Activity modulation MEE growth of group III nitrides on Si(111) using PA-MBE

Tadashi Ohachi[a,b], Osamu Ariyada[c], Yuuki Sato[b], and Shinzo Yoshikado[b], Motoi Wada[b]

[a] *Interface Reaction Epitaxy Laboratory, Doshisha University*

[b] *Department of Electrical Engineering, Doshisha University* , and [c] *Arios Inc.*

tohachi@irel.jp

Objective

Growing high quality group III nitrides on a large size Si wafer using RF-MBE !

- Improve activity modulation (AM) migration enhanced epitaxy (MEE)
- Seek Continuous process system from a Si wafer to AlN, GaN, InN and their alloy using PA-MBE
- Interface reaction epitaxy (IRE) of β-Si_3N_4 and IRE-AlN
- Apply AM-MEE growing ally group III nitrides (InGaN and InAlN) using HB and LB SS-jet flux

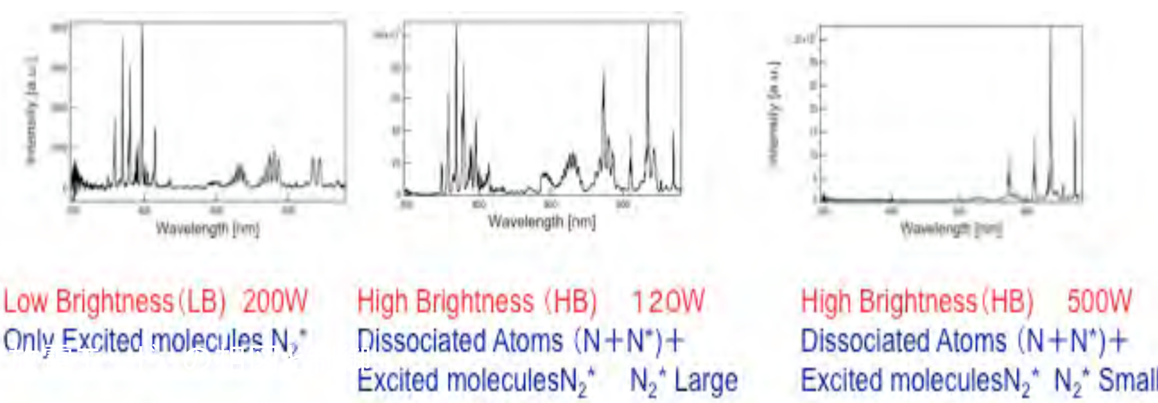
Method and Principle

rf ICP two discharge modes:

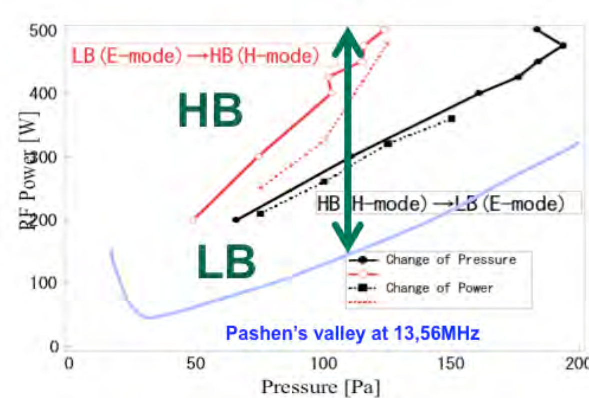
LB mode and HB mode

Low brightness (LB)
E (Excitation)-mode
Excited molecules N_2^*

High bright (HB)
D (Dissociation)-mode
Dissociation to N Atoms
Ground and excited state
Atoms N + N*


Low Brightness (LB) 200W — Only Excited molecules N_2^*
High Brightness (HB) 120W — Dissociated Atoms (N+N*)+ Excited molecules N_2^* N_2^* Large
High Brightness (HB) 500W — Dissociated Atoms (N+N*)+ Excited molecules N_2^* N_2^* Small

Mode control for AM-MEE:



As maximum power of power supply is 500W, mode change control is possible under about 120Pa

[1] T. Ohachi, N. Yamabe, M. Wada and O. Ariyada, Jpn, J. Appl. Pyhs. **50** (2011) 01AE01.
[2] T. Ohachi, N. Yamabe, H. Shimomura, T. Shimamura, O. Ariyada, M. Wada, *J. Crystal Growth* **311** (2009) 2987–2991.
[3] T. Ohachi, N. Yamabe, Y. Yamamoto, M. Wada and O. Ariyada, Phy. Status Solidi **C8(5)** (2011) 1491.
[4] T. Ohachi, N. Yamabe, Y. Yamamoto, M. Wada and O. Ariyada, *J. Crystal Growth* **318** (2011) 468.

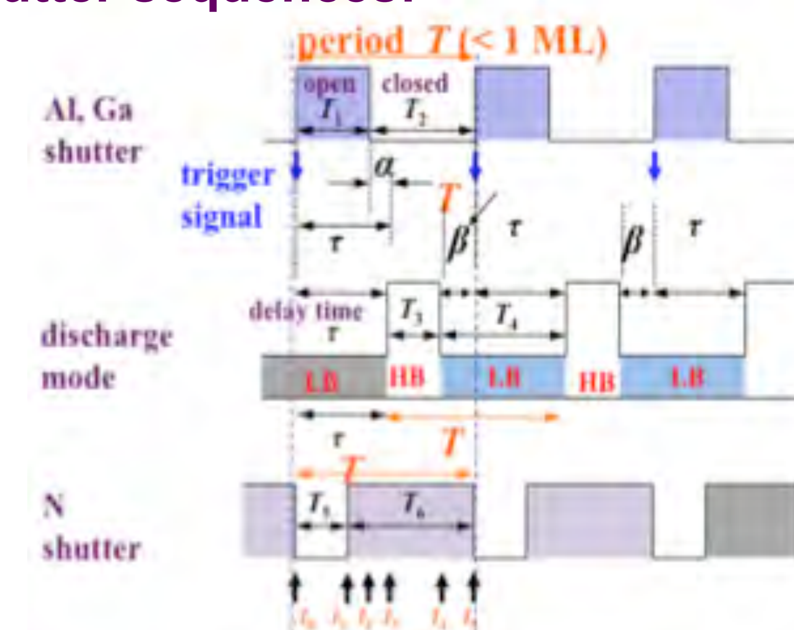
Physical and Chemical Activities:

Molecules N_2^* Physically : migration and evaporation
Atoms N + N* Chemically: chemical reaction

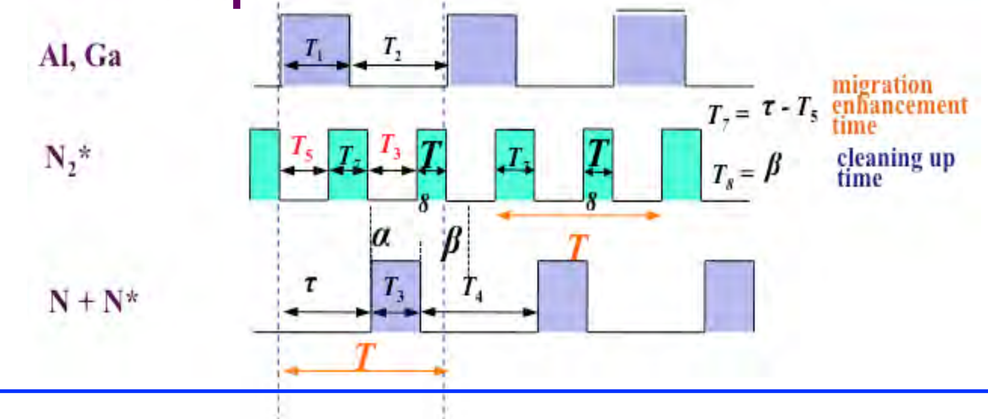
Direct and indirext exposure of N and N_2^*:

Direct exposure: Super sonic jet flow
Indirect exposure: Uniform & interface reaction epitxy (IRE)

Shutter sequences:

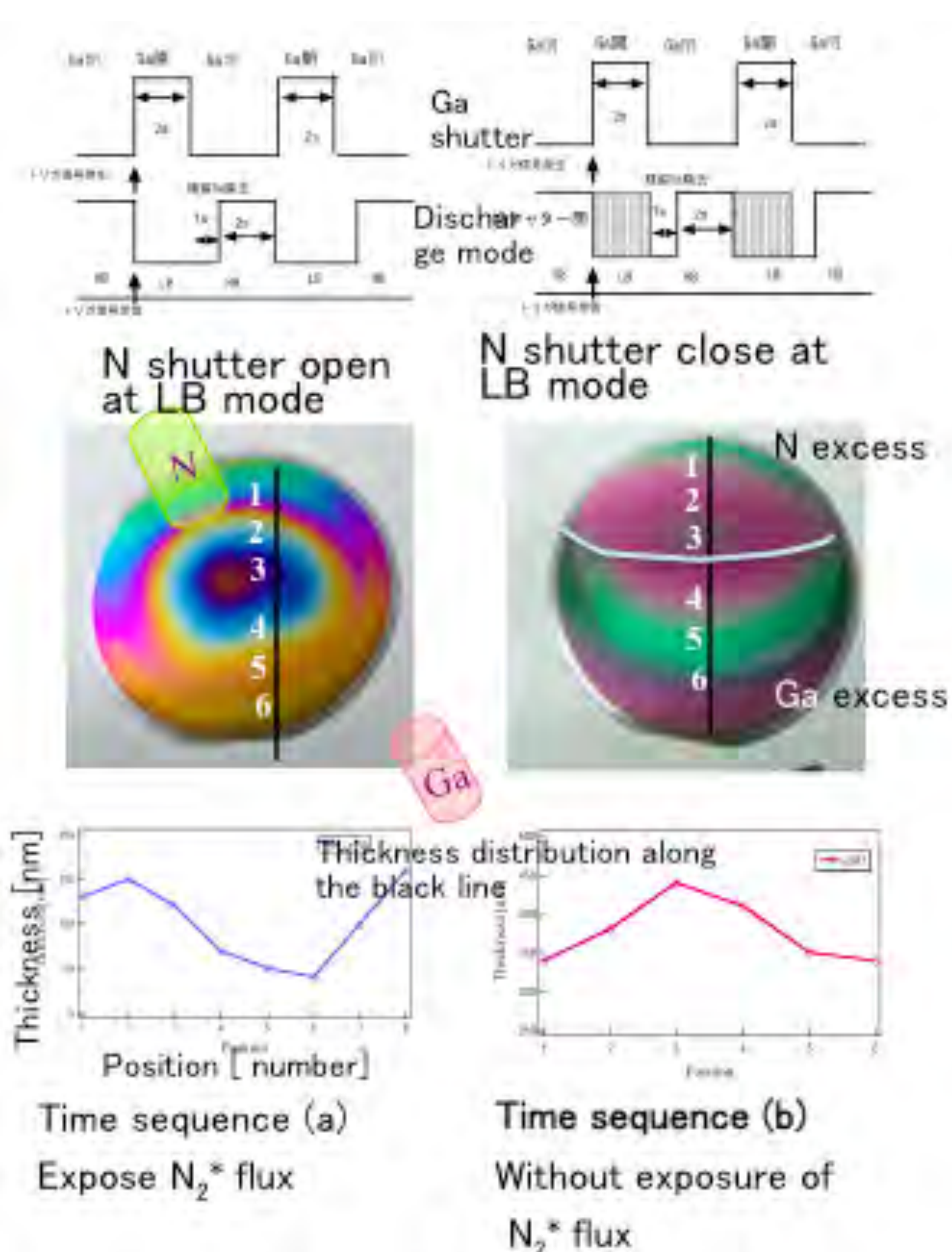


AM-MEE sequences:

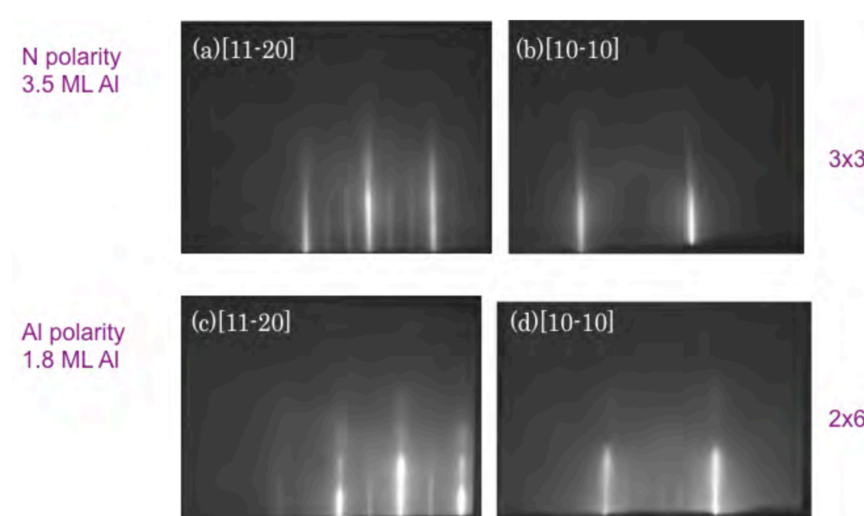


Results and Discussion

Effect of AM-MEE : evaporation + migration

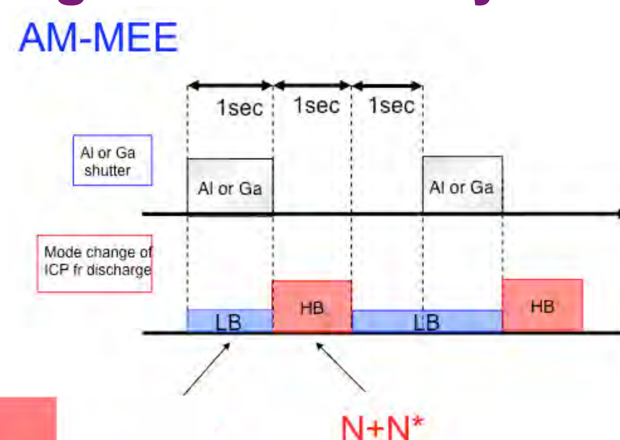


Polarity control of 2H-AlN



2H-GaN grown on AlN by AM-MEE

AM-MEE

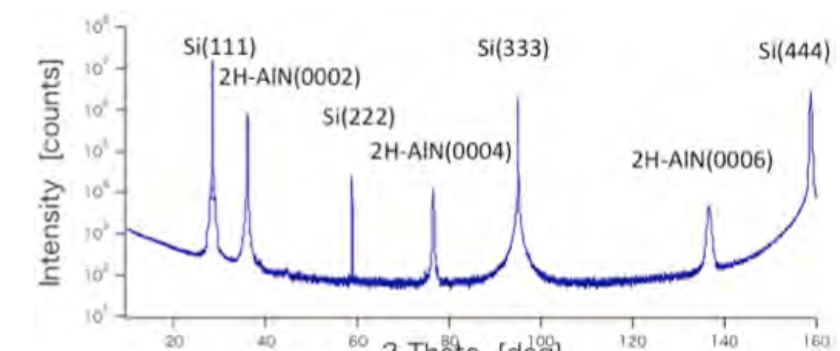


GaN
AlN
IRE-AlN
β-Si_3N_4
Si(111)
} DBL

ω-FWHM [arcmin]	T_{sub} = 780 [°C]	T_{sub} = 830 [°C]
AlN	73.8	74.4
GaN	58.2	55.2

2H-AlN grown on DBL by AM-MEE

IRE-β-Si_3N_4
- Nitridation times : 6 min
- Pressure N_2 : 75.6 Pa
- Input power : 500 W
- T_{sub} : 780 °C, 830 °C



Peak	FWHM 60 nm [deg]	FWHM 200 nm [deg]
Si(111)	0.06159	0.06035
AlN(0002)	0.20177	0.1166
Si(222)	0.06085	0.0686
AlN(0004)	0.31471	0.27608
Si(333)	0.07311	0.07441
AlN(0006)	0.92242	0.87635
Si(444)	0.20957	0.2176

Conclusion

AM-MEE able to control the growth of group III nitrides and their alloy.

Further impruvement of AM-MEE growth using PA-MBE is requirerd to produce high quality films.