

On the synthesis of highly-oriented GaN thin films by RF-magnetron sputtering

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Outline

- Motivation
- Thin film growth by RF magnetron sputtering
- Microstructural/morphological analysis
- Conclusions

➤ Motivation

- Growth
- Processing
- Fabrication
- Characterization (structural and functional)



- New positron moderator

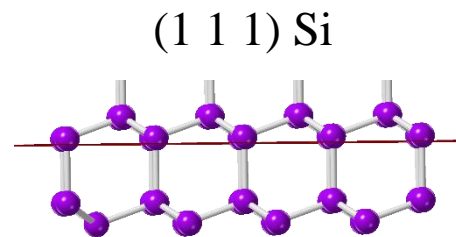
➤ Motivation

- Growth
- Processing
- Fabrication
- Characterization (structural and functional)

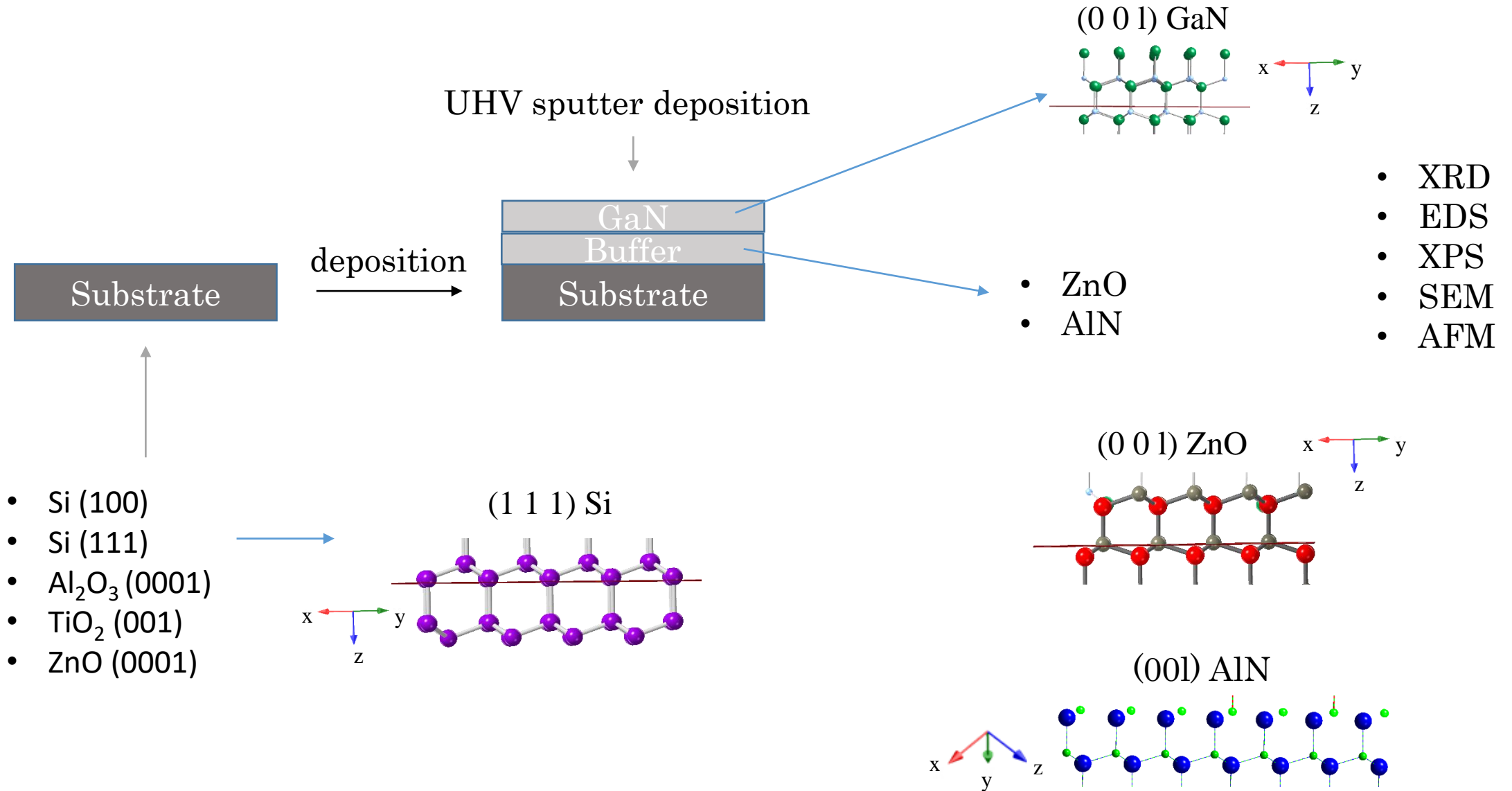
- New positron moderator

Substrate

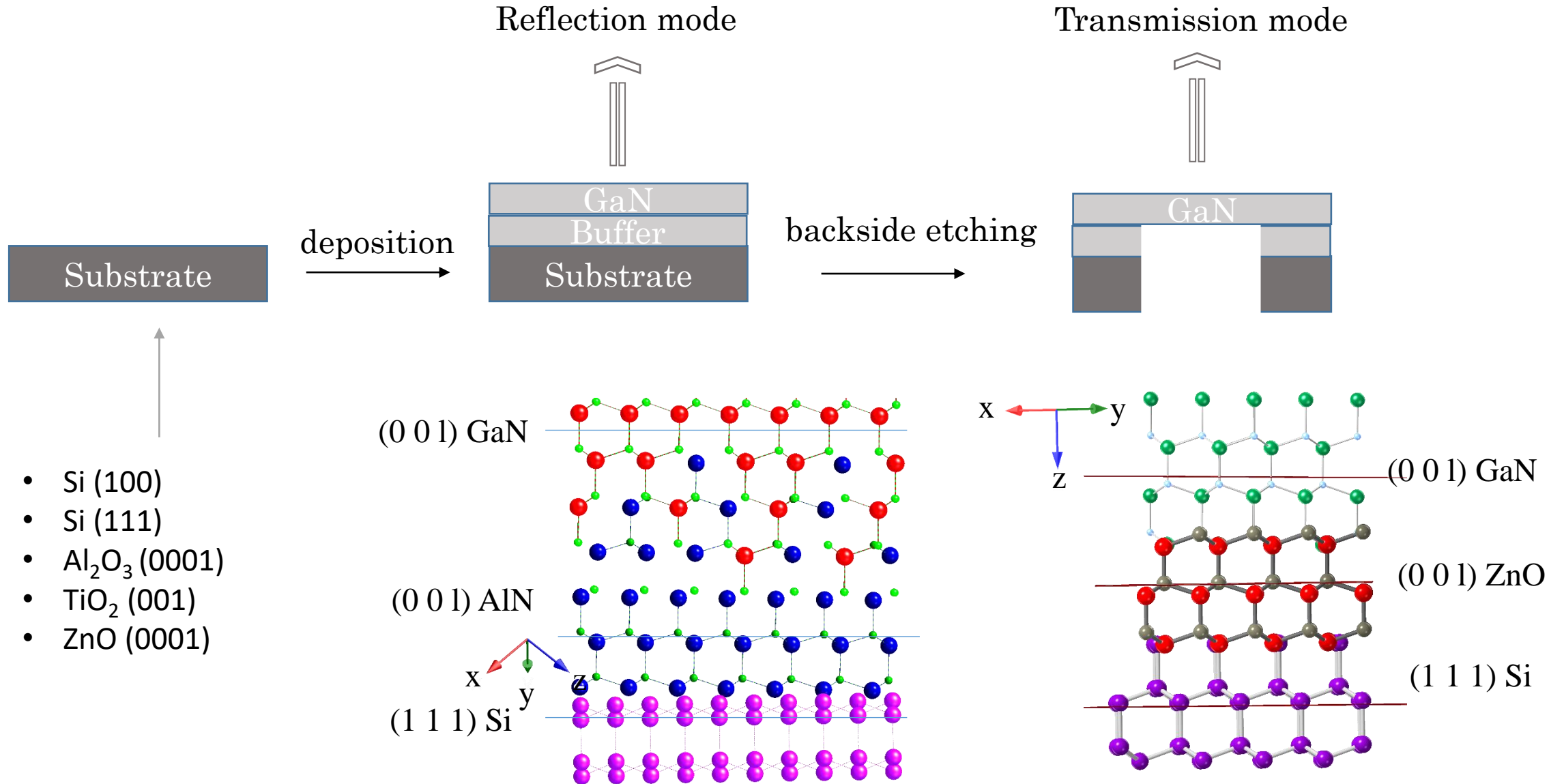
- Al_2O_3
- ZnO
- Si
- TiO_2



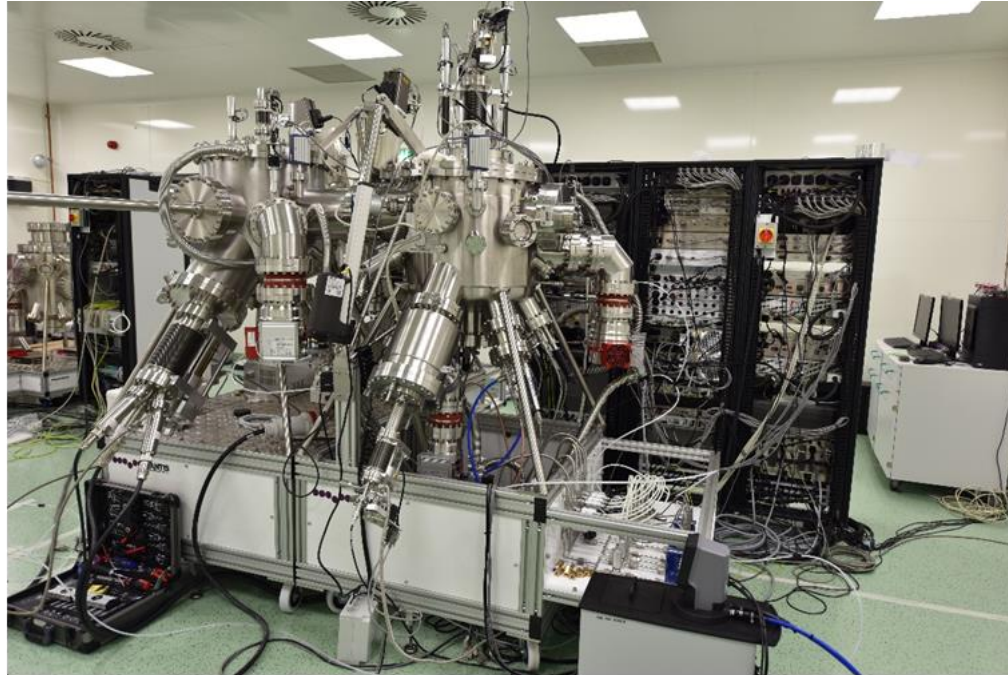
➤ Motivation



➤ Introduction



➤ Thin film growth by RF magnetron sputtering

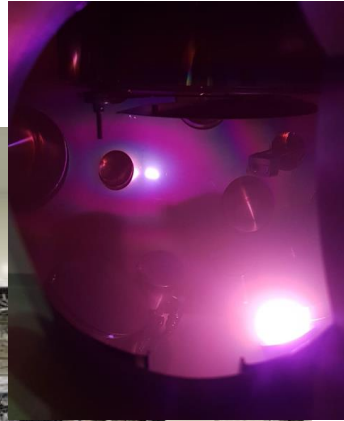
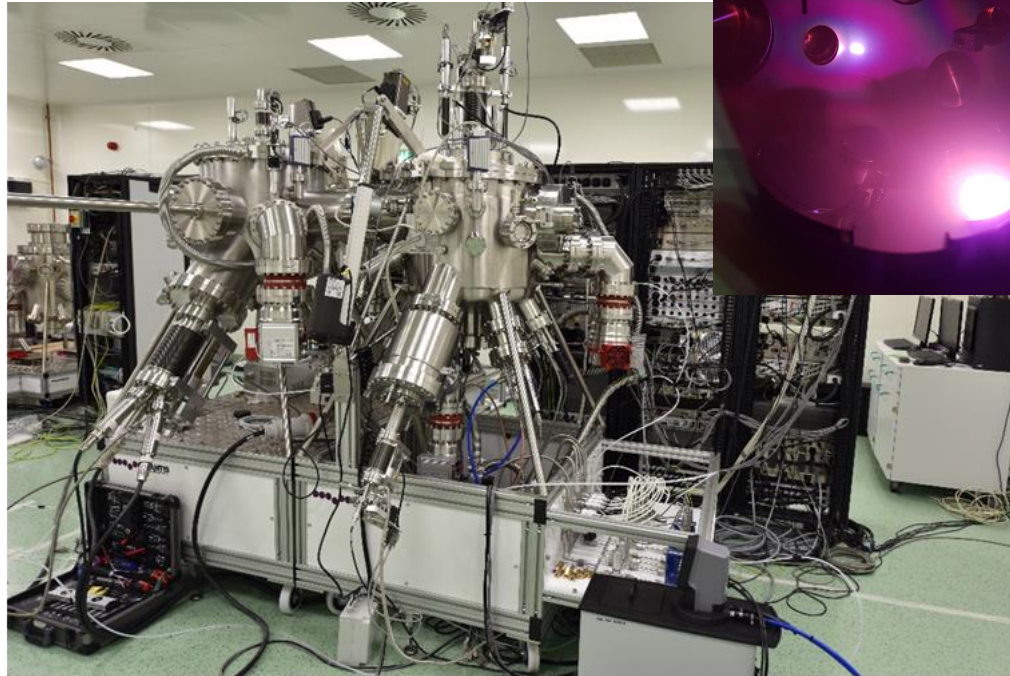


ELI-NP UHV-cluster for RF/DC sputter deposition of nitrides, metals, oxides, hybrid structures

- Interconnected chambers
- In-situ manual transfer of samples
- Ar-ion milling
 - *for soft cleaning of the substrate
 - *for physical etching

Wafers 5-150 mm; $T_{\text{dep.}}$ up to 800°C (metals /nitrides)/1000°C (oxides)
(Mantis Deposition, UK)

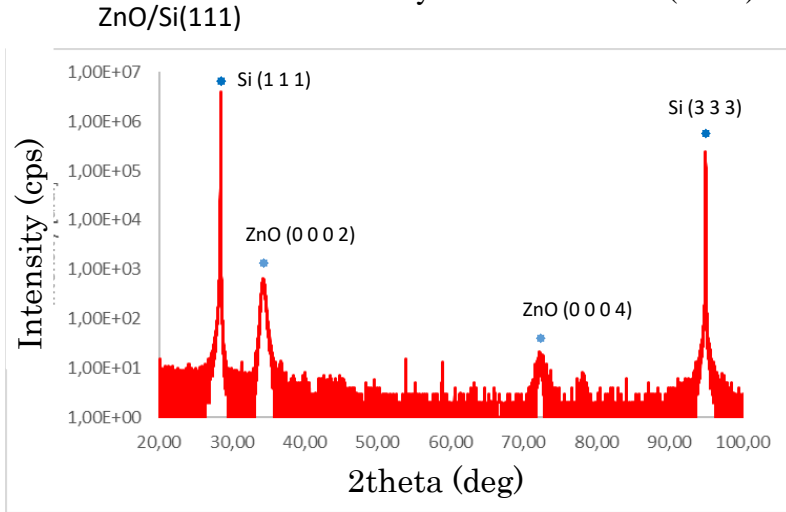
➤ Thin film growth by RF magnetron sputtering



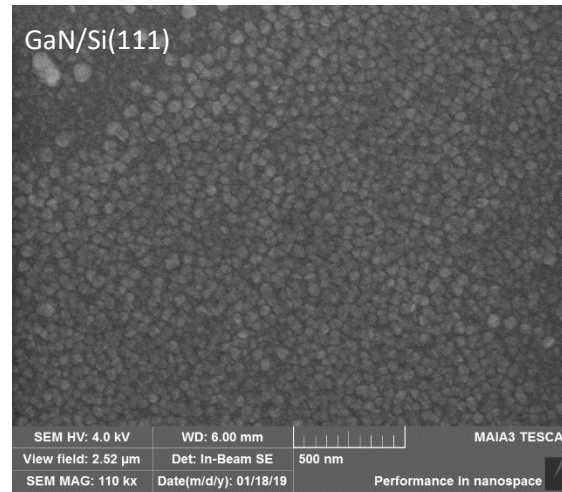
Set	Target	Substrate	Power	Working pressure	Atmosphere ratio		T (°C)	Time (min)
			W	p (mbar)	Ar	N ₂		
1	GaN (CT)	Si 100	75	9.00E-03	0.5	0.5	700	60
	GaN (CT)	Si 111	75	9.00E-03	0.5	0.5	700	60
2	GaN (CT)	Si 100	100	8.00E-03	0.3	0.7	700	60
	GaN (CT)	Si 111	100	8.00E-03	0.3	0.7	700	60
	GaN (CT)	TiO ₂	100	8.00E-03	0.3	0.7	700	60
	GaN (CT)	ZnO	100	8.00E-03	0.3	0.7	700	60
	GaN (CT)	Al ₂ O ₃	100	8.00E-03	0.3	0.7	700	60

Microstructural/morphological analysis

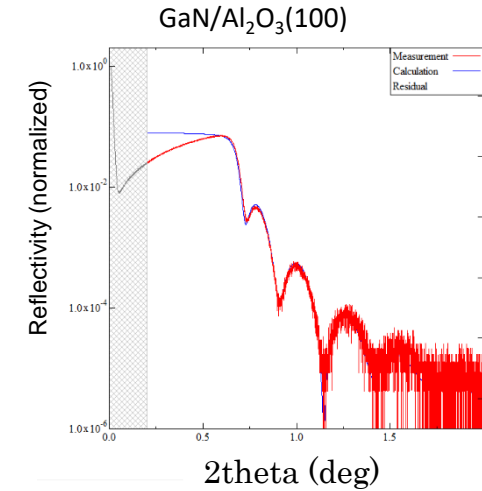
X-ray Diffraction scans (XRD)



Scanning Electron Microscopy (SEM)

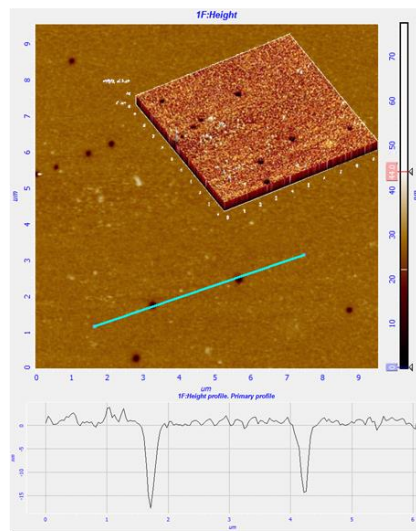
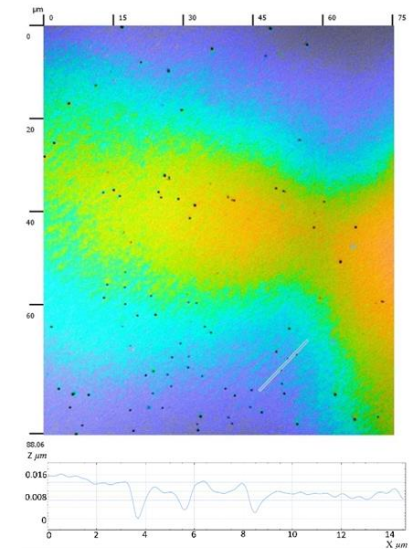


X-ray reflectivity (XRR)

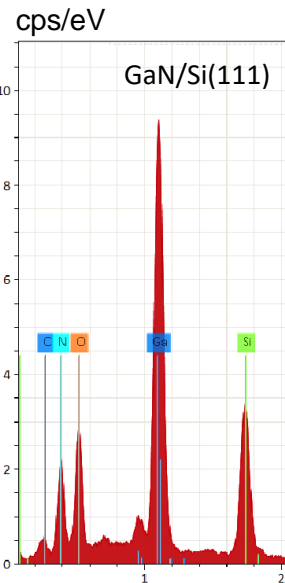


Optical Profilometry(OM)

Atomic Force Microscopy (AFM)



Energy Dispersive X-ray Spectrometry (EDX)

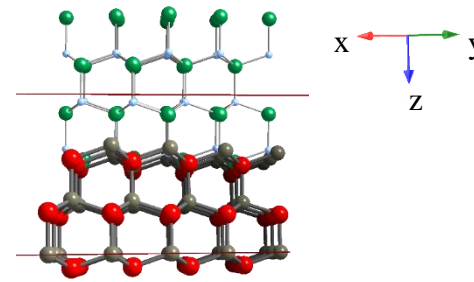


Set	Substrate	Film	Substrate	Contamination			
			Si/Ti/Al/Zn	Carbon			
1	Nitrogen	Gallium	Oxygen	Oxygen			
	Si 100	8.54 (0.15)	15.54 (0.91)	55.82 (1.30)	-	1.99	17.84
	Si 111	8.67 (0.15)	15.87 (0.92)	55.46 (1.28)	-	(0.05)	(0.15)
	Si 100	15.69 (1.26)	14.03 (2.29)	57.04 (3.45)	-	2.05	17.86
2	Si 111	15.53 (0.23)	20.8 (1.16)	44.27 (0.99)	-	(0.05)	(0.28)
	TiO ₂	8.13 (0.1)	19 (1.07)	19.4 (0.8)	49.41 (0.7)	3.08	10.14
	ZnO	13.57 (0.17)	17.24 (0.86)	25.11 (1.13)	38.91 (0.47)	(0.27)	(0.93)
	Al ₂ O ₃	11.97 (0.21)	15 (1.03)	22.41 (0.61)	48.67 (0.82)	3.28	16.2 (0.25)
						(0.06)	(0.06)

➤ Conclusions

- ❑ The correlation of the target chemical composition with the films it was observed;
- ❑ Slight contamination on the samples surface;
- ❑ Substrate temperature, working pressure, gas feed, electrical input type, forwarded power and target-substrate distance parameters need to be optimized in order to obtain preferred orientation and homogeneous morphology
- ❑ Several types of structures were grown on different substrates:

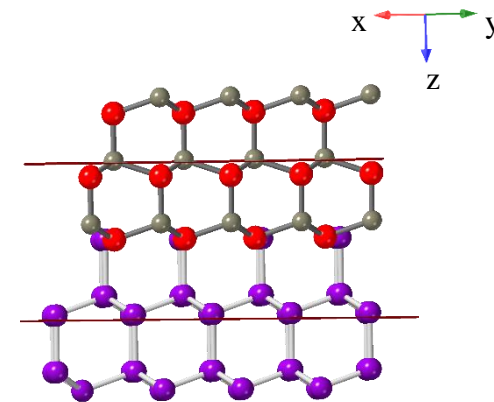
- – GaN - Ga₂O₃ / Si (100);
- – GaN - Ga₂O₃ / Si(111);
- – GaN - Ga₂O₃ / Al₂O₃ (0001);
- – GaN - Ga₂O₃ / TiO₂ (001);
- – GaN - Ga₂O₃ / ZnO (0001);
- – GaN / Si (100);
- – GaN / Si (111);
- – GaN / Al₂O₃ (0001);
- – GaN / TiO₂ (001);
- – GaN / ZnO (0001).



GaN (0 0 2) || (0 0 2) ZnO

- – ZnO / Si (100);
- – ZnO / Si (111);

- – Al - AlN / Si (100);
- – Al - AlN / Si (111);



ZnO (0 0 2) || (1 1 1) Si

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➤ Acknowledgements:

ELI-NP

V. Leca
C. Gheorghiu
N. Djourelou
D. Dinescu
I. Zai

UPB

V.L. Ene
B. Vasile

Thank you for attention!