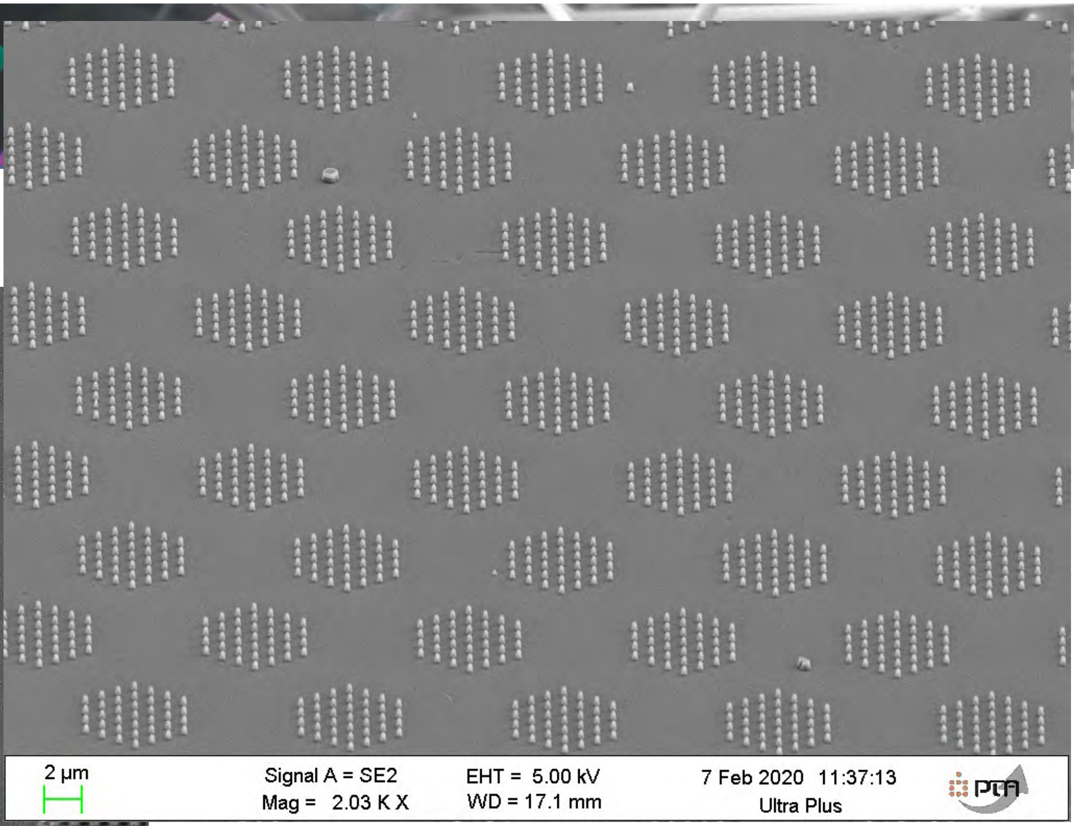


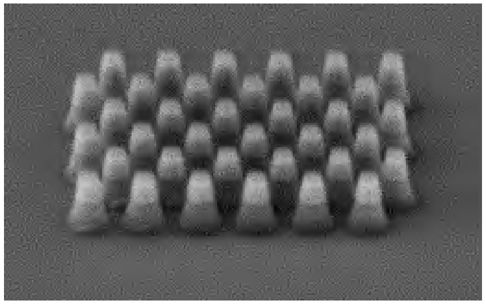

20.3 nm
15.7 nm
194 nm
17.5
29.6
274 nm
556 nm
49.9 nm
204 nm
480 nm

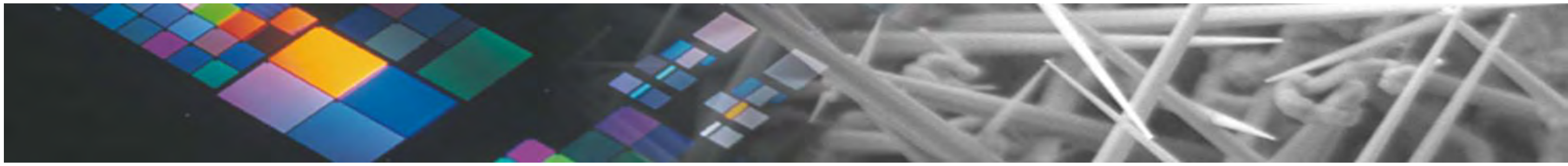

Si
O
C
Ga
N
Al

Réseaux pour µleds









Conclusion

- Réseaux de piliers 100 nm par nanoimpression UV/Thermique
- Limitation des défauts tels que piliers manquants par combinaison hard-PDMS / tricouche
- Process mature pour la réalisation de µLeds