Characterization of LPCVD TEOS Thin Film using Ellipsometer

by

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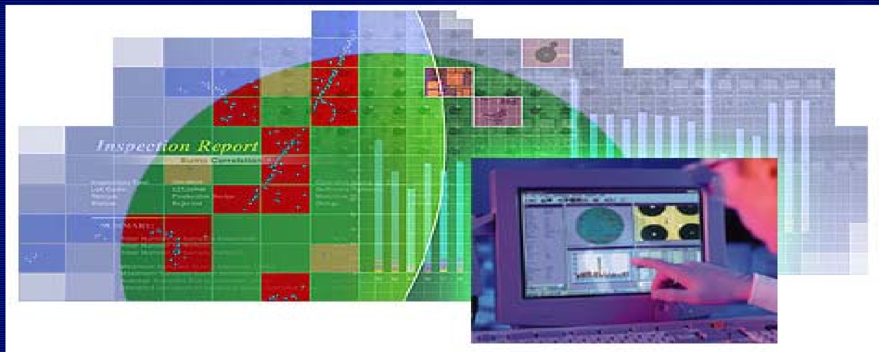
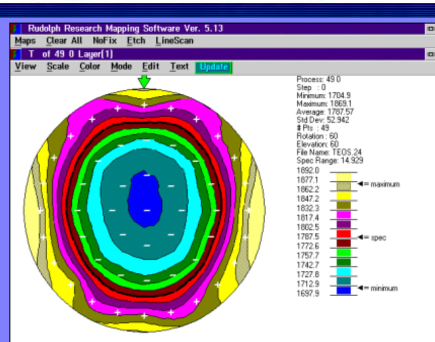
KEY OF THIN FILM GROWTH FOR MICROELECTRONICS

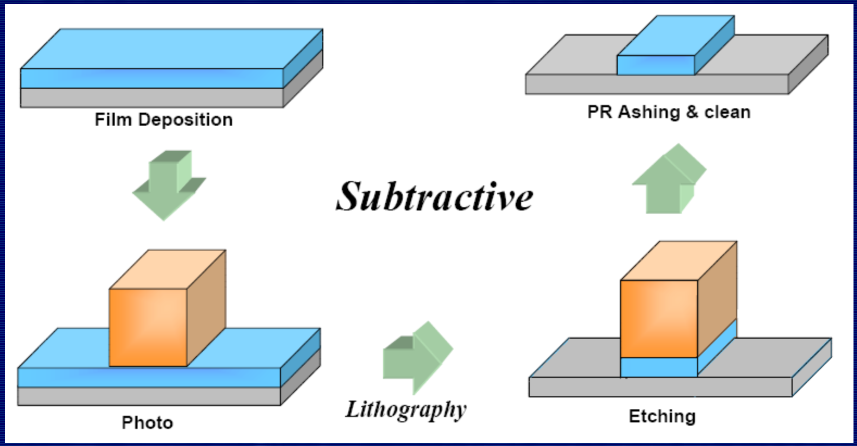




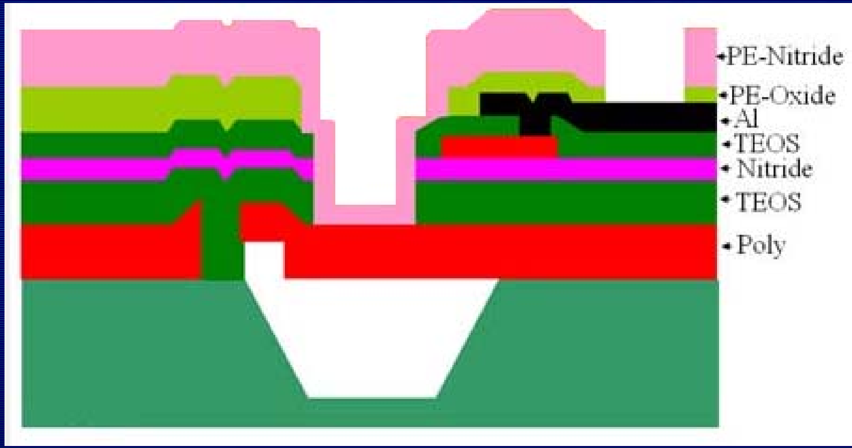
Basic Fabrication process consist of three major steps:

1. Deposition of thin films
2. Photolithography
3. Selective etching of the films.

THIN FILM DEPOSITION FOR BASIC ETCH PROCESS



THIN FILM DEPOSITION FOR FABRICATION PROCESS



Outline

- Thin film technology
- LPCVD system
- TEOS thin film deposition
- Characteristics of TEOS thin films
- Conclusion

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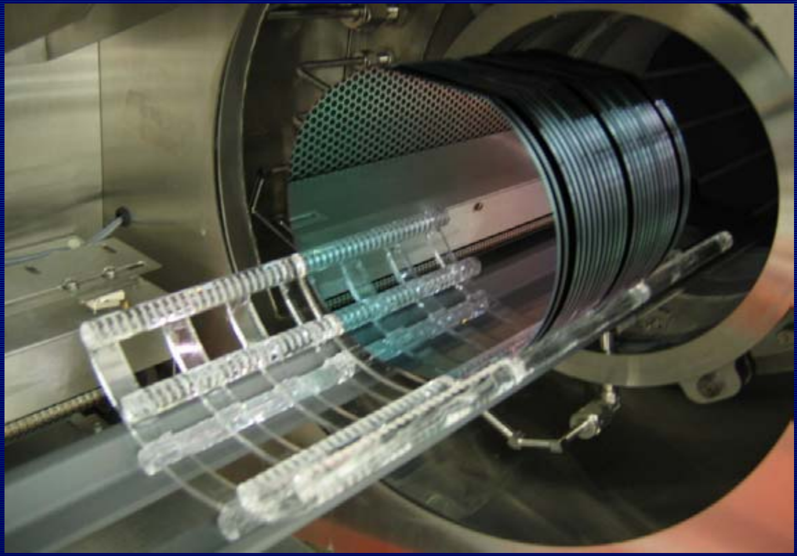
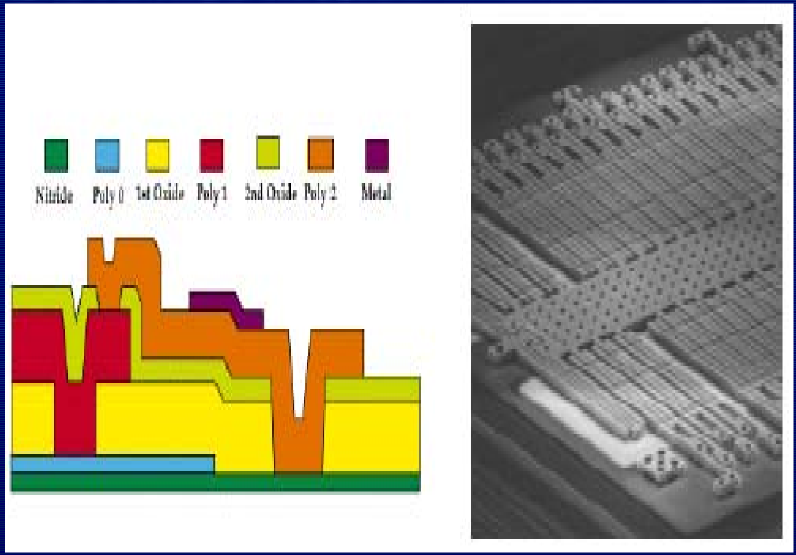
Thin film technology

Deposition technologies can be divided into two groups:

1. Physical Vapor Deposition (PVD) process
2. Chemical Vapor Deposition (CVD) process





Type of Deposition Methods

Physical Vapor Deposition: PVD

- Evaporation
- E Beam evaporation
- Sputtering

Chemical Vapor Deposition: CVD

- Plasma Enhanced CVD (PECVD)
- Atmospheric Pressure CVD (APCVD)
- Low Pressure CVD (LPCVD)

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Low Pressure CVD (LPCVD)

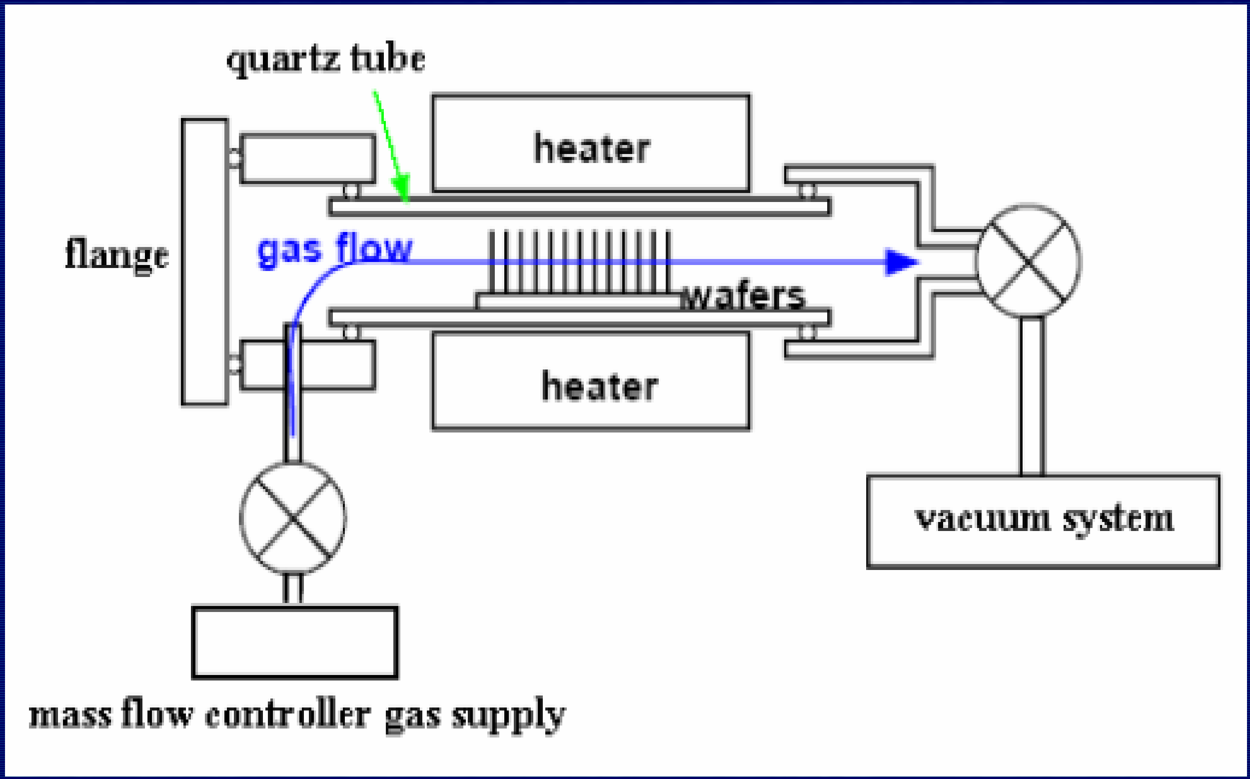
Advantage

- Moderate deposition rates
- Very high throughput
- Minimal contamination

Disadvantage

- Film contamination (reaction products and carrier gases)

LPCVD horizontal hot-wall furnace system

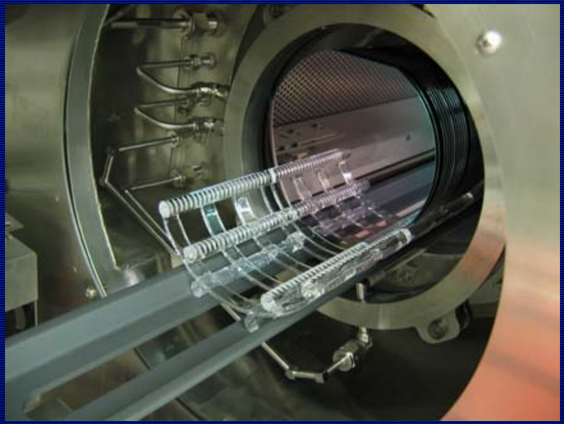


SVG LPCVD furnace THERMCO TMX2603 at Thai Microelectronics Center (TMEC)

Structure of LPCVD TEOS furnace

Computer Control

TEOS liquid source



Quartz Boat

Gas cabinet & Vacuum System

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Step in film growth

- Gases are introduced into a reaction chamber
- Gas species move to the substrate
- Reactants are adsorbed on the substrate
- Film-forming chemical reactions
- Desorption and removal of gaseous by-products

Oxide (SiO_2) Films Deposition

- Silane & Oxygen (300-500 C)

$$SiH_4 + O_2 \xrightarrow{450\ C} SiO_2 + 2H_2$$

- Tetraethylorthosilicate: TEOS (500-800 C)

$$Si(OC_2H_5)_4 \xrightarrow{700\ C} SiO_2 + \text{by-products}$$

- Dichlorosilane & Nitrous (~900 C)

$$SiCl_2H_2 + 2N_2O \xrightarrow{900\ C} SiO_2 + 2N_2 + 2HCl$$

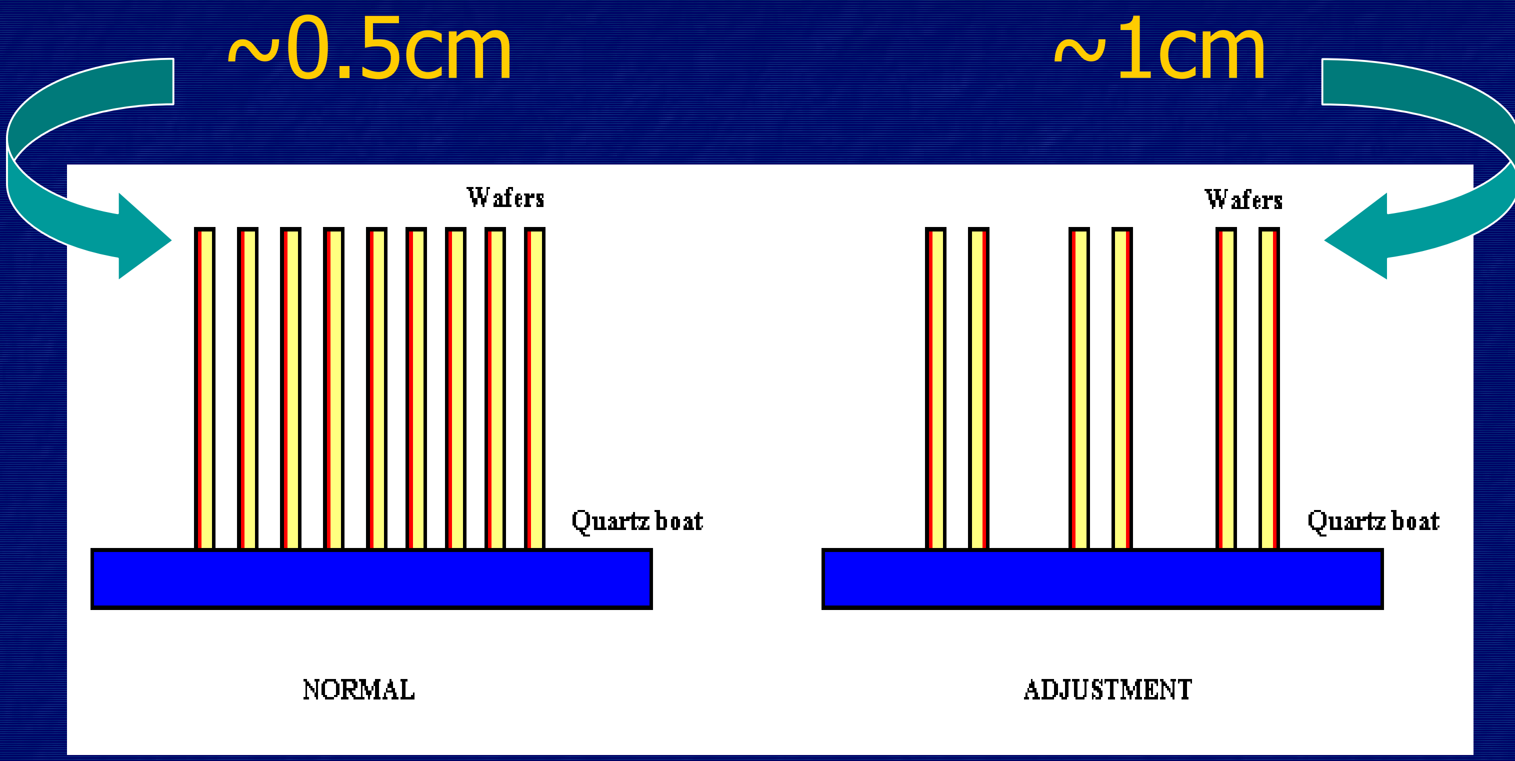
TEOS Films by LPCVD

Advantage

- Isolation layer
- Step coverage
- Hard mask
- Moderate deposition rate

Disadvantage

- Bad thickness uniformity (~3%)



Uniformity (%) = [Standard deviation/ Thickness average] × 100

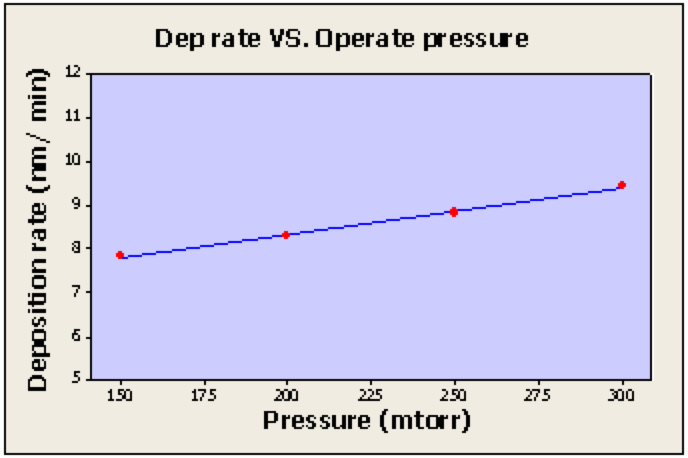
Process A: Different Operate Pressure

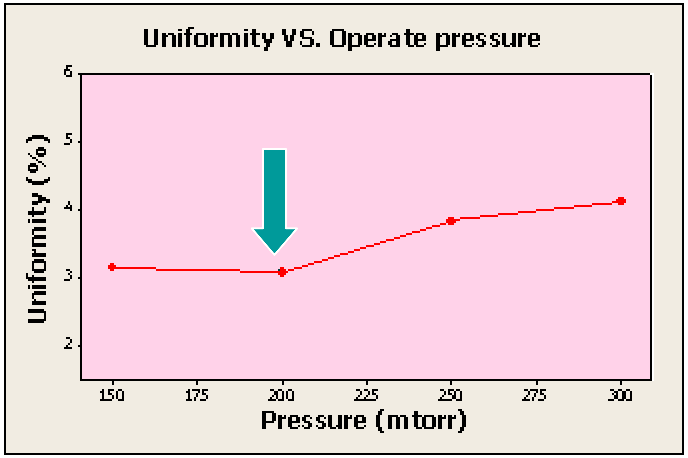
Technique	LPCVD
Temperature	705 °C
Gas flow TEOS	80 SCCM
Operate Pressure	150, 200, 250, 300 mtorr
Deposit Time	20 minute
Wafer spacing	Normal

Process B: Different Temperature

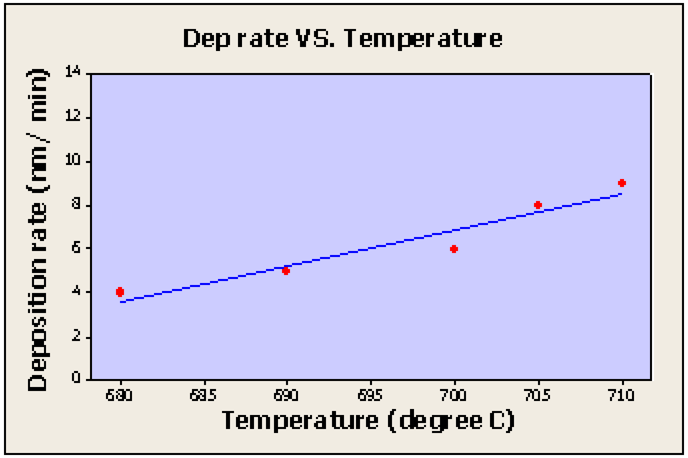
Technique	LPCVD
Temperature	680, 690, 700, 705, 710 °C
Gas flow TEOS	80 SCCM
Operate Pressure	200 mtorr
Deposit Time	20 minute
Wafer spacing	Normal

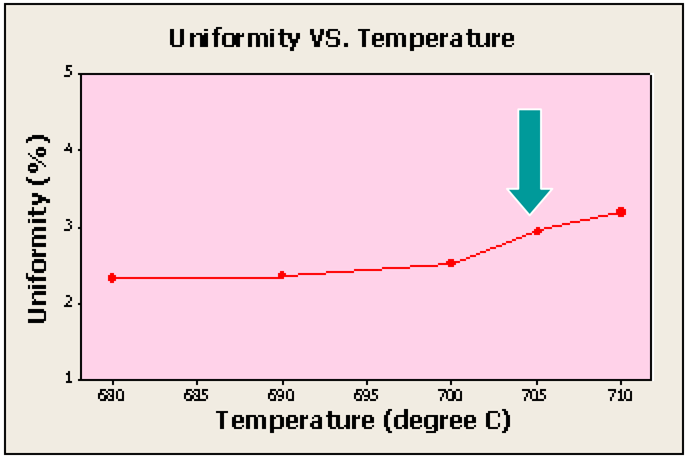
Process A.





Process B.





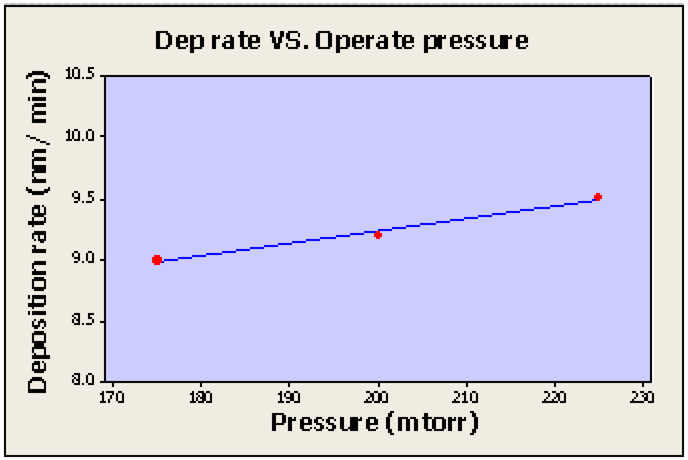
Process C: Wafer spacing

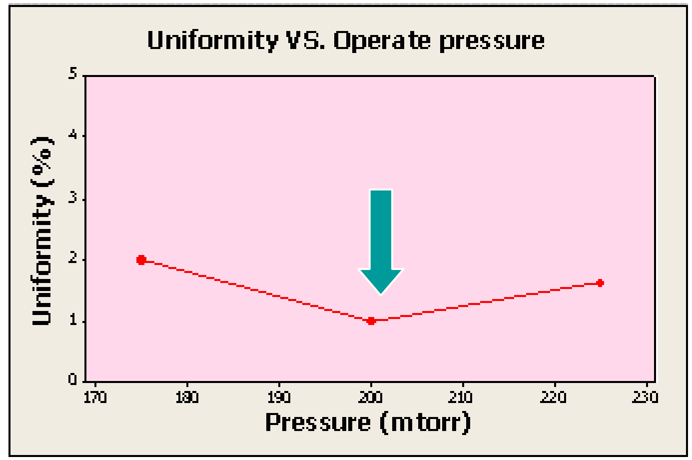
Technique	LPCVD
Temperature	705 °C
Gas flow TEOS	80 SCCM
Operate Pressure	175, 200, 225 mtorr
Deposit Time	20 minute
Wafer spacing	Adjustment

Process D: Different Deposition Time

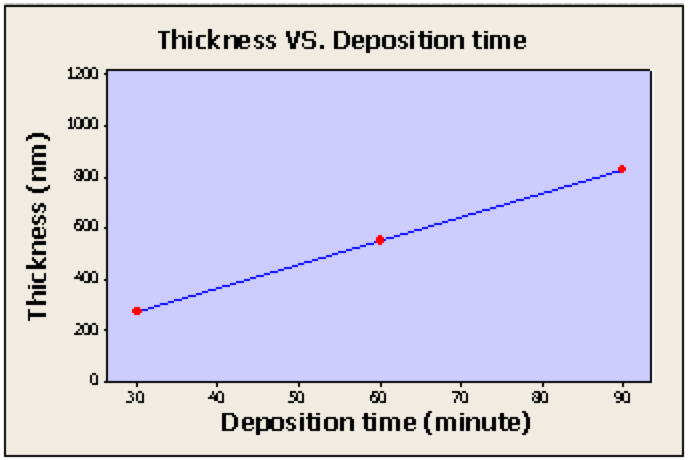
Technique	LPCVD
Temperature	705 °C
Gas flow TEOS	80 SCCM
Operate Pressure	200 mtorr
Deposit Time	30, 60, 90 minute
Wafer spacing	Adjustment

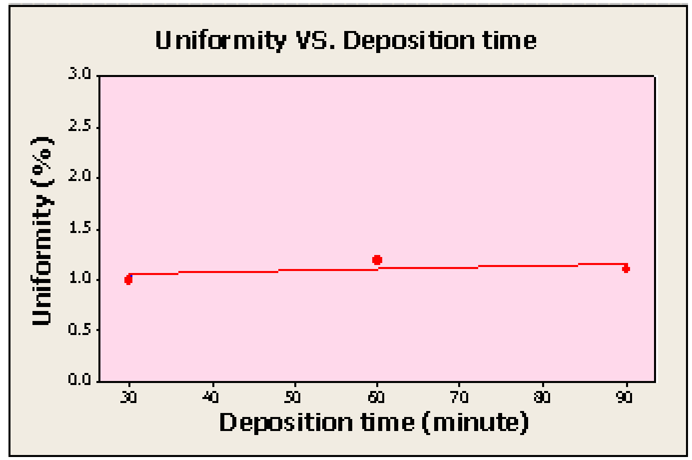
Process C.





Process D.





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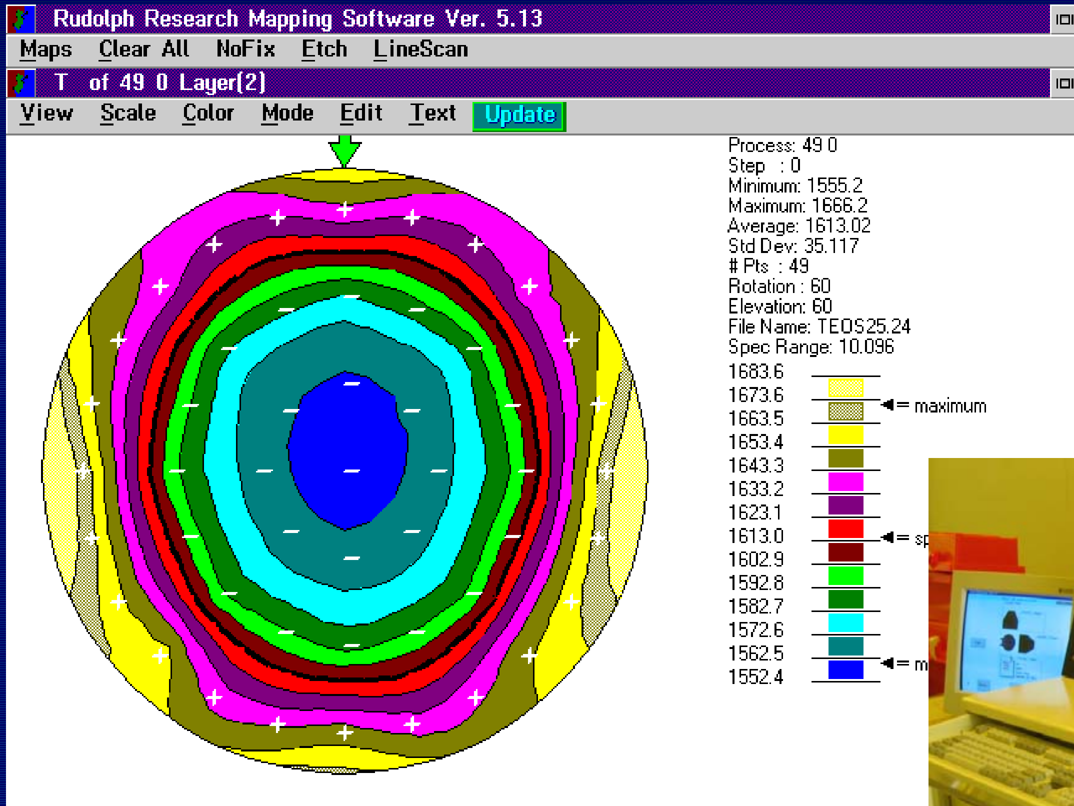


Map TEOS film

ELLIPSOMETER

Thin Film Measurement at Thai Microelectronics Center (TMEC)

Properties of Silicon Dioxide Films

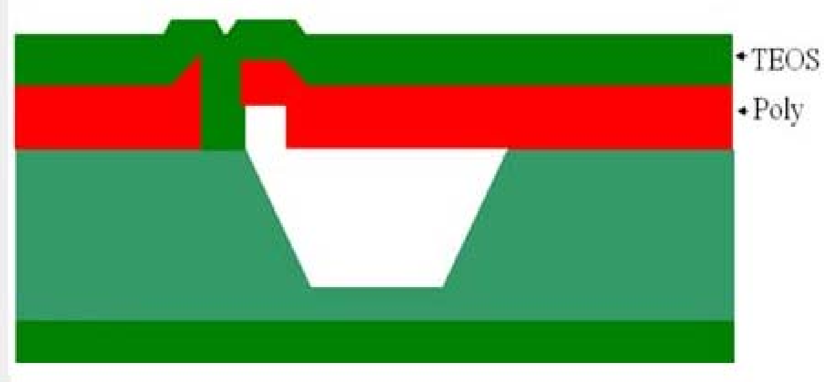
Property	Thermally at 1000 C	SiH4+O2 at 450 C	TEOS at 700 C	SiCl2H2+N2O at 900 C
Composition	SiO_2	$SiO_2(H)$	SIO_2	$SiO_2(Cl)$
Density(g/cm^3)	2.2	2.1	2.2	2.2
Refractive index	1.46	1.44	1.46	1.46
Strength($10^6 V/cm$)	>10	8	10	10
Etch rate (nm/min) (100:1 H2O:HF)	3	6	3	3
Etch rate (nm/min) (buffered HF)	44	120	45	45
Step coverage	-	non conformal	conformal	conformal

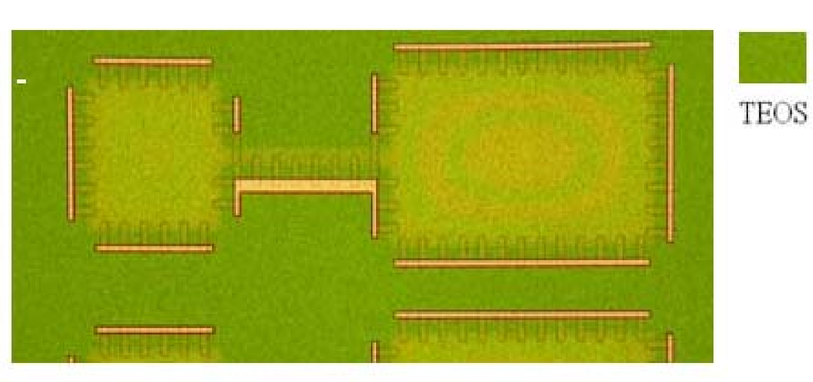
Fundamentals of Semiconductor Fabrication (page 158)

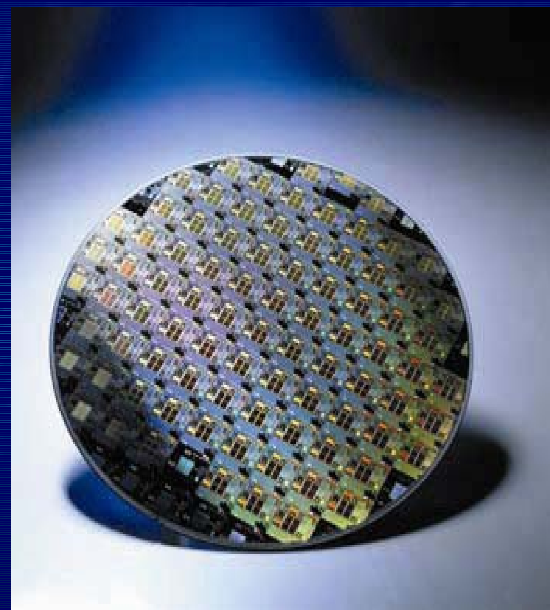
Properties of TEOS Films by LPCVD

Property	TEOS at 705 C
Composition	SiO_2
Refractive index (n)	~1.45
Absorption coefficient (k)	0.0000
Wafer uniformity (%) 6 inch wafer	~1.0
Deposition rate (nm/min)	9.2
Etch rate (nm/min) HF3%	66
Step coverage	Conformal

TEOS Thin Film by LPCVD for Application







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The silicon dioxide (TEOS) films have
wafer uniformity about 1.0 %
refractive index about 1.45
absorption coefficient of 0.0
deposition rate of 9.2 nm/min
Etch rate (HF3%) of 66 nm/min

Acknowledgements

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Thank you for your attention