ICPCVD

Plasma lab System100, ICP180

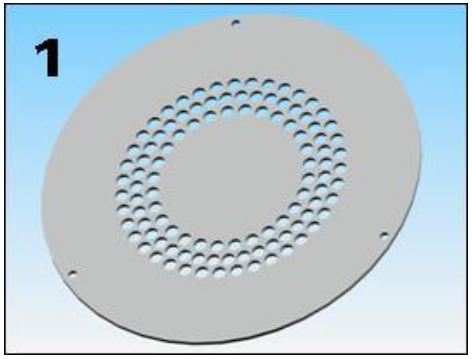
OXFORD INSTRUMENTS

Specifications

- 2”,4”,8” and small pieces
- Si_xN_Y, SiO_2, SiO_XN_Y, a-Si
- Room temperature to 320degC
- Load lock chamber vacuum – 10^{-3} Torr
- Process chamber vacuum – 10^{-7} Torr
- He pressure - applied to the back of wafers to provide good thermal contact between lower electrode and wafer

- Recipes provided by OIPT (Oxford Instruments Plasma Technology)……

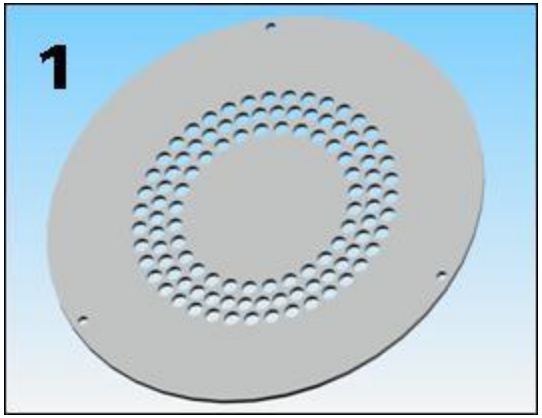
Recipes for SiO2 , SixNy with gas transmission disc 1 from OIPT



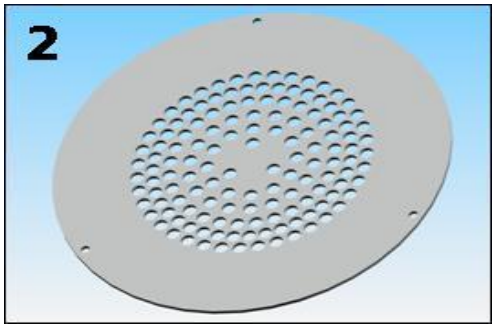
Process Parameter	SiO_2		SiN_x
	Low Rate	High Rate	
100% SiH_4 (sccm)	4	16	14.5
N_2 (sccm)			10
N_2O (sccm)	13	40	
Ar (sccm)			40
He (T)	10	10	10
ICP Power (W)	1000	1000	1000
RF Power (W)	optional	optional	optional
Pressure (mT)	2	4	8
Temperature (^oC)	70	70	70
Deposition rate	9.7nm/min	45nm/min	9.7nm/min
Film thickness uniformity (4inch, 7mm edge exclusion)	<±3	<±3	<±4
Refractive Index	1.460	1.460	1.99
Film Stress	<-100MPa	<-100MPa	-120MPa
Wet Etch rate (10:1 BHF)	Depends on deposition temperature		

More recipes…

Process Parameter	SiO_2	SiN_x	SiON
100% SiH_4 (sccm)	6 - 8	15	15
N_2 (sccm)		10	10
N_2O (sccm)	30 - 40	-	10-20
Ar (sccm)		40	30-40
He (T)	10	10	10
ICP Power (W)	1000 - 2000	1000	1000
RF Power (W)	optional	optional	optional
Pressure (mT)	3 - 5	7 - 8	7 - 8
Temperature (°C)	>250	>250	>250
Deposition rate	7-17nm/min	~7nm/min	>7nm/min
Refractive Index	~1.46	~2.00	~1.6-1.7



Recipes using gas transmission disc2



Process Parameter	SiN_x	SiON	a-Si
100% SiH_4 (sccm)	15	15	10
N_2 (sccm)	12	12	-
N_2O (sccm)	-	10	-
Ar	-	-	20
He (T)	10	10	10
ICP Power (W)	750	1000	500
RF Power (W)	optional	optional	optional
Pressure (mT)	8	7 - 8	10
Temperature (°C)	>250	>250	200
Deposition rate	10nm/min	~10nm/min	~5nm/min
Refractive Index	1.99	~1.6-1.7	<±4

Additional information for a-Si films

- Increase deposition rate can be achieved using higher ICP power (e.g 1000W).
- Si deposited on silicon generally results in a bubbly texture, due to poor adhesion and moderate-to-high compressive film stress, it is recommended that a-Si films are deposited on glass, silicon dioxide, or silicon nitride coated wafers for deposition tests.
- Additional N2O plasma treatment prior to deposition also aids film adhesion to the underlying material.

Recipe from OIPT for NH3 based SiN film

- Silane 18-20sccm
- Nitrogen 10 sccm
- Ammonia 10 sccm
- Argon 40 sccm
- Chamber pressure 4mT
- Temperature 70degC
- RF 40W
- ICP 1000W

- You can also try removing the nitrogen but you will need to either reduce the silane flow (~13.5sccm) or increase the ammonia flow to 20sccm.

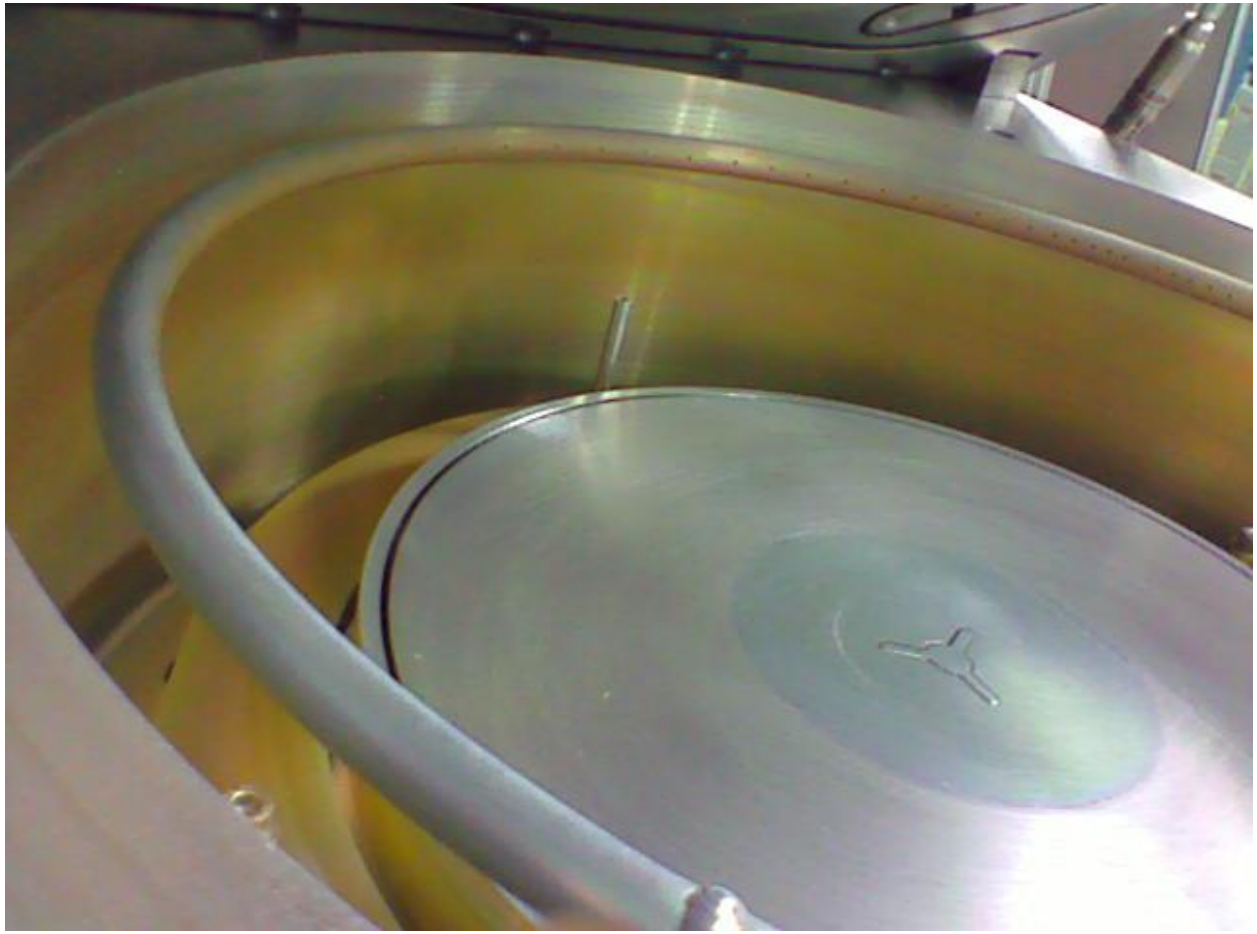
Deposition Techniques

Deposition Techniques	Deposition Temperature
LPCVD	>600^{o}C
PECVD	150-400^{0}C
ICP CVD	**<150^{0}C**

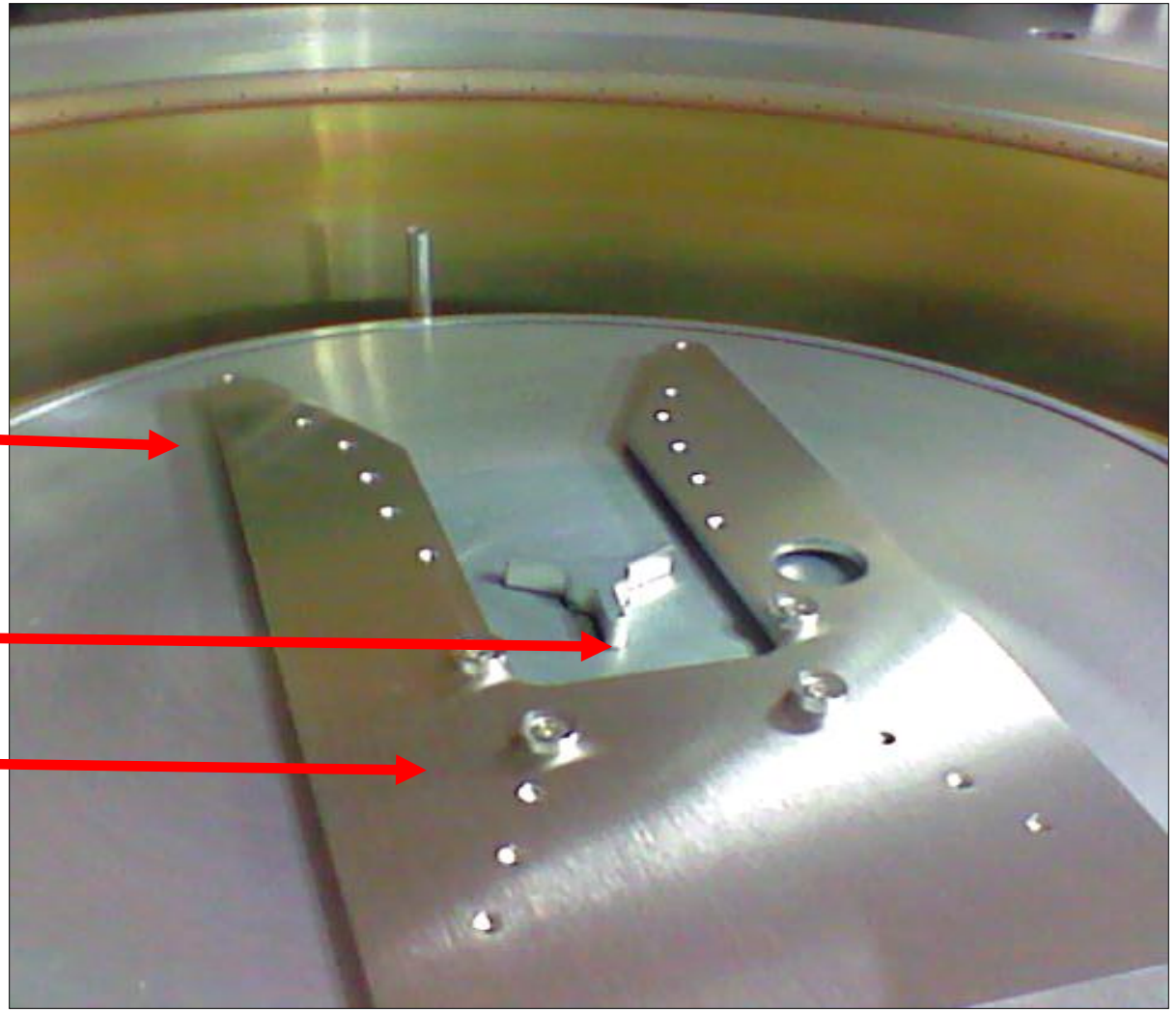
•Provided by OIPT

- Some photographs of the system located in the Nano lab……

Process Chamber



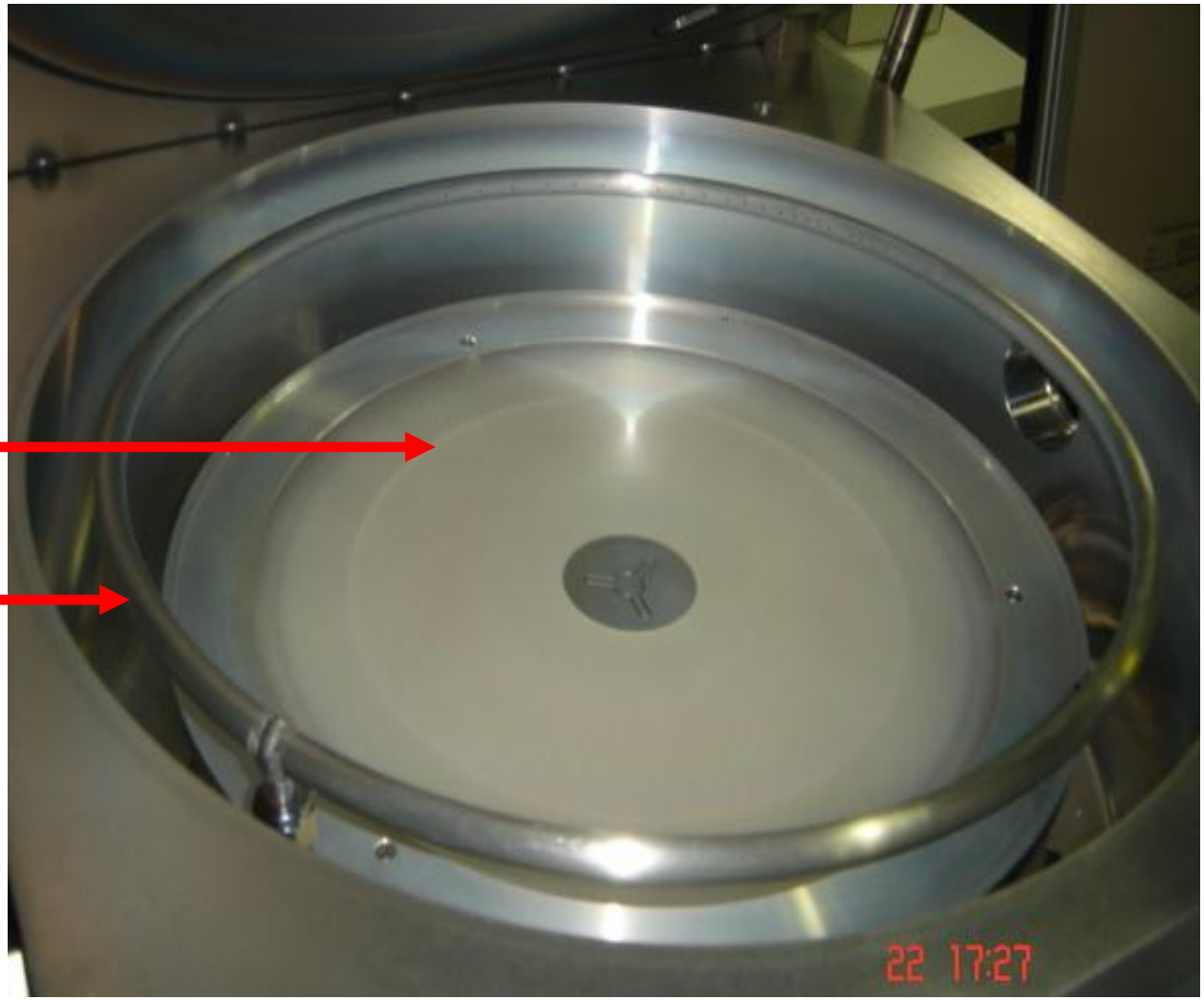
Process Chamber



- Lower electrode
- Wafer lift
- Arm

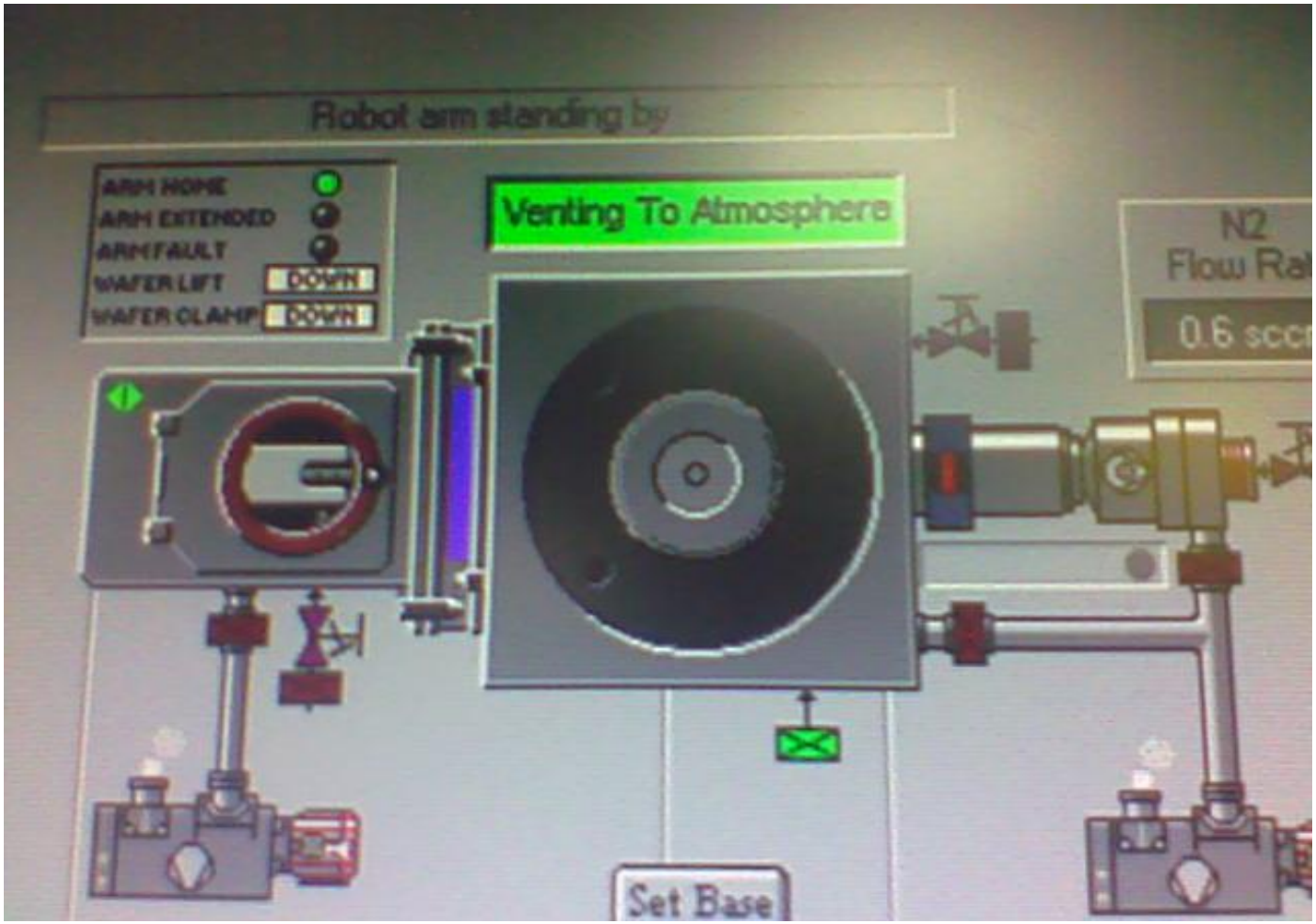
Process Chamber

- **Quartz Wafer Clamp**
- **Transmission ring for SiH4**

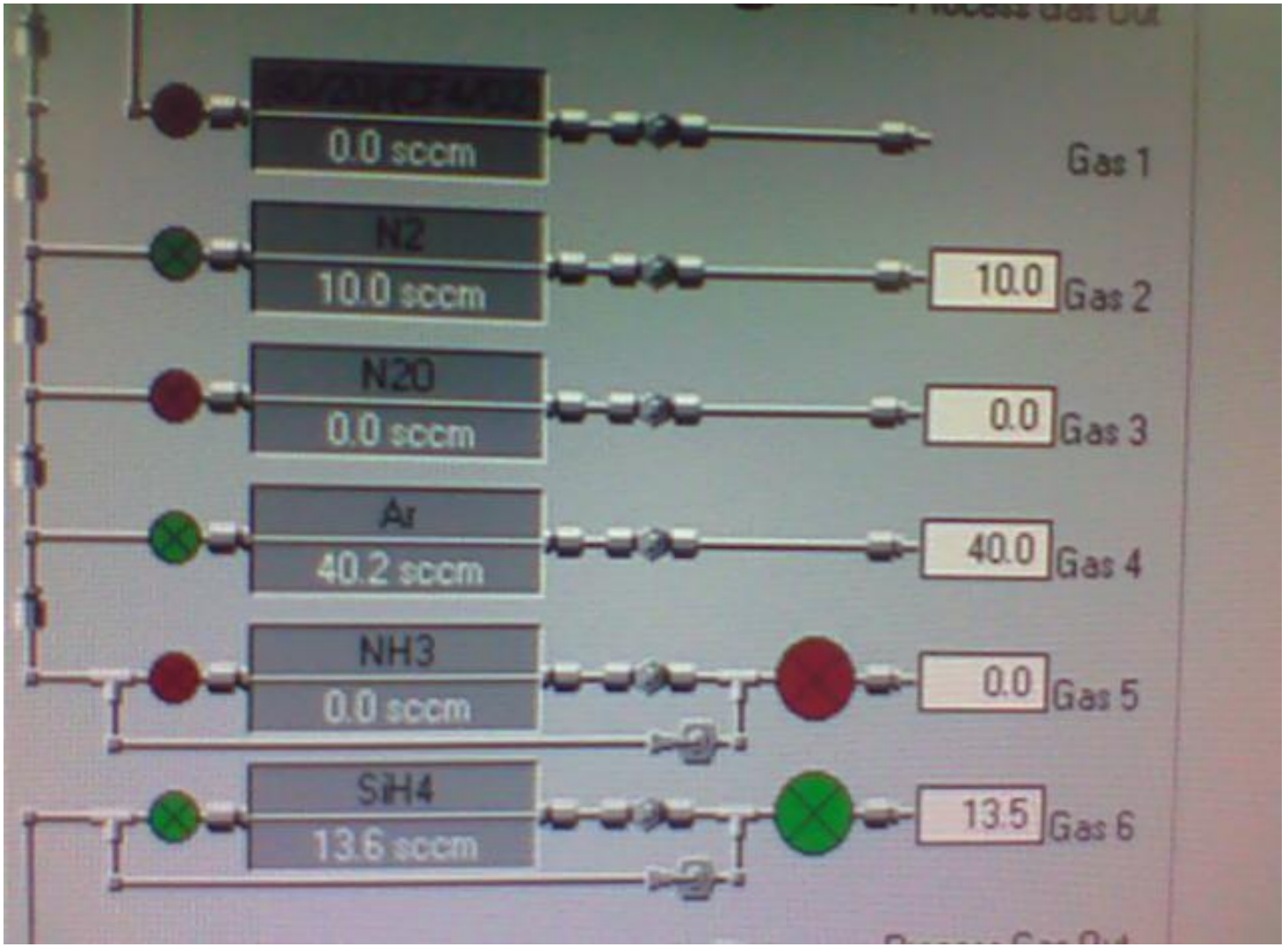


Gas Transmission Disc 1

Simulated display on the PC



Simulated MFCs on the PC



- Our results so far……

Si3N4 Optimization- Optical Characterization

Process parameter	Optimized recipe
SiH4 flow	13.5 sccm
N2 flow	10 sccm
Ar flow	40 sccm
RF for lower electrode	40W
RF for ICP chamber	1000W
Chamber pressure	4mT
Temperature	70 deg

Silicon nitride characterization

Ellipsometer was used to find deposition rate and refractive index. The model selected was that of Si3N4 PECVD.

- Refractive index 2.01
- Deposition rate 21nm/min

Raman Spectroscopy

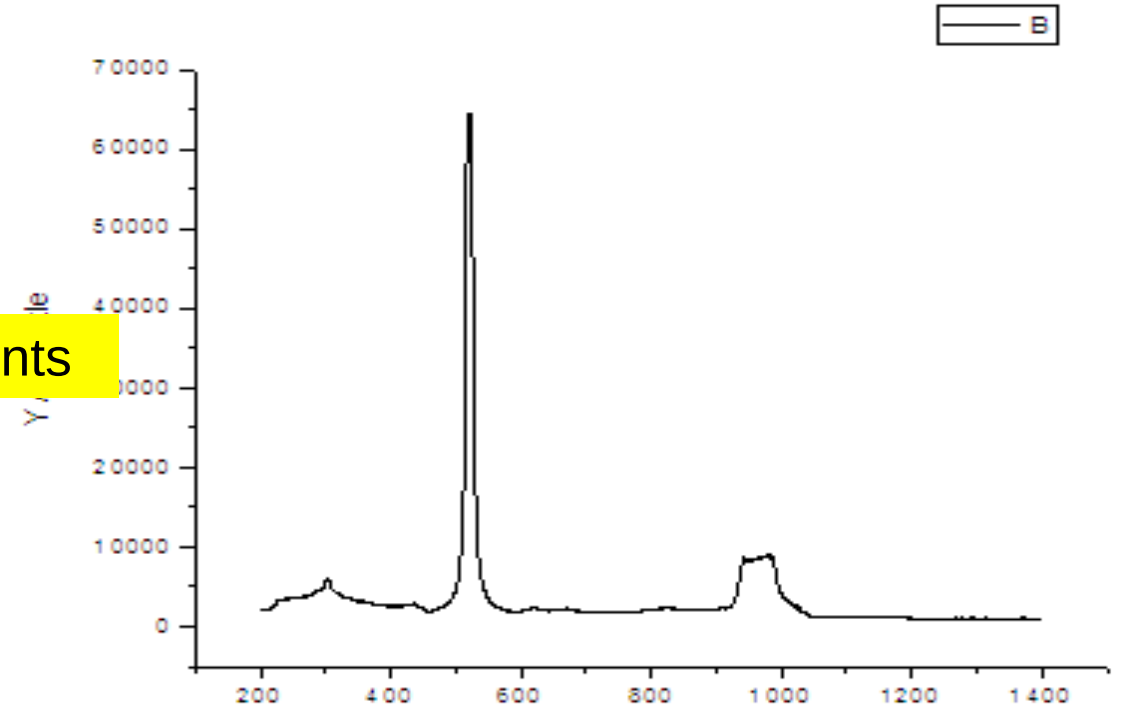
Si3N4

At 520cm-1

Si peak

Broad peak at 1000cm-1

Si3N4



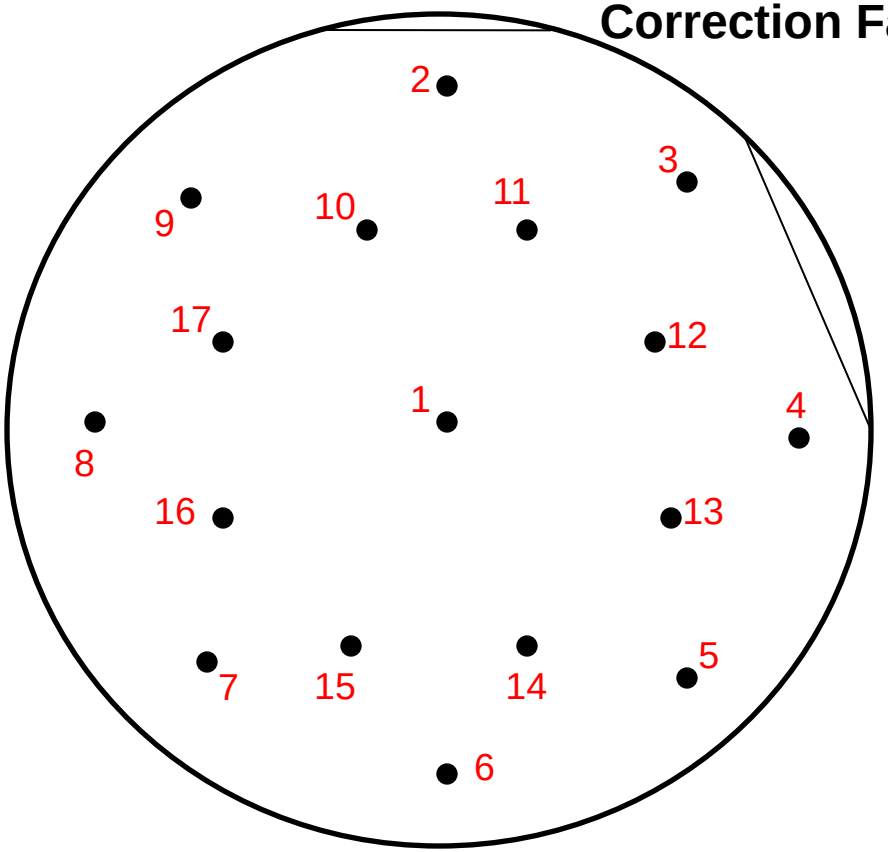
SiH_4 (sccm)	N_2 (sccm)	RF (W)	ICP (W)	Temp (deg C)	Time (min)	Ch. Pr (mT)
13.5	10	40	1000	70	10	4

4” Silicon Wafer

Thickness Uniformity data of Si_3N_4 Film (Optimized) – ICP CVD

Thickness Measurement – Ellipsometer

Correction Factor = 0.5-0.6



Point No.	Thickness (nm)	R . I
1	173	2.1
2	174.98	1.99
3	174.50	2.046
4	174.69	2.049
5	173.21	2.057
6	172.85	2.034
7	172.38	2.044
8	172.90	2.048
9	176.46	2.016
10	172.67	2.067
11	173.25	2.083
12	173.45	2.081
13	173.23	2.099
14	173.07	2.083
15	173.52	2.073
16	172.61	2.081
17	173.53	2.064

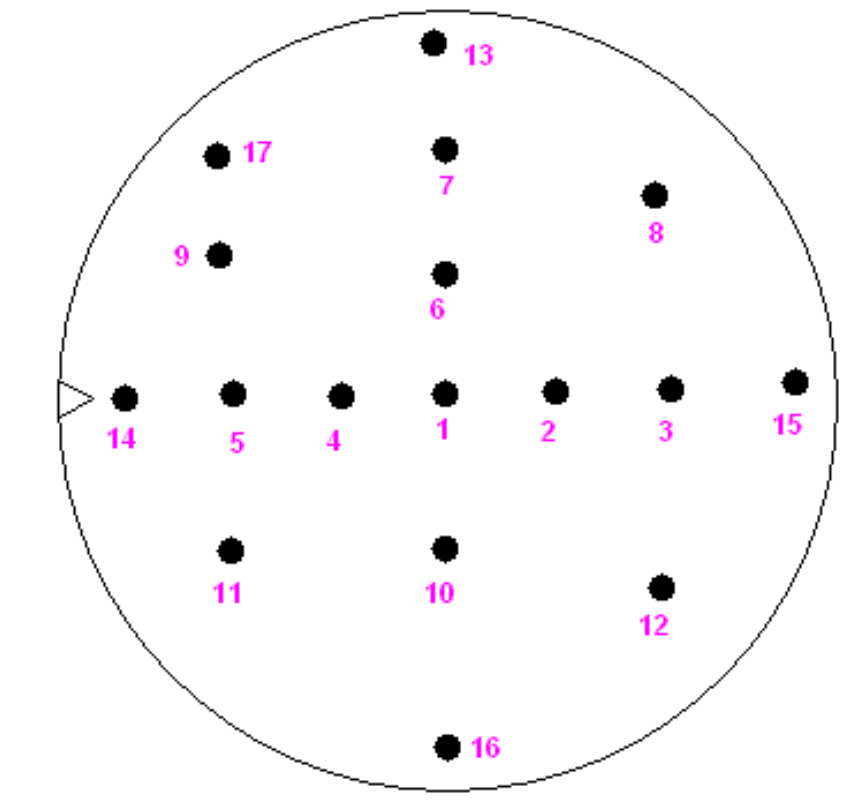
SiH_4 (sccm)	N_2 (sccm)	RF (W)	ICP (W)	Temp (deg C)	Time	Ch. Pr (mT)
13.5	10	40	1000	70	10 min	4

8” Silicon Wafer

Thickness Uniformity data of SiO2 Film – ICP CVD

Thickness Measurement – Ellipsometer

Correction Factor = 0.06



Point No.	Thickness (nm)	R . I
1	54.38	1.55
2	53.97	1.557
3	55.57	1.521
4	55.31	1.545
5	56.92	1.522
6	54.71	1.546
7	56.57	1.525
8	55.64	1.528
9	57.1	1.528
10	54.98	1.516
11	55.48	1.519
12	54.31	1.519
13	55.33	1.517
14	51.39	1.525
15	54.15	1.502
16	54.6	1.516
17	56.89	1.537

SiH_4 (sccm)	N_2O (sccm)	RF (W)	ICP (W)	Temp (deg C)	Time	Ch. Pr (mT)
7	13	40	1000	250	3min 30sec	2

Plasma inside Process Chamber