DETECTION AND QUANTIFICATION OF AIRBORNE AND SURFACE MOLECULAR CONTAMINANTS IN THE SEMICONDUCTOR INDUSTRY

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INTRODUCTION

- **To maintain high yield while scaling down semiconductor structures we need tighter contamination control**
- **This in turns mandates the use of a wide panel of high sensitivity analytical techniques**
- **Specie identification allows corrective actions to be put in place**

CLASS OF CONTAMINANTS

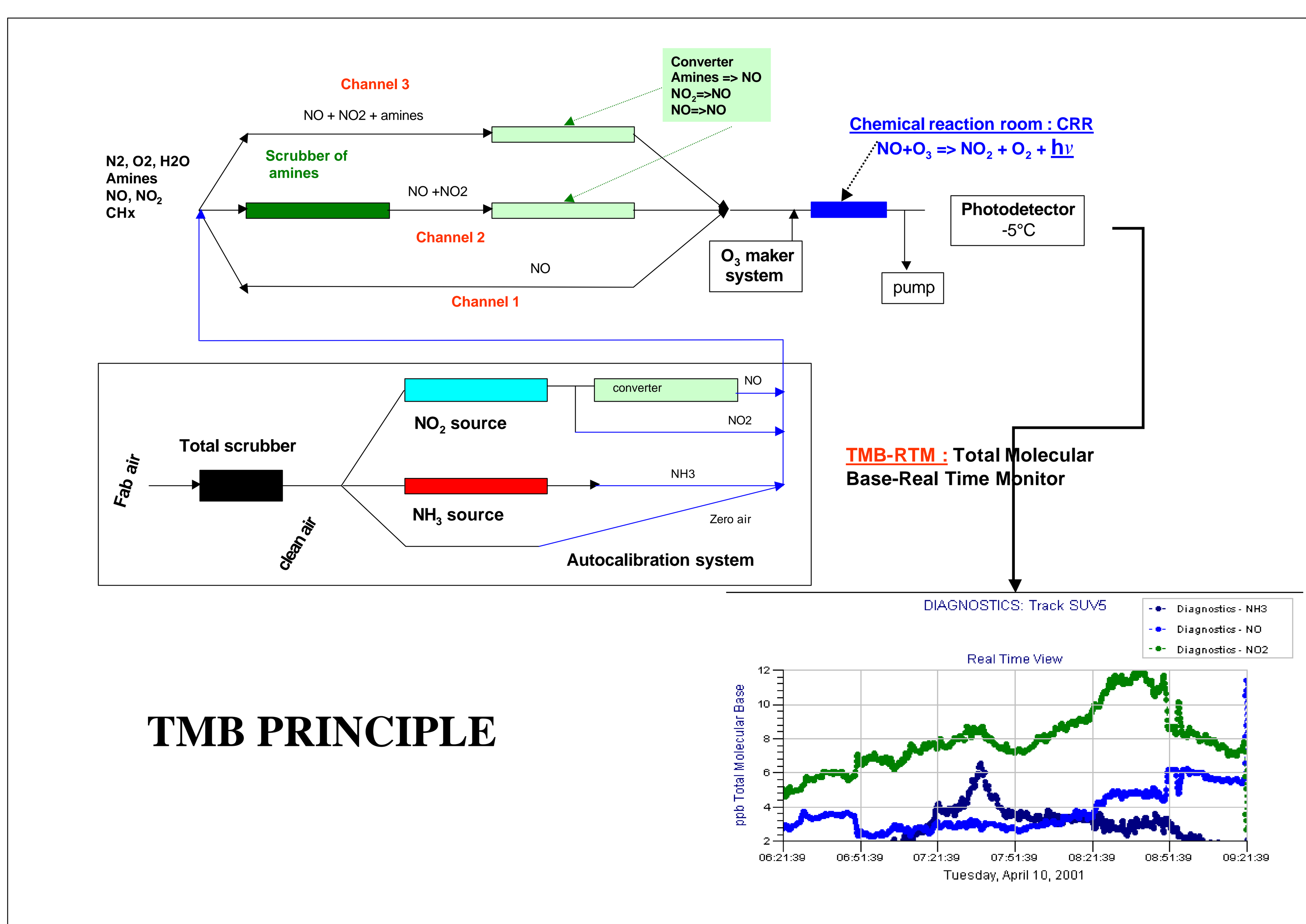
TYPE OF CONTAMINANTS	EXEMPLES	EFFECTS
BASE	NH_3, NMP, amines	T-topping effect on DUV photoresists
Metals	Na, Ca,… Fe, Cu, Ni, Al,…	Junction leakage, free carrier lifetime decrease, …
Organics	silicones, HMDS …	Effects on : epitaxy deposition, gate oxide integrity, etching velocity
Acids	HCl, HF, H_2SO_4, H_3PO_4 …	Corrosion of metal lines
Dopants	B, P, organophosphates	Effect on shallow junctions (depth profil changing)

AVAILABLE TECHNIQUES (* used in our plant)

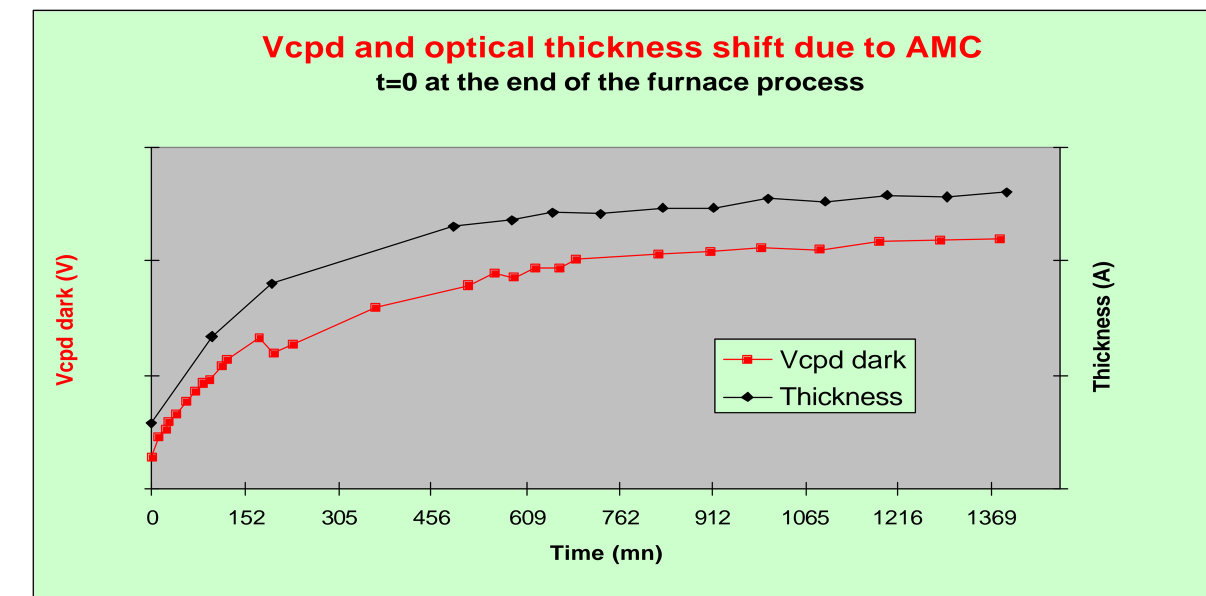
Class	Technique	Quantification	LDD	Implementation
Base	CL* IMS	Yes Yes	500ppt 100ppt	Real time Real time
Metals	TXRF* ICP-MS*	Yes Yes	10^9-10^{10}at/cm² 1-100ppt	In-line/Off-line Off-line
Organics	TD GC-MS* TOF-SIMS* Ellipsometry*	No No No	N/A N/A N/A	Off-Line Off-line In-Line
Acids	IMS IC*	Yes Yes	≈1ppb 0.1 – 1 ppb	In-line Off-line
Dopants	ICP-MS*	Yes	≈ 100 ppt	Off-line

TYPICAL SAMPLING PLAN

Class	Technique	Sampling
Base	CL IMS	Continuous : air monitoring Continuous: air monitoring
Metals	TXRF ICP-MS	On witness wafer , one/area/week Bubblers: one /area/week
Organics	TD GC-MS TOF-SIMS Ellipsometry	Tenax tube analysis: one/area/week On witness wafer, one/area/week On monitor wafer as needed
Acids	IMS IC	Continuous : air monitoring Bubblers: one/area/week
Dopants	ICP-MS	Bubblers: one /area/week



IN-LINE MEASUREMENT OF ORGANICS ADSORPTION

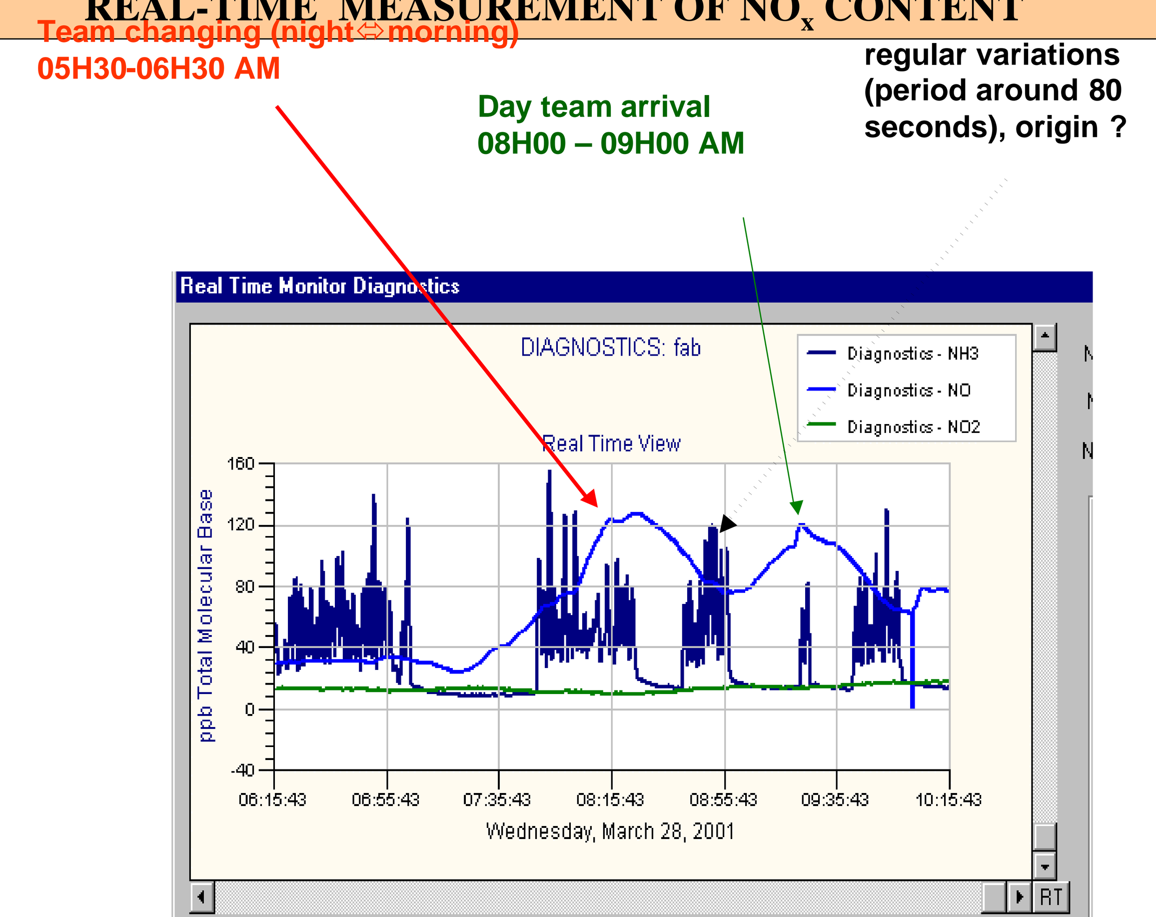


REAL-TIME MEASUREMENT OF NO_x CONTENT

Team changing (night⇨morning)
05H30-06H30 AM

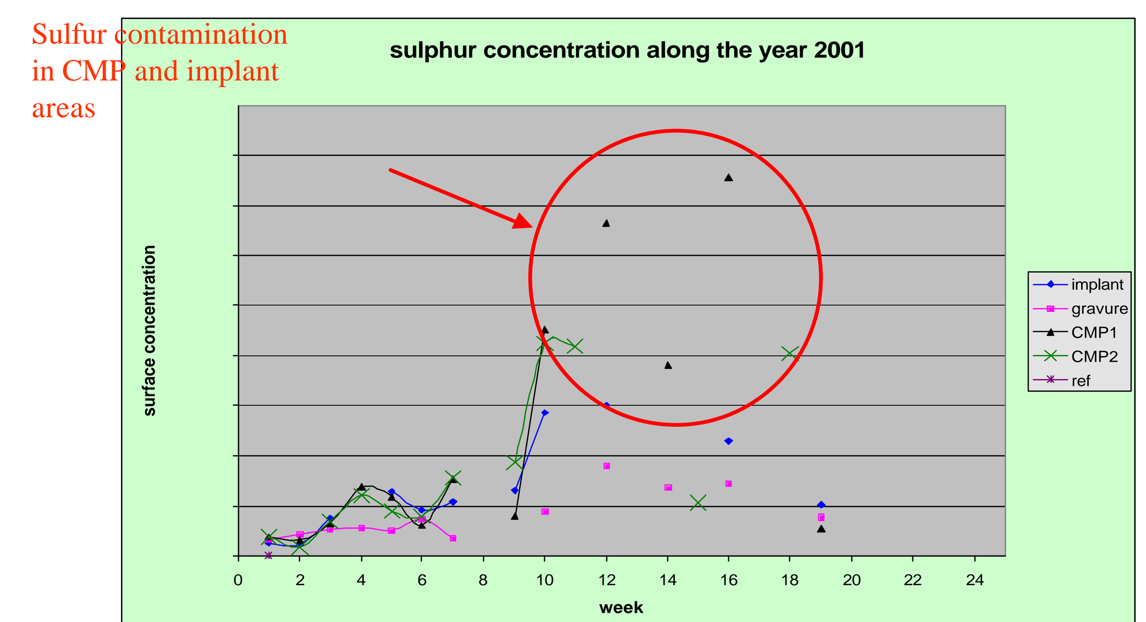
Day team arrival
08H00 – 09H00 AM

regular variations (period around 80 seconds), origin ?



AMC INCIDENT DETECTED BY OUR MONITORING

Sulfur contamination in CMP and implant areas



OFF-LINE MEASUREMENT (TOF-SIMS) TO DETERMIN SULFUR ORIGIN

Ions:	C	F	P	S	Cl	SO	SO_2	^79Br	SO_3	I
Mass:	12.00	19.00	30.97	31.97	34.97	47.97	63.96	78.92	79.96	126.90
AREA	Corrected normalized Peak Intensity (%):									
CMP	5612.7	10103.2	17.1	1418.9	52291.0	3087.7	8803.2	2020.5	34770.9	40.5
DIIFUSION	5400.8	5336.2	10.3	370.2	29965.4	564.7	1504.4	990.1	3256.0	13.4
ETCH	3418.9	2368.1	5.1	235.4	6273.9	313.7	832.0	1078.5	2212.9	3.2
IMPLANT	5117.3	7186.1	15.8	651.0	41029.6	1201.7	3216.3	1025.3	11495.7	11.8
reference	198.6	1194.1	0.3	10.3	117.7	5.7	13.2	4.8	18.9	0.0

Implant area : SF_6 leakage on an implant tool

CMP area : tool leakage because of a harsh environment
⇒ change some polymer tubes attacked by acids + optimisation of exhausts

CONCLUSION

- **Baseline can easily be established and excursion detected**
- **Relationship between ambient an on the wafer (yield impact) AMC level is poorly known**
- **Need for more in-line, real-time analytical techniques**