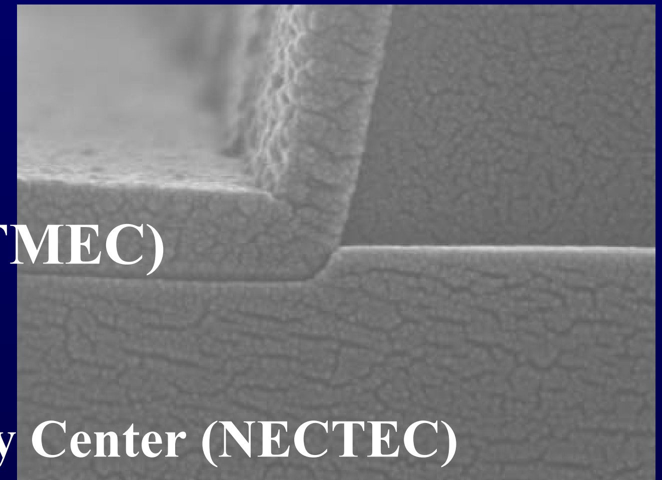
The Study of Plasma-Enhanced Silicon Nitride Deposition Using SiH4/NH3/N2 Mixture

Ladthai Thaiyotin

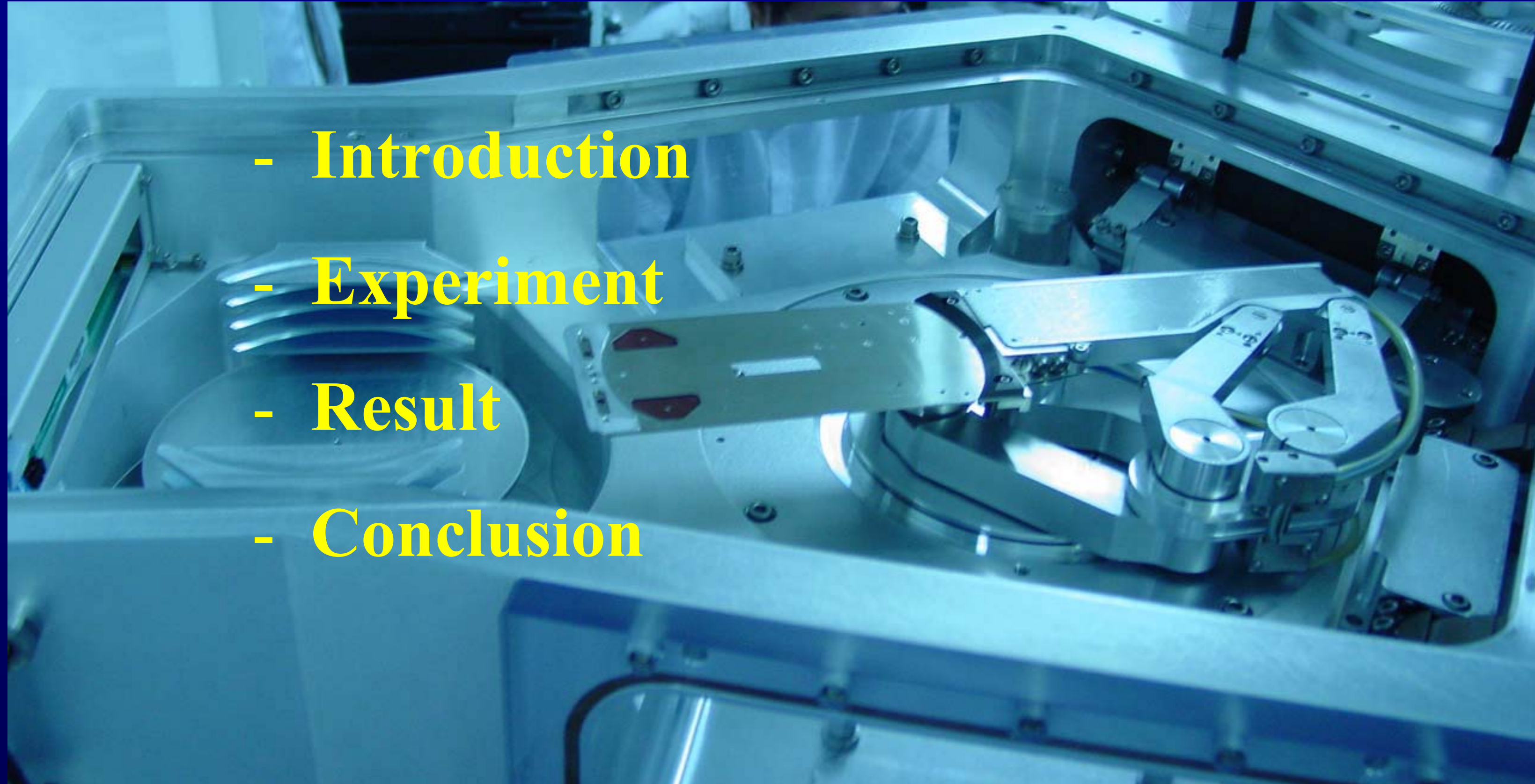
Sompong Charoenkit, Win Bunjongpru, Charndet Hruanan and Itti Rittaporn

Thai Microelectronic Center (TMEC)

National Electronics and Computor Technology Center (NECTEC)



Out line



Introduction

Plasma Enhanced Chemical Vapor Deposition (PECVD)

- IC and MEMs Passivation Layer

Low processing temperature, Good step coverage, good passivation for both moisture and sodium ions.

- Process Gas

SiH_4+N_2 ----> Less controllable

SiH_4+NH_3 ----> More Hydrogen content

$SiH_4 + NH_3 + N_2$

The Study of Plasma-Enhanced Silicon Nitride Deposition Using $SiH_4/NH_3/N_2$ Mixture

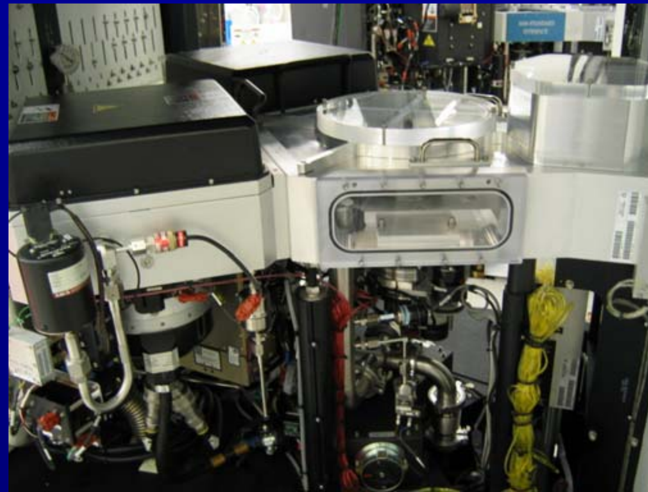
Experiment

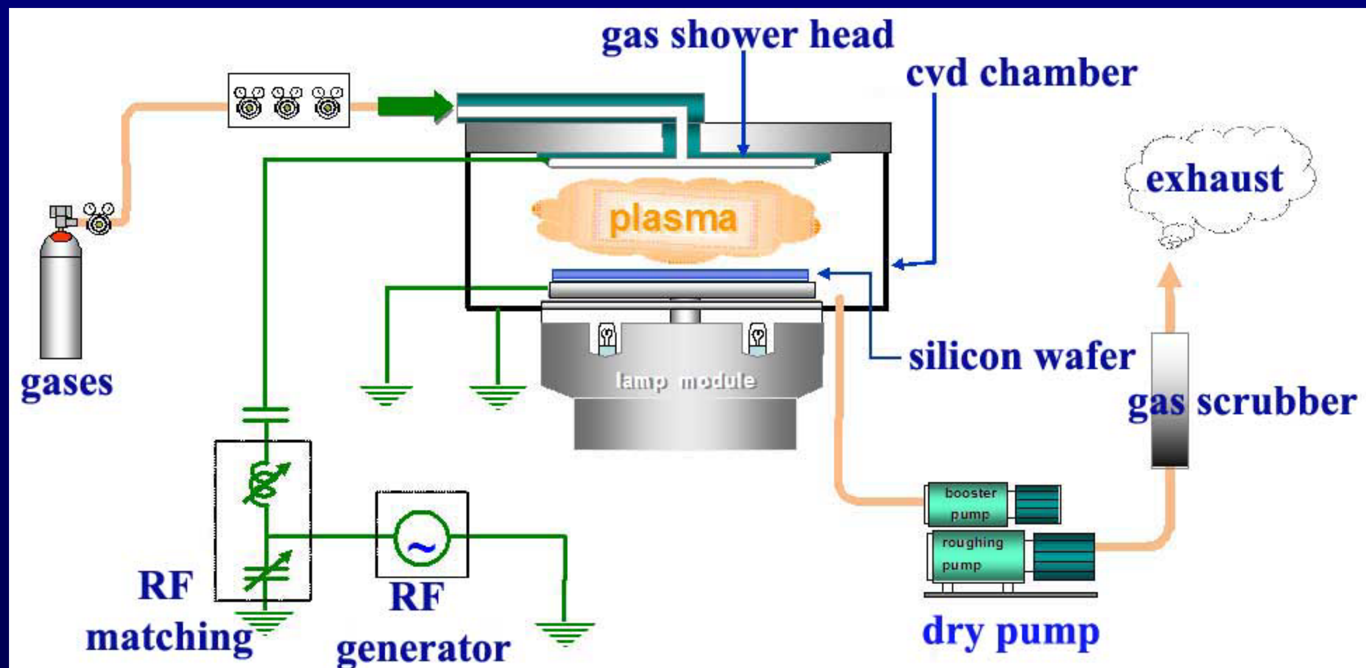
PECVD

Model: P5000 Mark II by AMAT

Figture 1. PECVD picture

TMEC Thai Microelectronics Center
ECTI-21 NECTEC NSTDA





Figture 2. PECVD Schematic

Table 1. Deposition parameters

Subs. temp. (^{o}c)	RF power (watt)	Spacing (mils)	Total pressure (torr)	Gas flow (sccm)
250-400	300-450	300-600	2-5	SiH4 150-250 NH3 25-100 N2 1500-4500

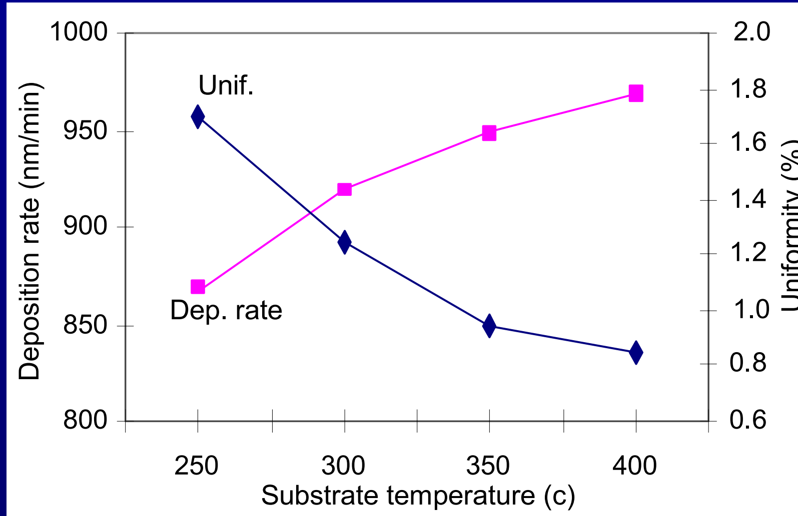
Comparision:

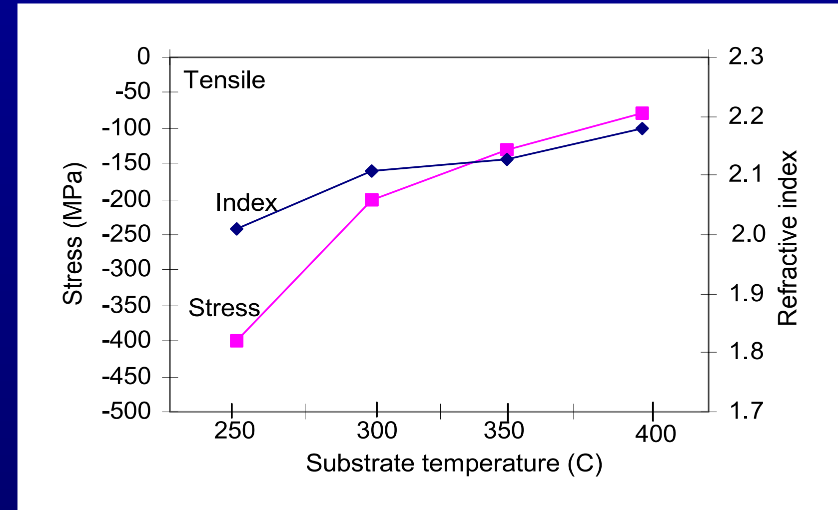
SiH4+NH3, SiH4+N2, SiH4+NH3+N2

- Etch rate
- Si-N ratio (Refractive index)
- Stress

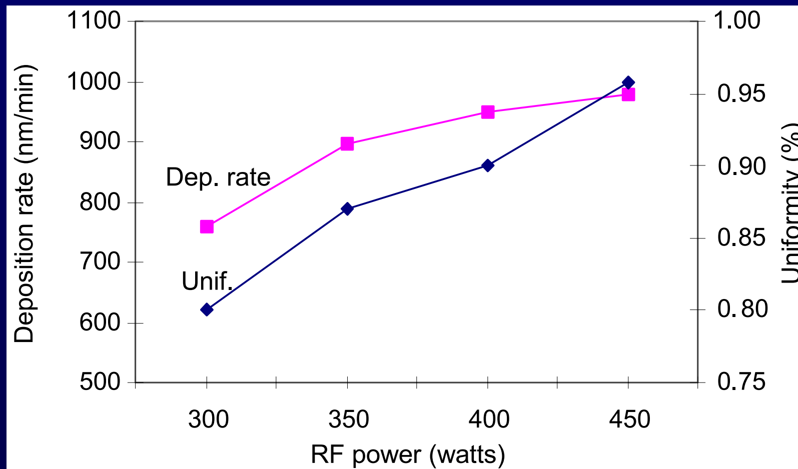
Results

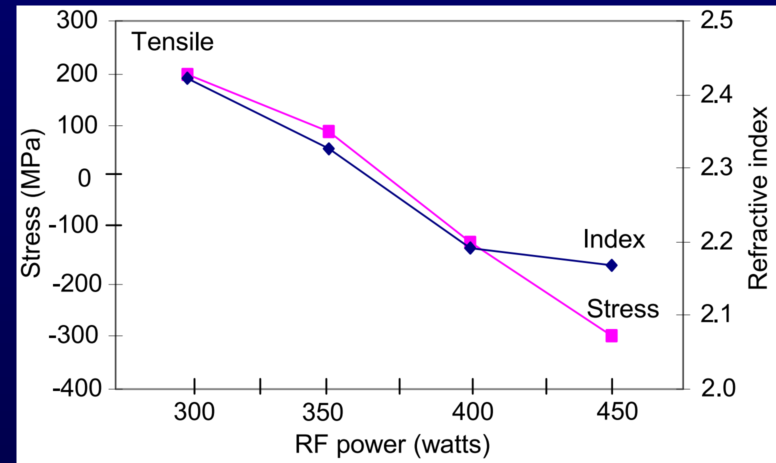
Substrate temperature (^{O}C)



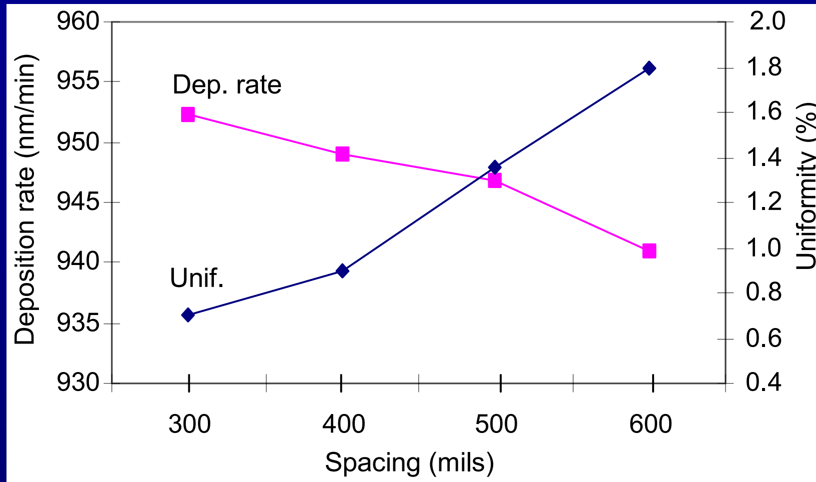


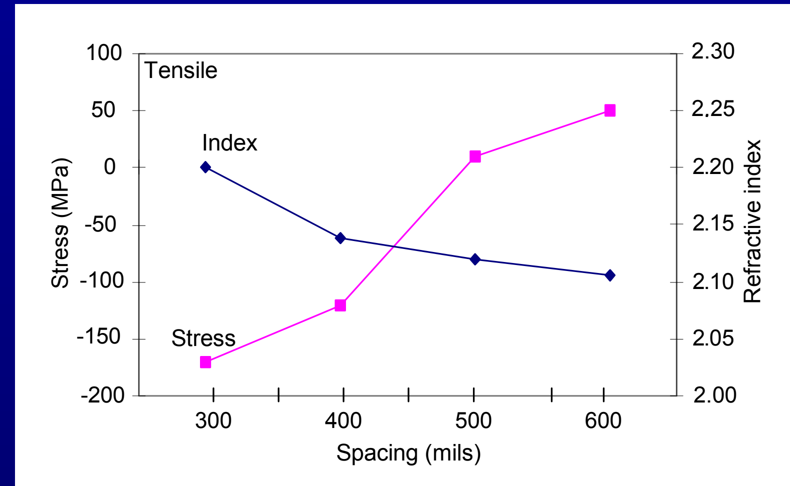
RF Power (watt)



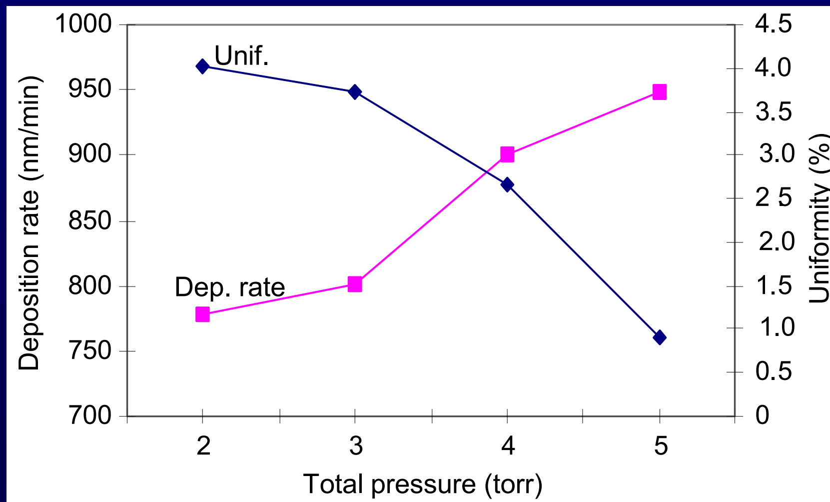


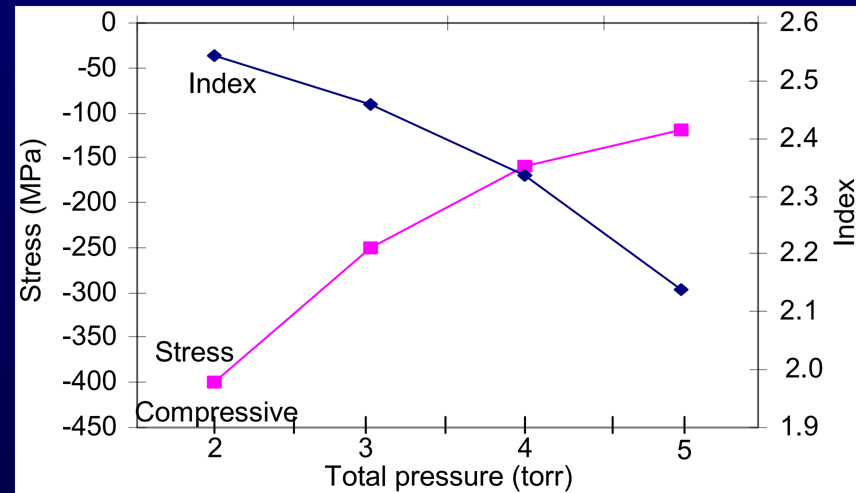
Spacing (mils)



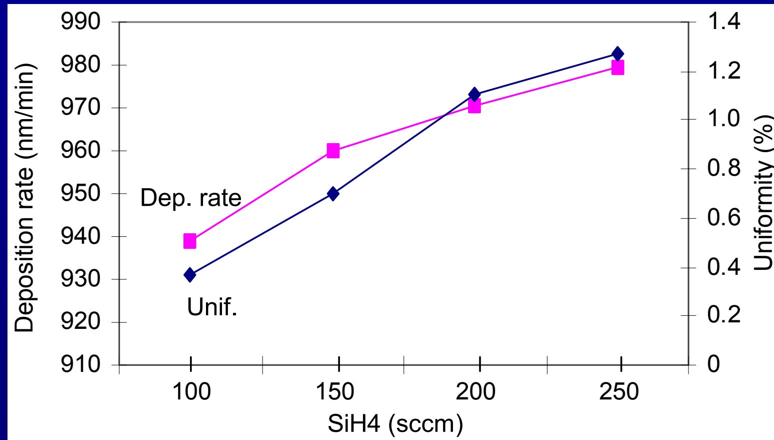


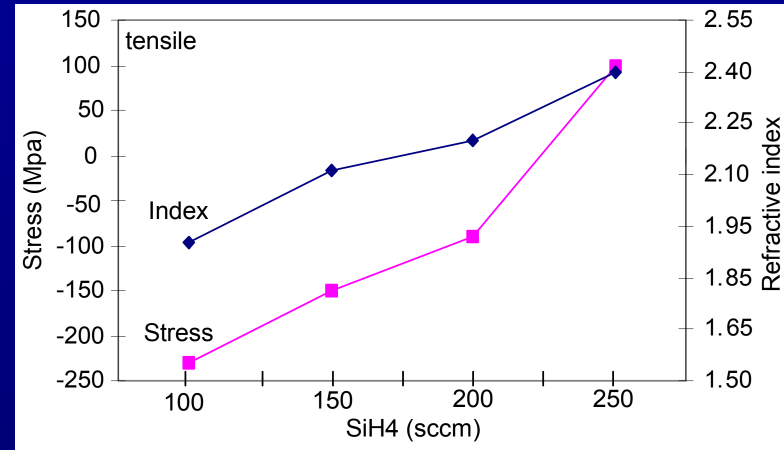
Total pressure (torr)



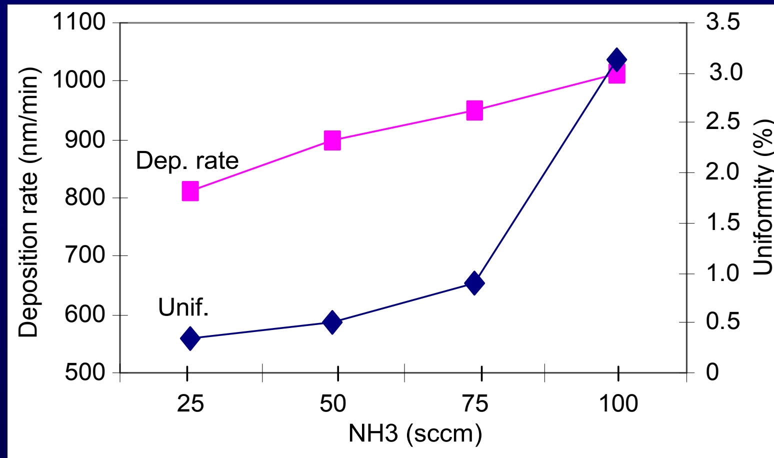


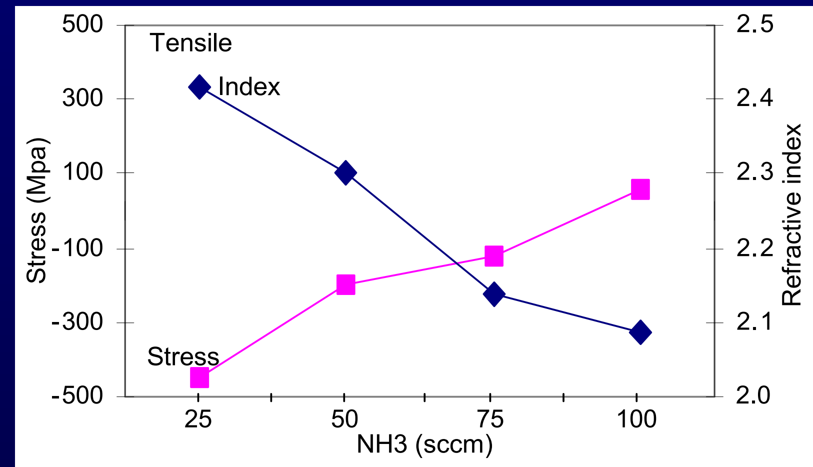
SiH4 (sccm)



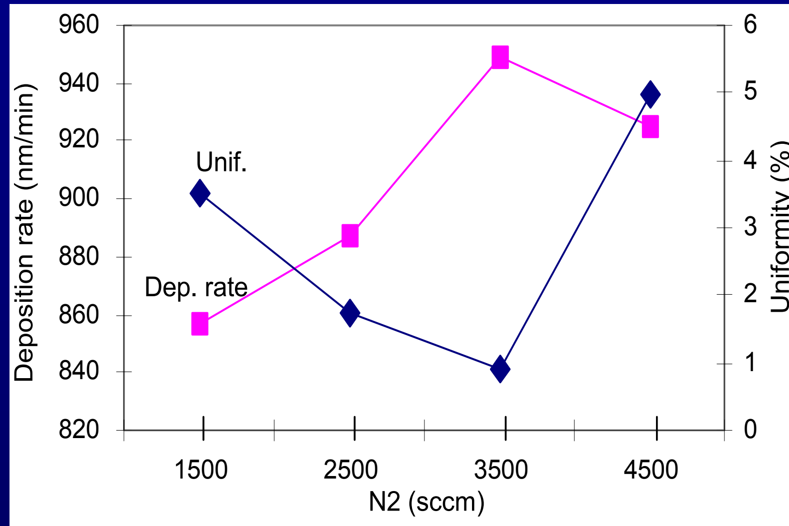


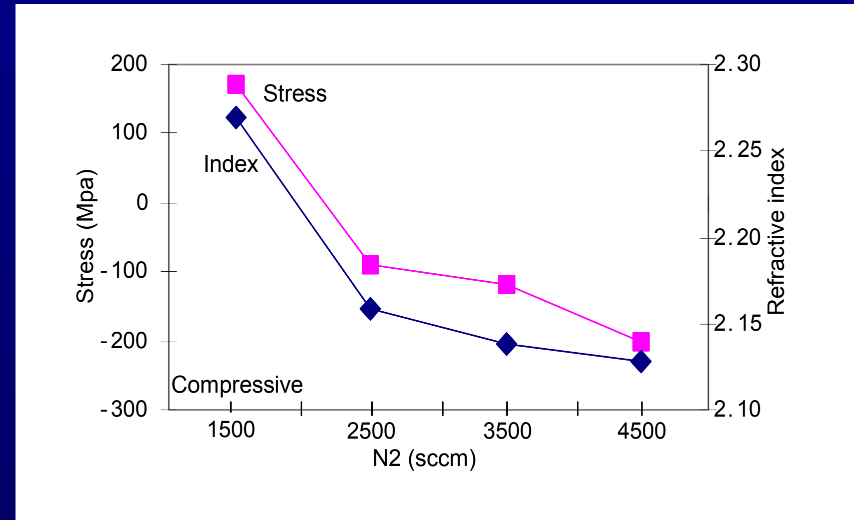
NH3 (sccm)





N2 (sccm)

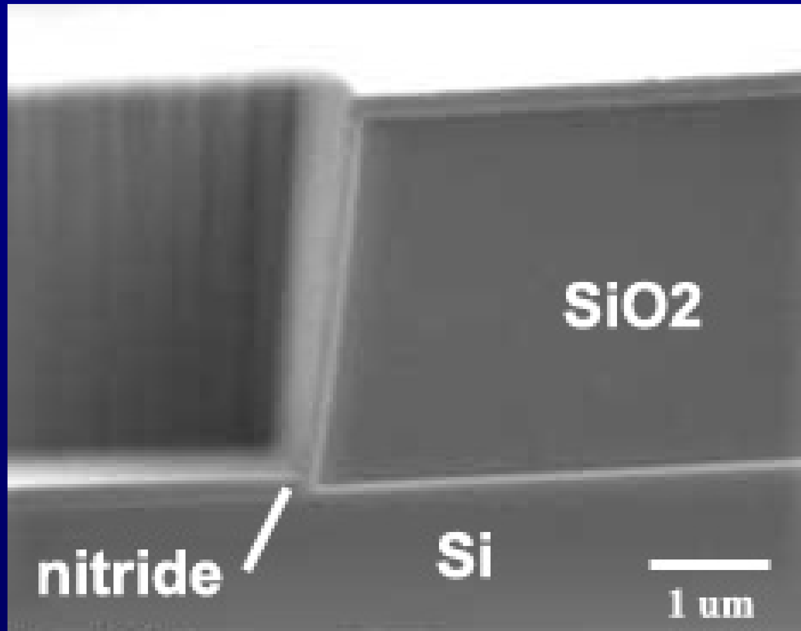


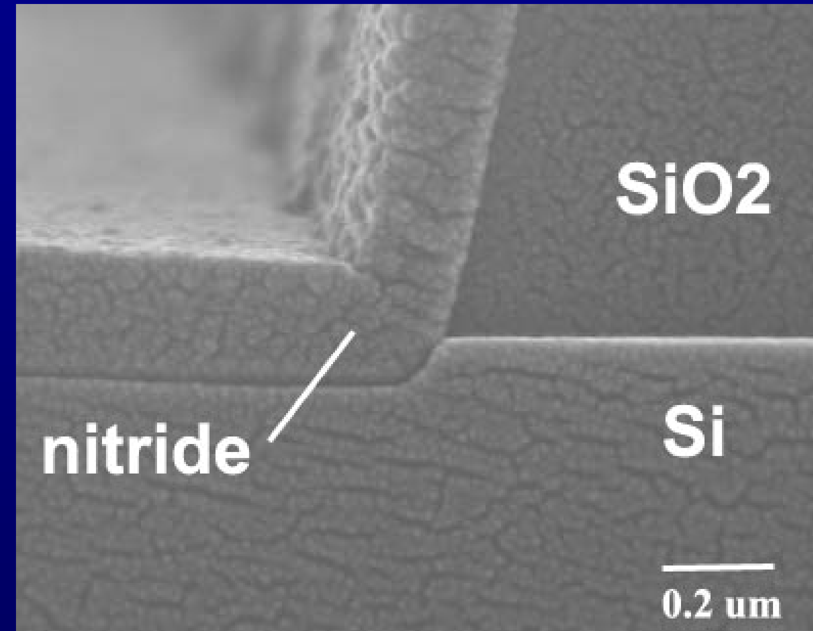


TMEC Thai Microelectronics Center
ECTI-21 NECTEC
NSTDA

Table 1. Silicon nitride trend summary.

Increase item	Deposition rate	Uniformity	Compressive stress	Refractive index
Substrate temp (^{o}C)	↑	↓	↓	↑
RF power (watt)	↑	↑	↑	↓
Spacing (mils)	↓	↑	↓	↓
Total pressure (torr)	↑	↓	↓	↓
SiH4 (sccm)	↑	↑	↓	↓
NH3 (sccm)	↑	↑	↓	↓
N2 (sccm)	↑	↓	↑	↓





Figture 3. Silicon nitride film

Table 3 Etch rate, Si/N ratio and stress of nitride films deposition using different gas mixture.

Gas mixture	SiH4/NH3	SiH4/N2	SiH4/NH3/N2
Etch rate (nm/min)	637	287	320
Si/N ratio	47	37	31
Stress (Mpa)	236	118	125

Conclusion

PECVD silicon nitride deposition using $SiH_4+NH_3+N_2$

Good uniformity

- Increase substrate temp, total pressure
- Decrease spacing and RF power

Refractive index (2.0-2.1) obtained by

- Increase RF power, total pressure

Reactive gas ratio

Good uniformity, increase N_2

Refractive index (2.0-2.1) obtained by

- increase NH_3 and N_2

Gas mixture	SiH4/NH3	SiH4/N2	SiH4/NH3/N2
Etch rate (nm/min)	High porocity	Low	Middle
Si/N ratio	Silicon rich	Nitrogen rich (index 1.9 - 2.1)	Nitrogen rich (2.0 - 2.2)
Stress (Mpa)	High	Low	Low

SiH4+N2 less controllable

SiH4+NH3 High Hidrogen

SiH4+N2+NH3 Optimum