Defect Reduction and Yield Enhancement, Part 1

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OUTLINE

Particulates

- Particle Definition
- Killer Defects
- Cost of a Killer Defect
- Yield Models
- Sources of Microcontamination
- Particle Counters and Scanners
- Particle Transport Mechanisms
- Defect Test Structures

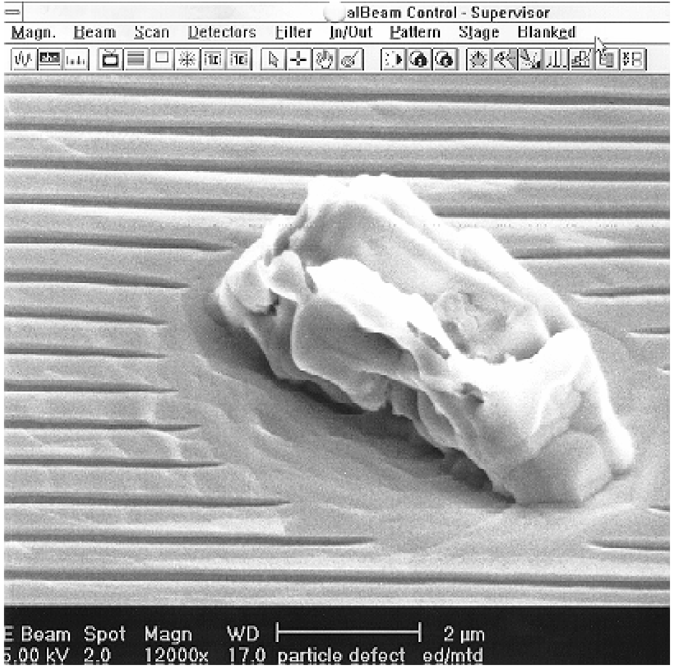
Material Defects

- Wafer Defects
- Gettering
- Oxygen Precipitation

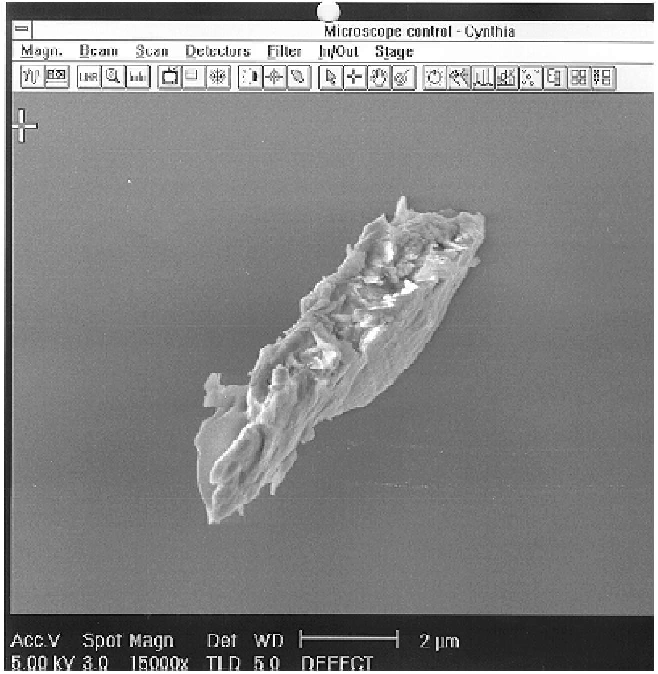
PARTICLE DEFINITION

Stable (Non-Volatile) Conglomeration of Molecules

Diameter ~2 nm to 2 mm



```
E Beam  Spot  Magn    WD   |--------|  2 µm
5.00 kV  2.0  12000x  17.0  particle defect  ed/mtd
```



```
Acc.V   Spot Magn    Det  WD  |--------|  2 µm
5.00 kV 3.0  15000x  TLD  5.0  DEFECT
```

KILLER DEFECTS

ANY PARTICULATE THAT CAUSES A DISRUPTION IN THE INTENDED MICROCIRCUIT PATTERN.

Size is about the minimum feature size and needs to be in a critical spot on the wafer at a critical time in the manufacturing process

ANY CRYSTAL DEFECT THAT CAUSES A DISRUPTION IN THE INTENDED MICROCIRCUIT PATTERN.

Defect needs to be near the surface (Top 5 to 30 micrometers)
Defect needs to be in a critical device area

KILLER DEFECTS (CONTINUED)

ANY CHEMICAL CONTAMINATE THAT CAUSES A DISRUPTION IN THE INTENDED ELECTRONIC DEVICE OPERATION.

Metals such as gold, copper, platinum etc causes decrease in lifetime of minority carriers causing devices such as memory and CCD's to fail (less than 10 parts per trillion)

Metals such as sodium and potassium causes shifts in threshold voltage of MOS FET's (less than one part per billion)

Metals such as boron, phosphorous, arsenic, aluminum, indium, antimony are semiconductor dopants
(less than one part per million)

COST OF KILLER DEFECT

THE COST OF ONE KILLER DEFECT PER WAFER

assume 5000 6 inch wafer starts per week
assume 1 cm x 1cm size chip
assume $10 selling price

AREA = **PI R^2**
(3.14)(7.5 cm)^2 = 176 cm2

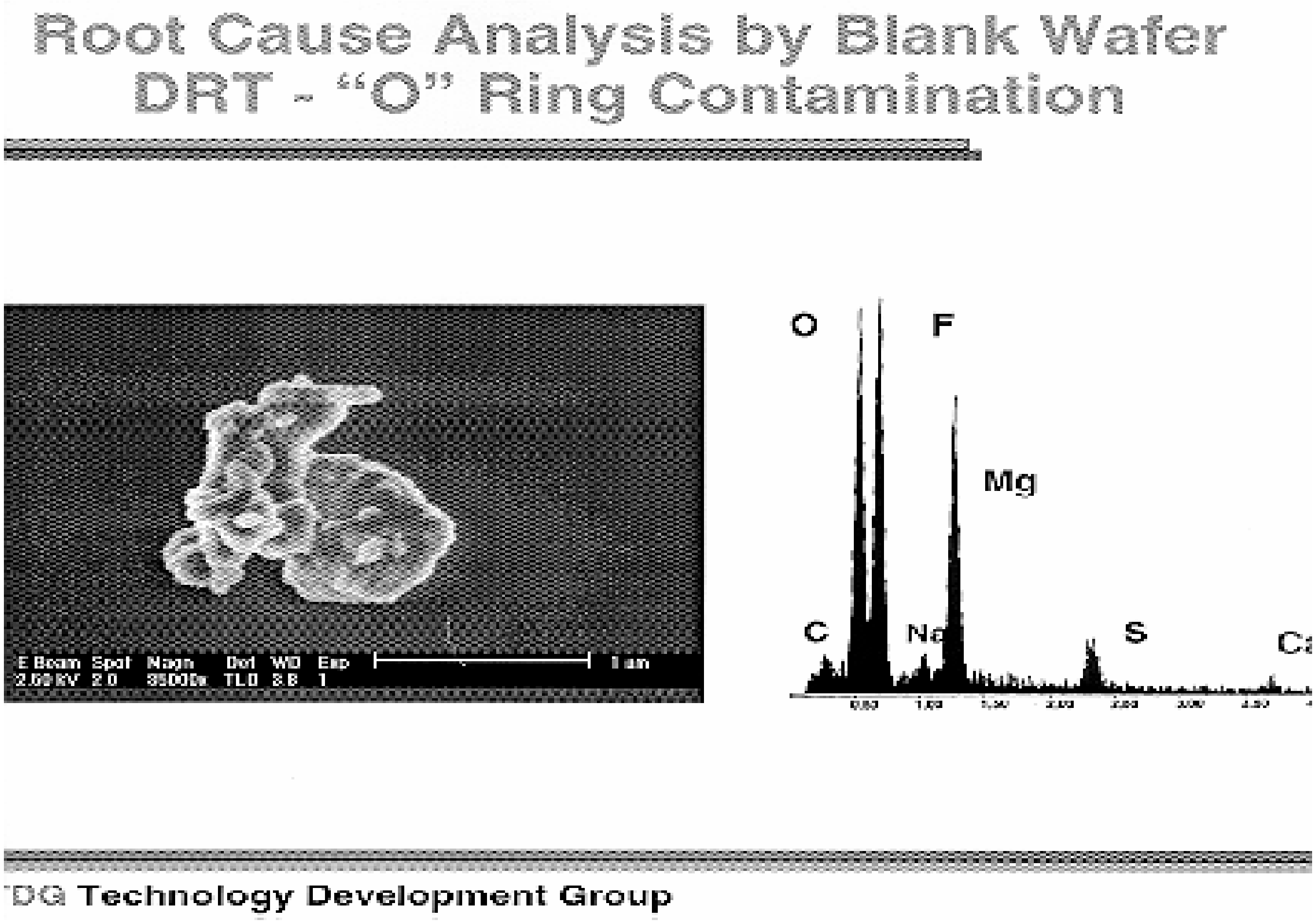
NUMBER OF DIE/WAFER = AREA/DIE AREA
= 176 die

NUMBER OF DIE PER YEAR =
= (50000wfr/wk)(52 wk/yr)(176 die/wfr)
= 45,760,000 die/year

DOLLARS/YEAR = $457,600,000/year

COST OF ONE ADDITIONAL KILLER DEFECT / WFR
= $457,600,000/176 = $2,600,000 / year

IDENTIFY SOURCE OF CONTAMINATION



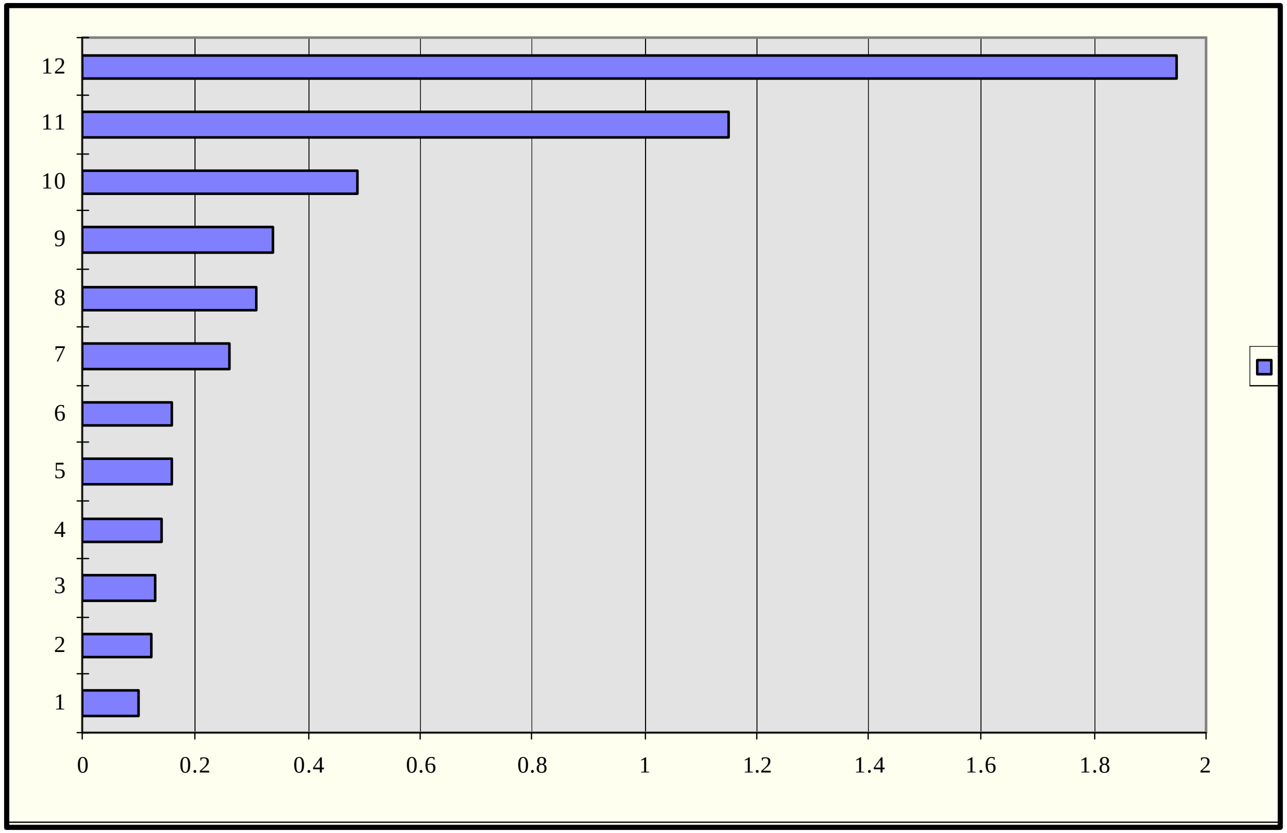
Root Cause Analysis by Blank Wafer DRT - "O" Ring Contamination

DG Technology Development Group

COST OPPORTUNITY

SEMATECH COST RESOURCE MODEL SENSITIVITY

Probe Yield
Fab Yield
Throughput
Downtime %
Tool Capital
Consumables
Materials
Maintenance
space
Salaries
Clean Room Layout
Operators



% Cost Chang per 1 % Change in Variable

YIELD MODELS

$$\mathbf{YIELD = e^{-AD}}$$

WHERE **A** is the **CHIP AREA (cm^2)**

D is the **DENSITY OF DEFECTS (#/cm^2)**

EXAMPLE: CHIP AREA is 1 cm^2 and **DEFECT DENSITY** is 1/ cm^2

then **YIELD = e $^{-1}$ = 37%**

MICROCONTAMINATION - CLEANROOM

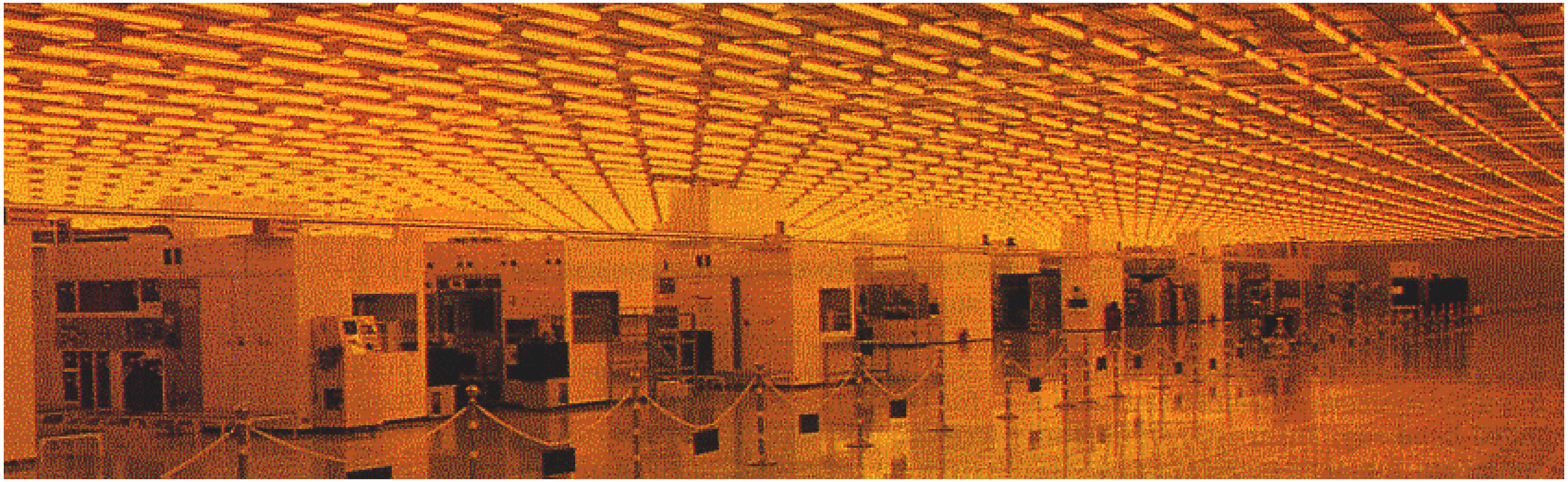
MAXIMUM NUMBER OF PARTICLES PER CUBIC FOOT OF AIR

	0.1 um	0.2um	0.3um	0.5um
CLASS 1	35	7.5	3	1
CLASS 10	350	75	30	10
CLASS 100		750	300	100
CLASS 1000				1000

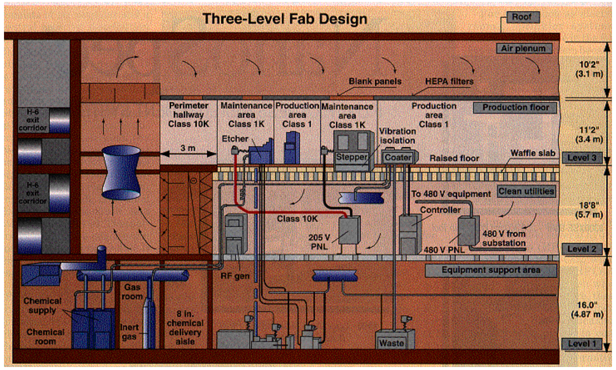
Federal Standard 209D, U.S. GSA 1989

CLEANROOM DESIGN

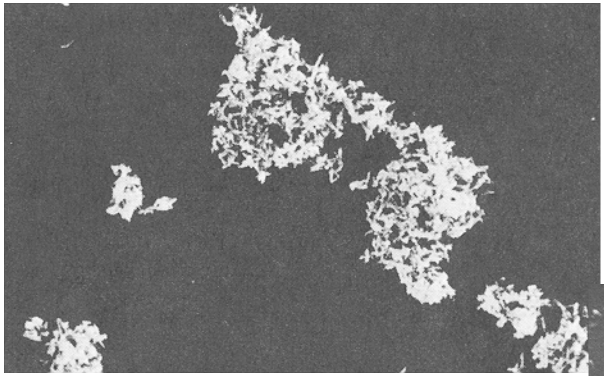
BALLROOM DESIGN
TUNNEL AND CHASE DESIGN
MINI-ENVIRONMENT



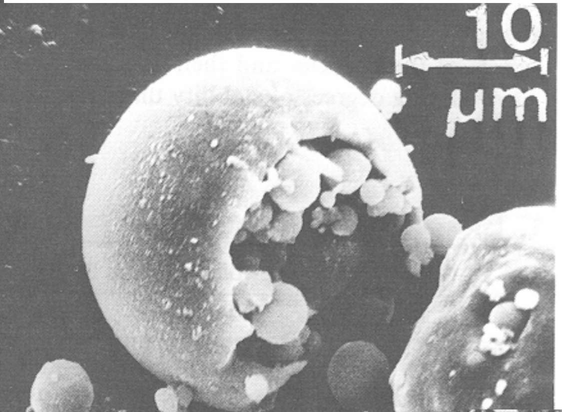
Ballroom Design



PARTICLES AND THEIR SOURCE

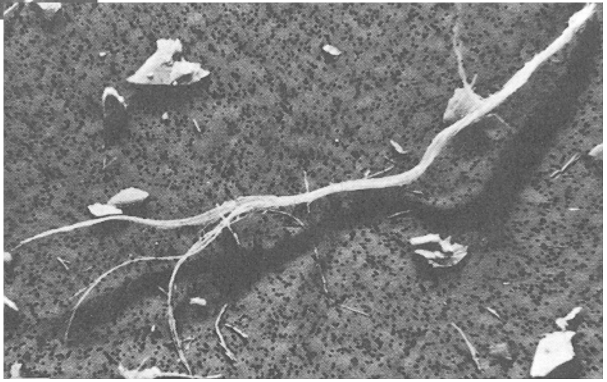


Iron oxide from welding process



Fly ash from coal burning power generation

Asbestos



Ref: William Hinds, “Aerosol Technology”

MINI ENVIRONMENT

SMIF Cassette Loading Tools

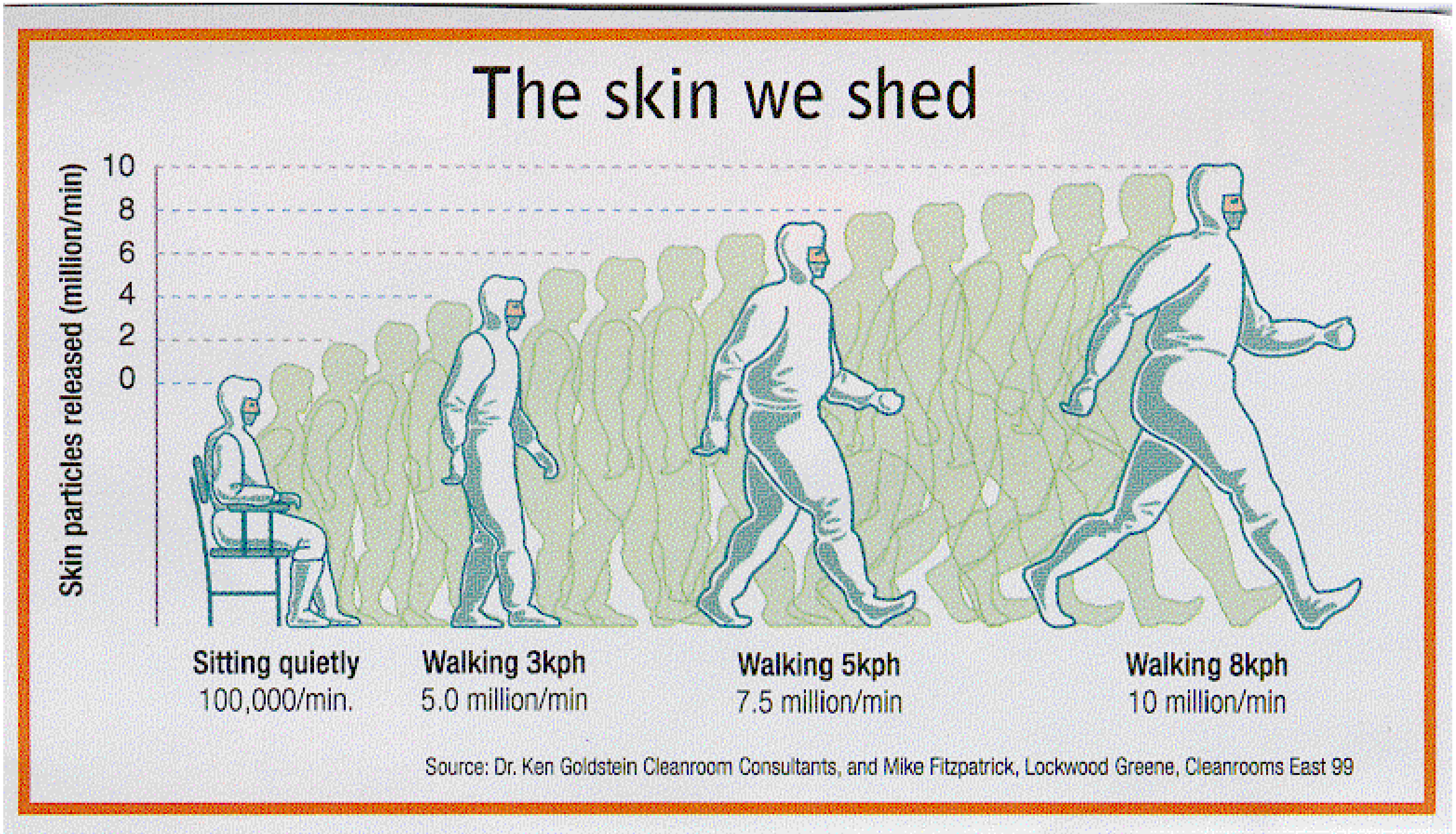
Open Cassette Loading

SMIF Cassette

MICROCONTAMINATION - PEOPLE

People can generate up to 2,000,000 particles per minute. By using white suits and other clean room protocols this number can be reduced to less than 10,000 particles per minute.

PEOPLE AND MOVEMENT

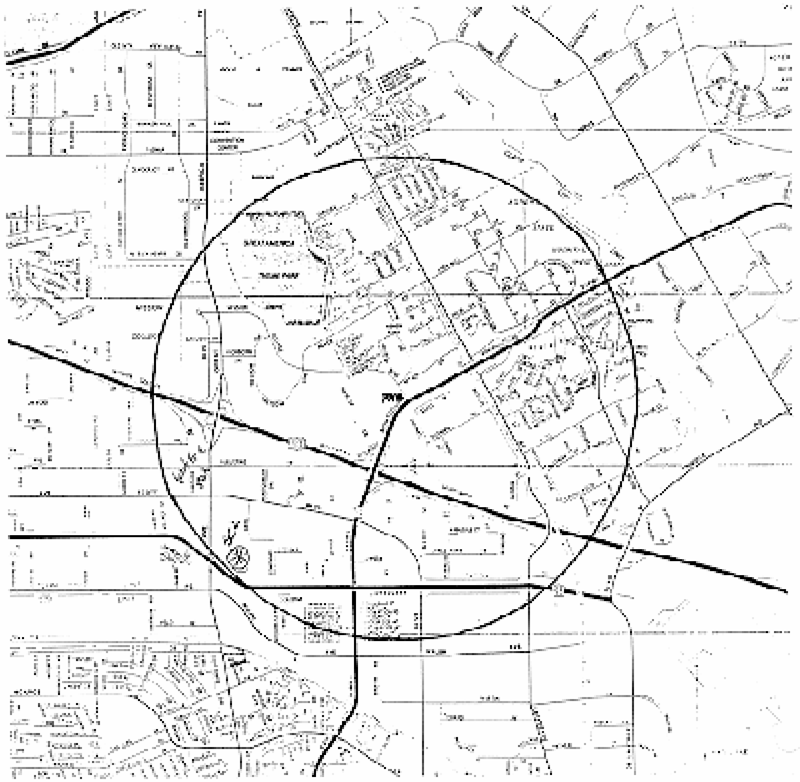


Source: Dr. Ken Goldstein Cleanroom Consultants, and Mike Fitzpatrick, Lockwood Greene, Cleanrooms East 99

RELATIVE SIZE

Finding a 1µm particle on an 8” wafer is equivalent to finding a penny in the city of Rochester, NY

Finding a 1 µm particle on an 8" wafer is equivalent to finding a penny in the area shown below.



PARTICLE COUNTS IN FAB OVER A WORKDAY

PARTICLE COUNTS OVER A WORKDAY

Laser Particle Counter (LPC) 3A and 3B and Condensation Nucleation Counter (CNC) 4A all at the same location in the fab.

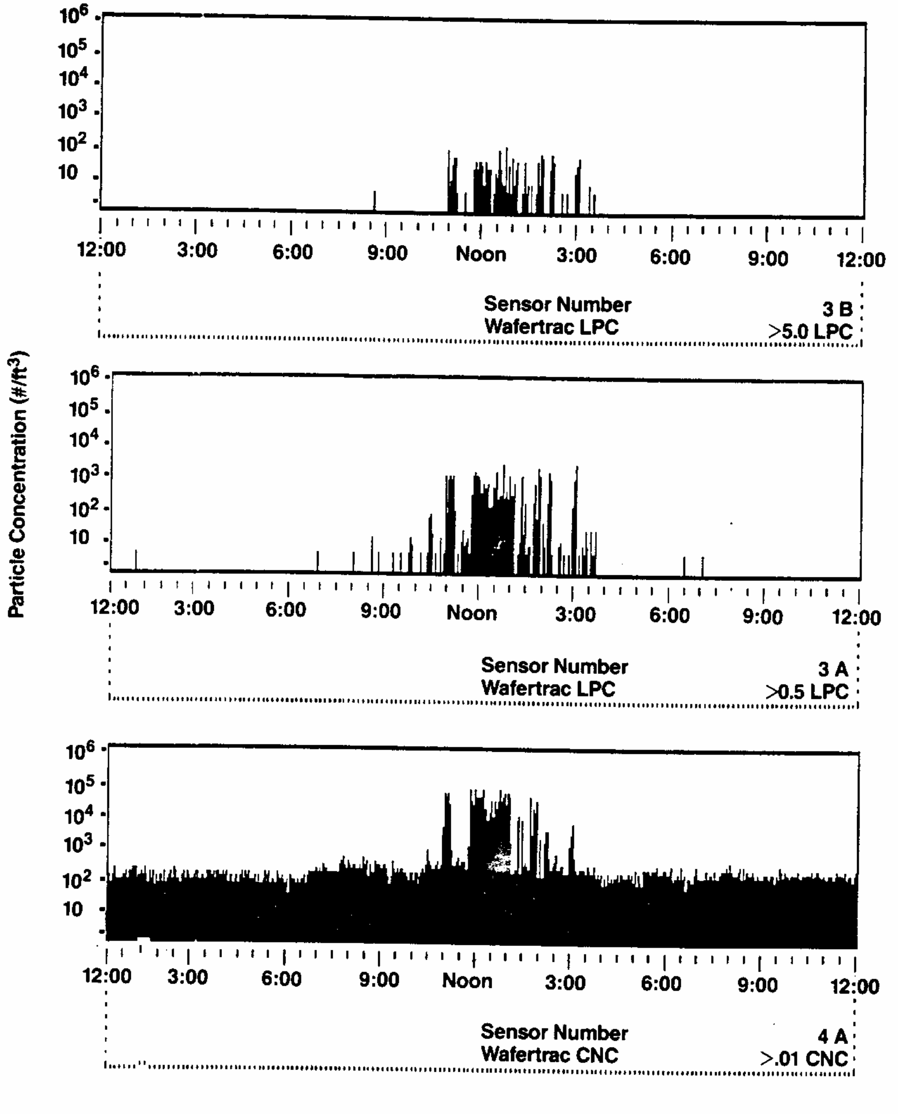


Figure 8-4. Particle size and concentration profiles for

POSITIVE PRESSURE IN A CLEANROOM

24 HOUR TRACE OF PARTICLE COUNT AND CLEANROOM PRESSURE

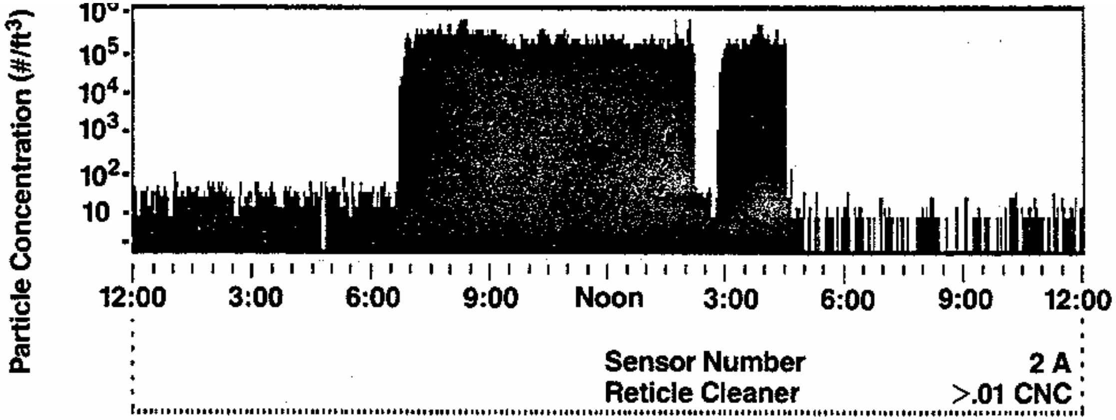
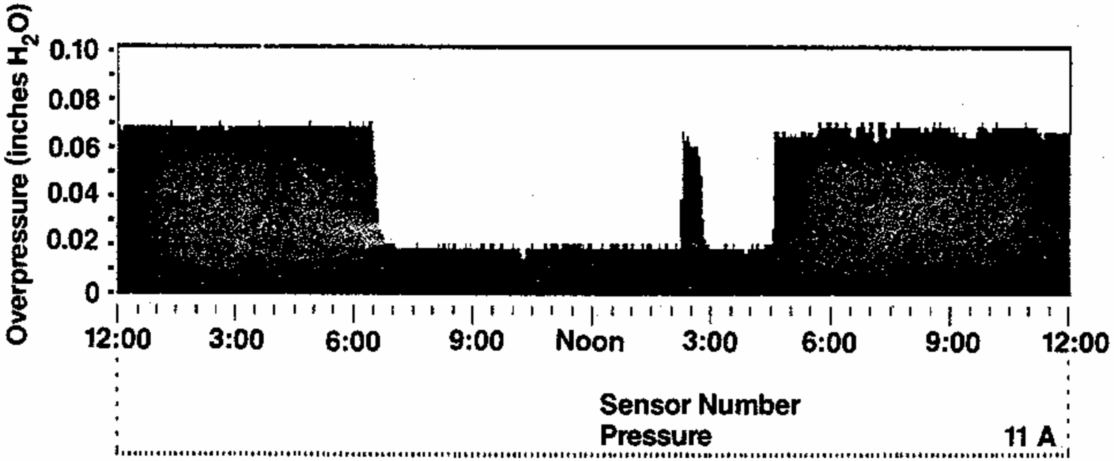
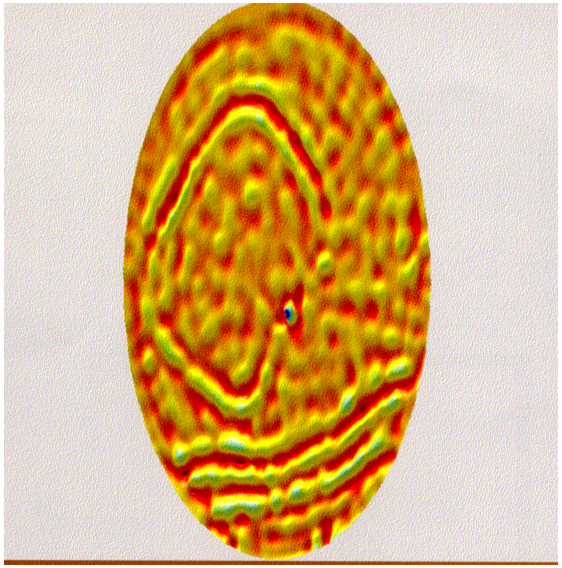
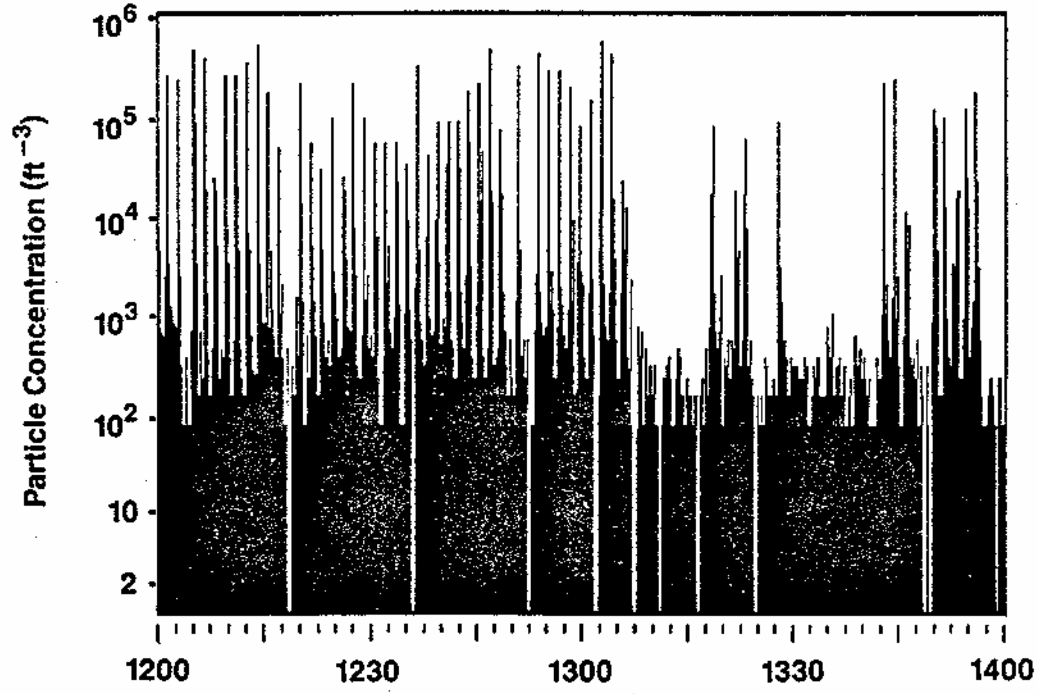


Figure 8-7a. A 24-h particle concentration profile measured near the reticle cleaner.



PARTICLES NEAR PHOTORESIST SPINNER



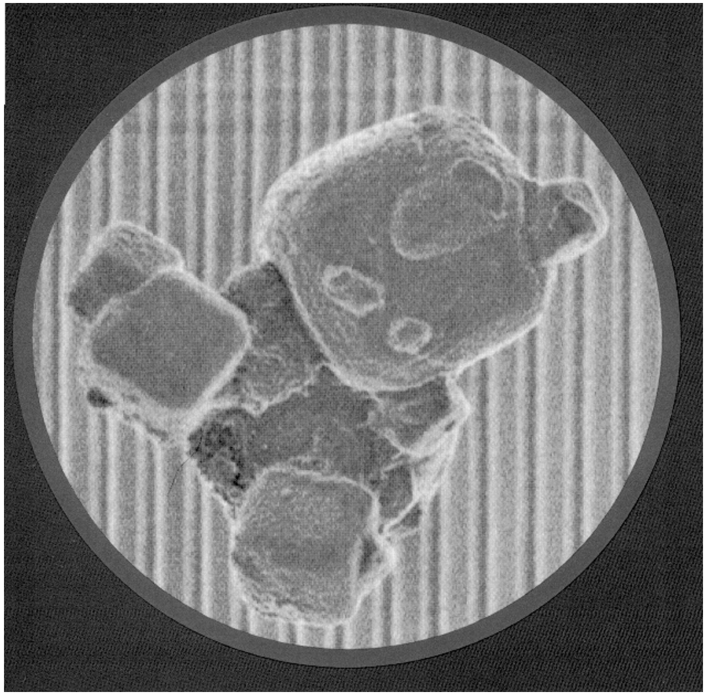


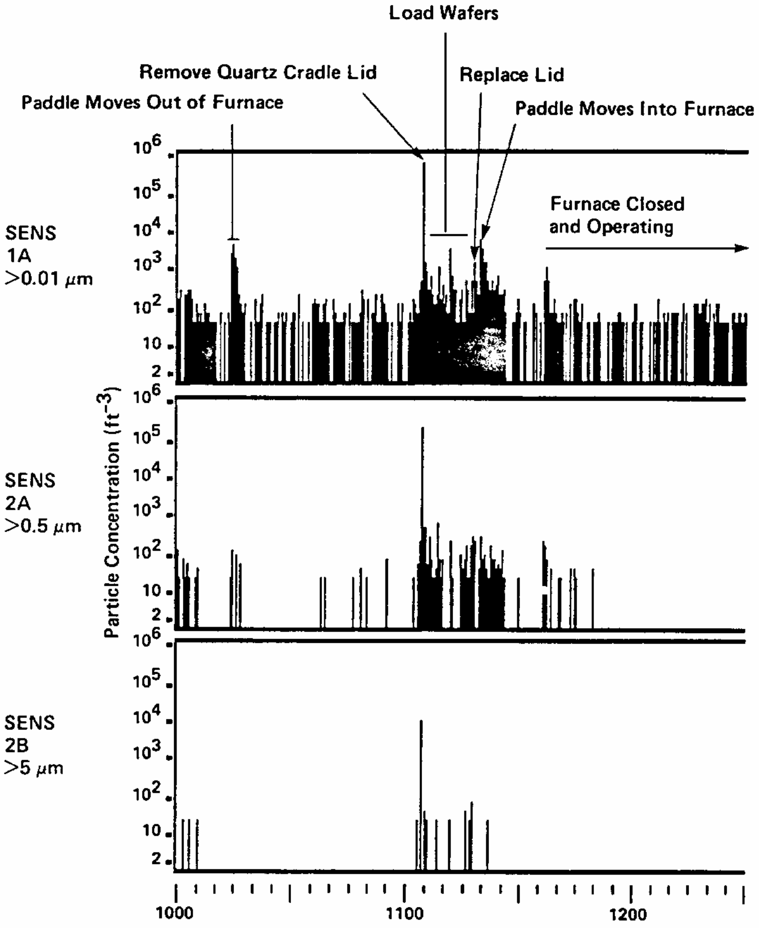
Source: Donovan et al., 1988

Figure 9-7. Periodic bursts of particles larger than 10 nm in the vicinity of a photoresist spinner.

PARTICLE COUNTS NEAR LPCVD SYSTEM

PARTICLES NEAR LPCVD LOAD STATION





Source: Donovan et al., 1988

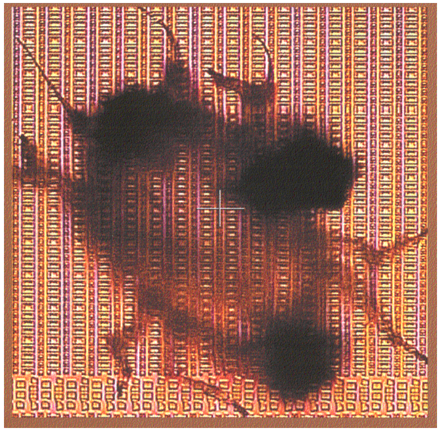
Figure 9-8. Particle concentration from the loading area of a low pressure chemical vapor deposition furnace.

MICRO CONTAMINATION - EQUIPMENT & PROCESS

MICRO CONTAMINATION IN IC MANUFACTURING

RCA CLEAN AND WET ETCH	**SCALE (0-10) IMPORTANCE**
particles in liquids	2
particles on surface of baths (langmire film deposition)	4
process design	8
PLASMA ETCH	
particles formed by the process	10
particles from the gas source	2
DIFFUSION	
particles generated in diffusion furnace due to mechanical movement	4
particles from the gas source	2

MICRO CONTAMINATION - EQUIPMENT & PROCESS



PHOTOLITHOGRAPHY

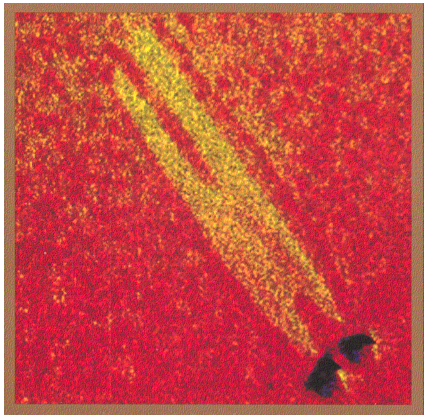
drips	2
airborne dust	2
solids in the resist	4
particles from dried developer	6
particles from spinners	4

METALIZATION

flakes from previous depositions	10

HANDELING

marks and scratches	4
edge marks from boats and positioning fixtures	4
particles from storage boxes	4



MICRO CONTAMINATION - EQUIPMENT & PROCESS

FACILITIES PROBLEMS

loss of positive pressure	5
dirty equipment	8
dirty areas	8
people	8
HEPA filter failure	2
air flow problems	8
procedures	10

LPCVD

flakes from previous depositions	10
particles formed by the process	10
particles from the gas source	2

ION IMPLANT

basically clean	0
mechanical movement	2

REVIEW

TODAY REDUCTION IN PARTICULATE CONTAMINATION IS CENTERED AROUND IMPROVEMENTS IN EQUIPMENT AND PROCESSES.

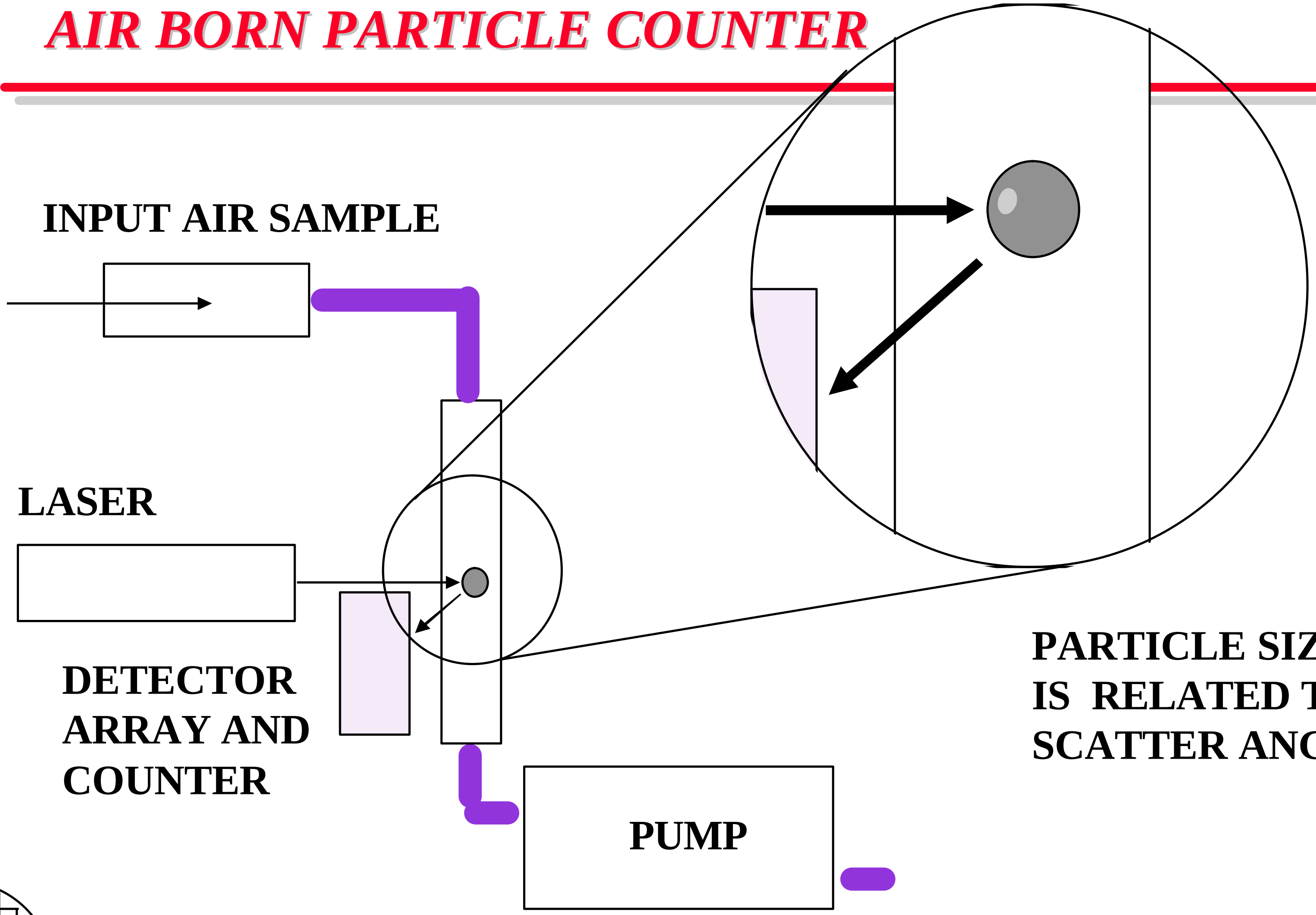
THE CLEANROOM CAN SHOW PARTICLE BURSTS MANY ORDERS OF MAGNITUDE ABOVE THE NOMINAL BACKGROUND PARTICULATE LEVEL.

MINI-ENVIRONMENTS OFFER FURTHER IMPROVEMENTS IN CLEANROOM ENVIRONMENTS.

PARTICLE COUNTERS

- **Scattered Light Counters Give Size and Count and Are Accurate down to 0.3 um**
- **Particle Size is related to scatter angle**
- **Condensation Nucleus Counter can be used for particles smaller than 0.3 um**
  - **particles are drawn through a saturated vapor (often alcohol) making the particles large enough to be counted**
  - **particle size is not easy to determine once nucleation is used**

AIR BORN PARTICLE COUNTER



INPUT AIR SAMPLE

LASER

DETECTOR ARRAY AND COUNTER

PUMP

PARTICLE SIZE IS RELATED TO SCATTER ANGLE

METONE PARTICLE COUNTER

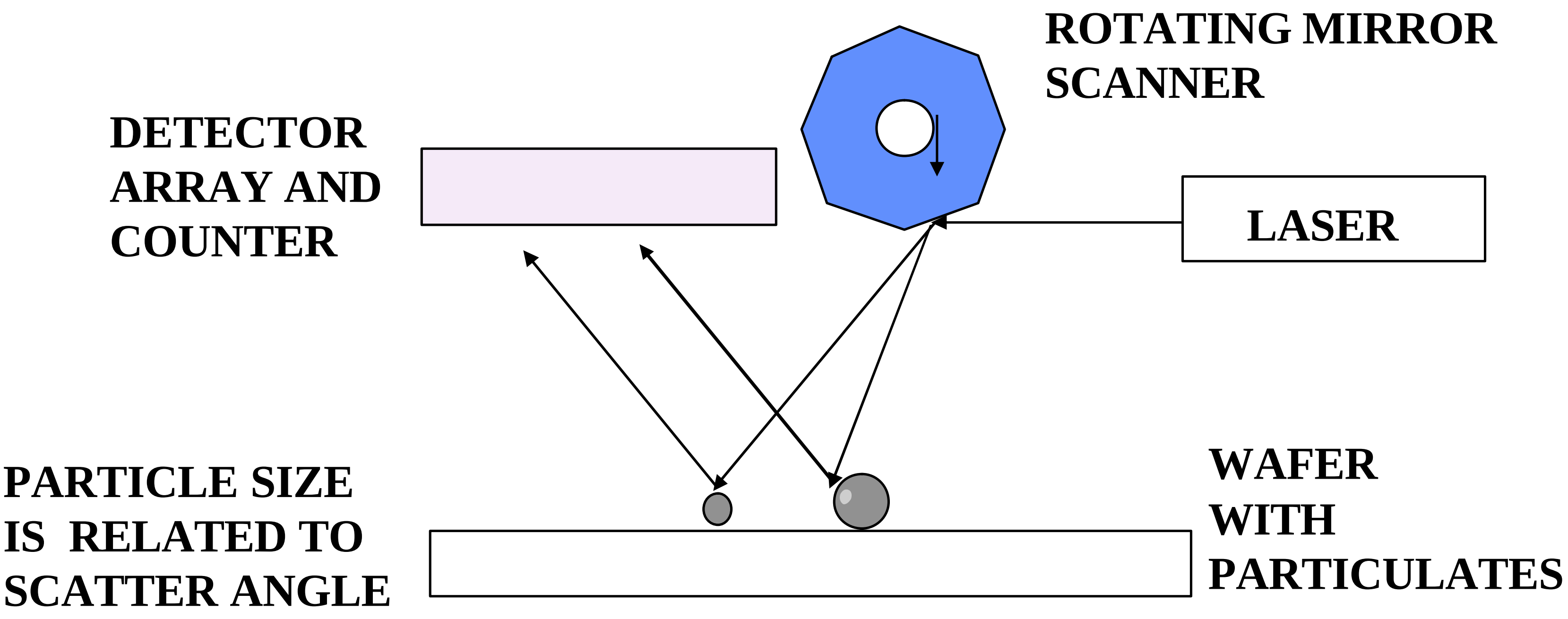
(LPC) Laser Particle Counter counts air born particles <0.3, 0.5, 1.0 2, 5, >10 µm sizes. System also measures temperature, humidity and air flow.

METONE PARTICLE COUNTER

EXAMPLE PARTICLE COUNT DATA

Date	Time	Temp	Hmd	10µm	5µm	2µm	1µm	0.5µm	0.3µm
1-17-96	1.18	66.4	37.4	1	1	41	84	278	348
1-23-96	1.42	65.8	46.6	3	6	40	69	325	467
1-25-96	1.18	66.6	47.3	0	0	101	205	1111	1592
1-26-96	9.28	66.4	47.3	6	10	71	129	460	572
1-29-96	12.28	66.1	50.5	2	3	32	47	137	156
1-30-96	1.53	67.2	47.3	2	3	20	47	209	280
2-1-96	1.03	68.9	45.5	3	4	30	66	240	289
2-5-96	12.28	67.6	47	11	11	47	86	267	343
2-6-96	12.26	67.4	46.7	0	1	30	52	190	259
2-7-96	1.05	66.8	53.4	1	1	26	44	177	248
2-8-96	12.23	66.4	52.1	5	7	119	227	870	1199
2-9-96	12.23	66.3	51.1	3	6	64	111	467	653
2-12-96	11.14	65.2	49.1	3	3	55	106	506	700
2-13-96	10.33	64.1	52	2	7	45	122	717	1181

SURFACE PARTICLE SCANNER

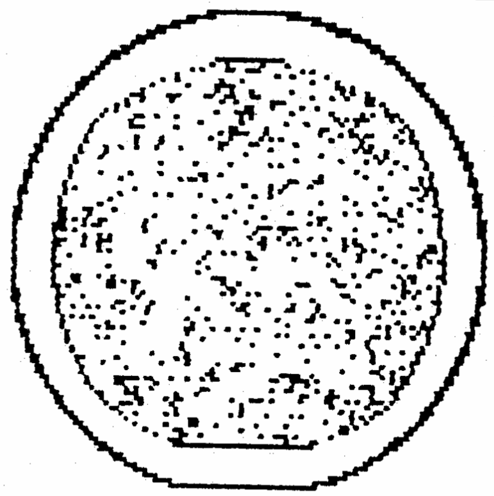


PARTICLE SIZE IS RELATED TO SCATTER ANGLE

TENCORE SURF SCAN

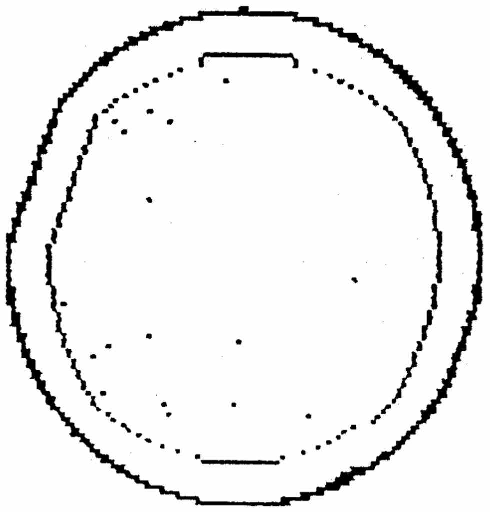
Gives total surface particle count and count in 4 bins <0.5, 0.5 to 2.0, 2.0-10, >10. Bin boundary can be selected. Edge exclusion eliminated count from near the edge of the wafer.

EXAMPLE SURFACE PARTICLE COUNT DATA



Before Cleaning (75 mm)

Size Range (µm)	Count
0.2 - 0.5	104
0.5 - 2.0	562
2.0 - 10	19
>10	2



After Cleaning (75 mm)

Size Range (µm)	Count
0.2 - 0.5	10
0.5 - 2.0	4
2.0 - 10	3
>10	0

PARTICLE TRANSPORT MECHANISMS

RAINDROP MODEL (NOT ACCURATE)

$$F = C V$$

F = DEPOSITION FLUX (# / sec / unit area)

C = PARTICLE CONCENTRATION (# / ft^3)

V = AIR VELOCITY (ft / sec)

EXAMPLE: **Class 100 clean room with air velocity of 100 ft/min**

$$F = (100)(100) / 60 ((2.54)(12))^2 = 0.02 \text{ particles/cm}^2 \text{ / sec}$$

this is close but overestimates the number of particles because some do not adhere to the surface. the relationship can be useful if v is replaced by an effective velocity Veff called the aerosol particle deposition velocity

PARTICLE DEPOSITION MODELS

Veff = Aerosol Particle Deposition Velocity (number of particles / time)

F = C Veff

or Veff = F / C

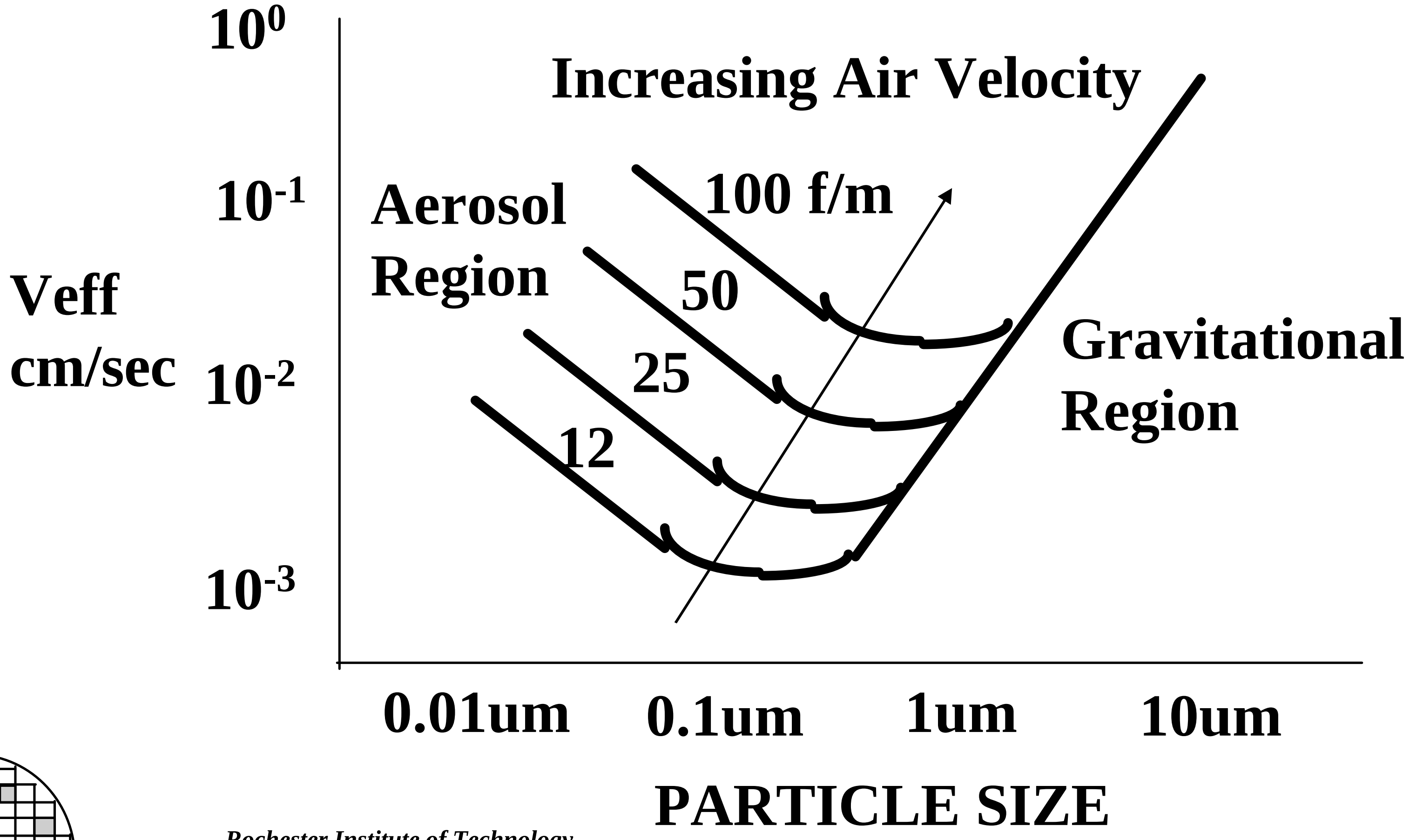
Where we find F from monitor wafers using a surface particle counter and C is measured using an Airborne Particle Counter

Example: After 8 hours in a class 100 clean room a 4 inch monitor wafer shows an increase in surface particle count from 50 to 550 particles.

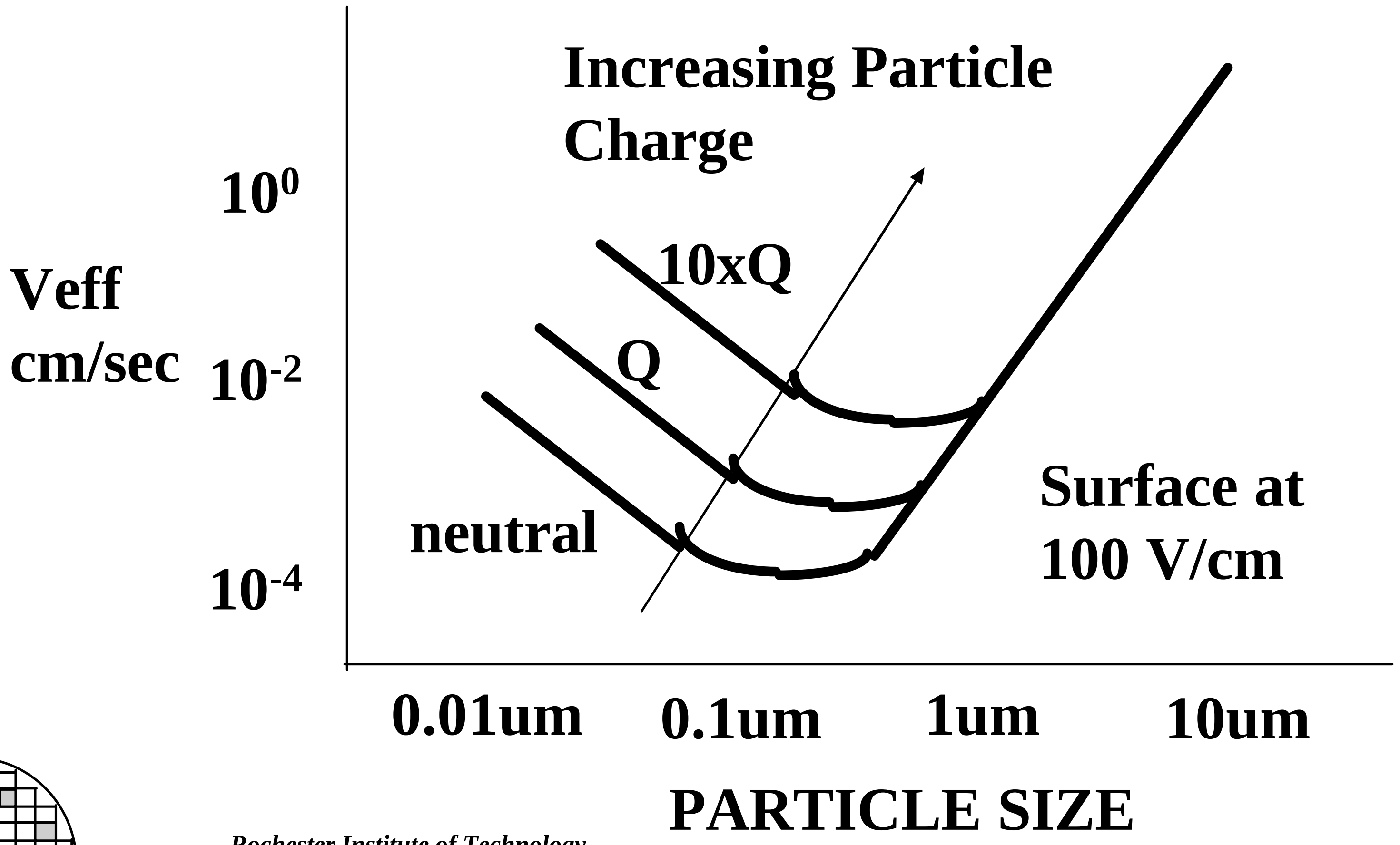
$$\text{Veff} = (550-50) /(8\text{x}60\text{x}60)((\text{Pi } (2/12)^2) \text{ particles/ ft}^2\text{sec / 100 particles/ft3}$$

$$= 0.12 \text{ ft/min} \quad \text{or} \quad 0.61 \text{ cm/sec}$$

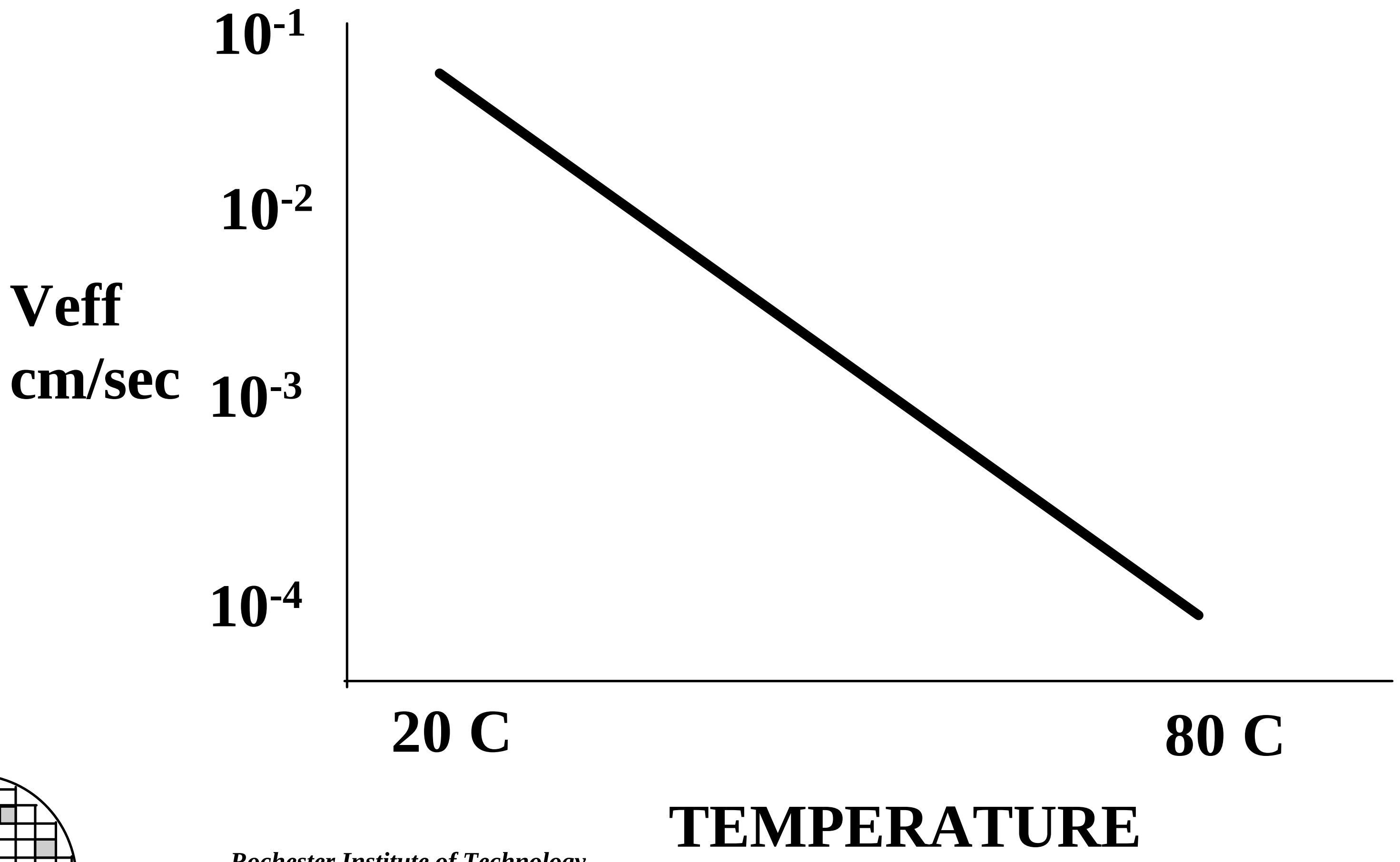
Veff VERSUS SIZE AND PRESSURE



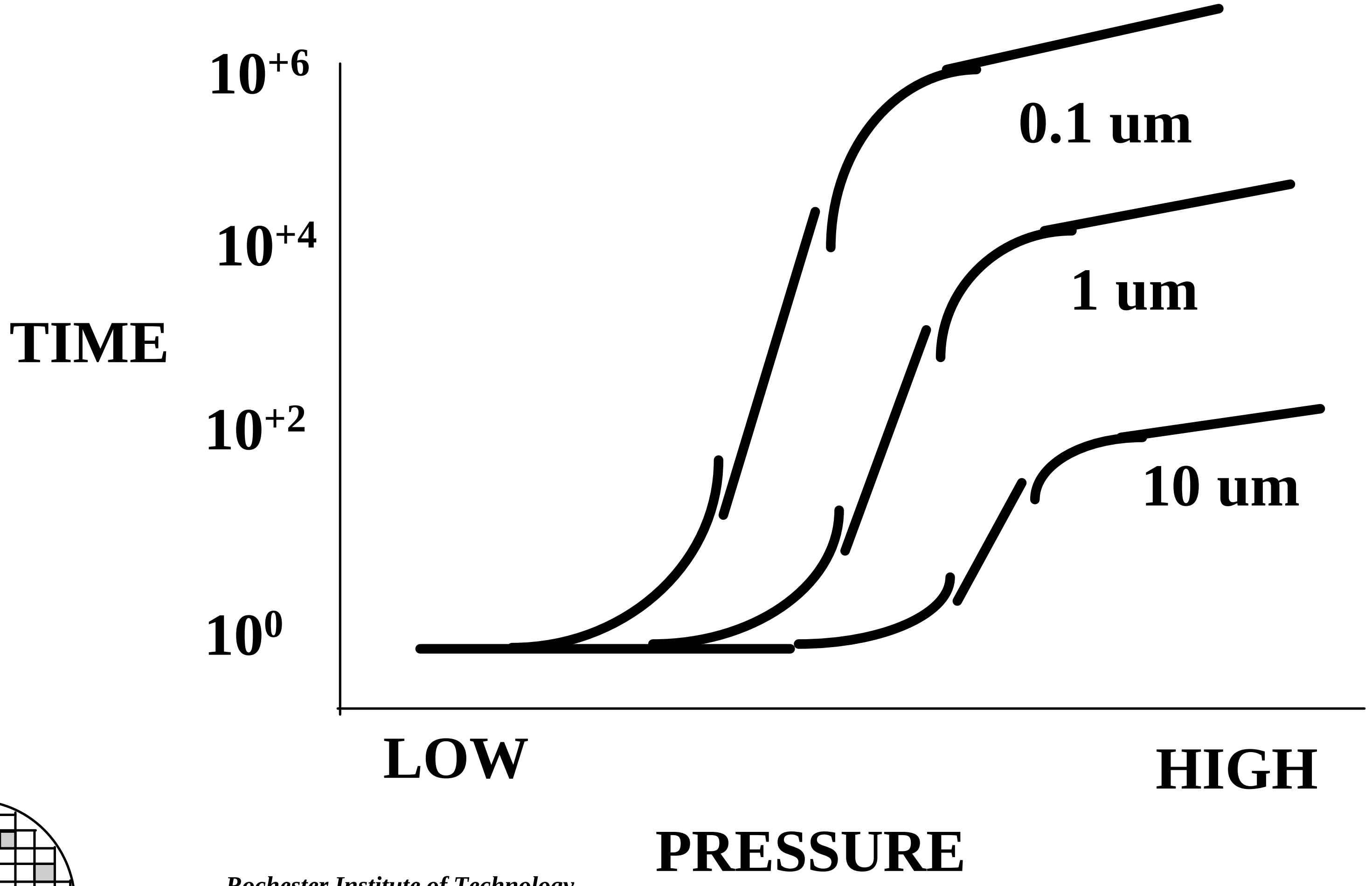
ELECTRIC FIELD EFFECTS



TEMPERATURE EFFECTS



TIME TO SETTLE VERSUS PRESSURE



REVIEW

ELECTRICAL EFFECTS CAN INCREASE THE DEPOSITION VELOCITY BY 2-3 ORDERS OF MAGNITUDE, EVEN FOR LOW FIELDS OF 100 V/M

HEATING THE WAFER CAN HELP PROTECT IT FROM PARTICULATES, 50 C CAN HELP BY ONE ORDER OF MAGNITUDE

WAFERS SHOULD BE FACE DOWN IN VACUUM SYSTEMS. WHERE GRAVITY IS THE IMPORTANT PARAMETER. (CAUTION: IN PLASMA SYSTEMS ELECTRIC FIELD IS MORE IMPORTANT THAN GRAVITY)

AEROSOL PARTICLE DEPOSITION RATE IS A FUNCTION OF PARTICLE SIZE

STATIC CHARGE

Static Charge causes a surface to be positive or negatively charged. This surface will attract oppositely charged particles and neutral particles from the air.

Sources of Static Charge:
Triboelectric or Friction Charging
Charging through Induction
Ion implant, SEMs or plasma processes

Triboelectric Series: (Positive) Air, Human Hair, Glass, Mica, Human Hair, Nylon, Wood, Lead, Aluminum, Paper, Cotton, Steel, Wood, Hard Rubber, Nickel and Copper, Brass and Silver, Gold and Platinum, Acetate, Rayon, Polyester, Polyurethane, Polyethylene, Polypropylene, PVC, Silicon, Teflon (Negative)

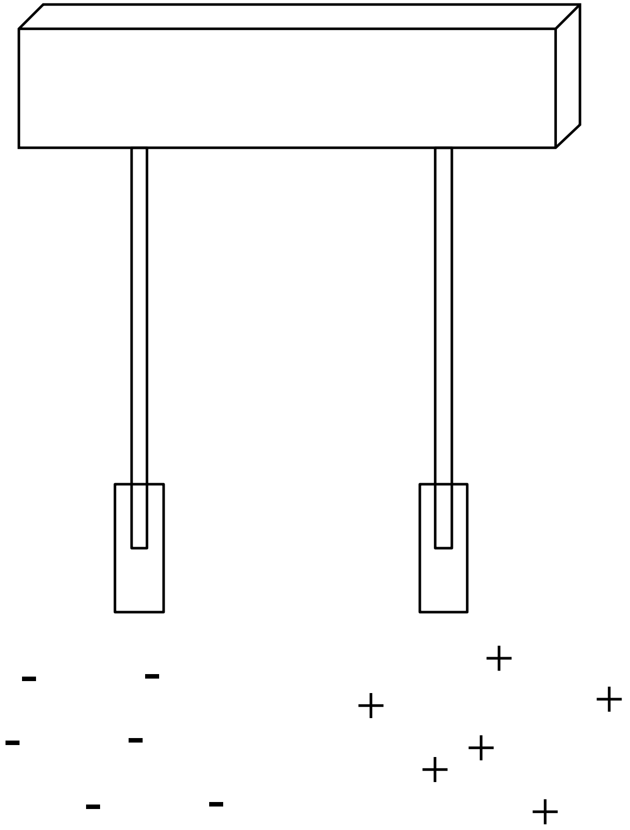
AIR IONIZATION

All air ionization systems work by flooding the atmosphere with positive and negative ions. When ionized air comes in contact with a charged surface, the charged surface attracts ions of the opposite polarity. As a result, the static electricity that has built up on products, equipment and surfaces is neutralized.

Ions are created by high electric fields (a combination of high voltages and sharp emitter tips) The voltage can be AC (60 Hz), DC, or Pulsed. In the case of AC the air near the tips must be moving fast enough to not recombine with oppositely charged ions generated 1/60 sec later from the same tip. In DC systems a continuous high voltage is applied generating equal numbers of + and - ions. Pulsed systems apply pulsed DC high voltages. Each pulse can be negative or positive and can have separately adjusted duty cycle. Pulsed systems allow more flexibility.

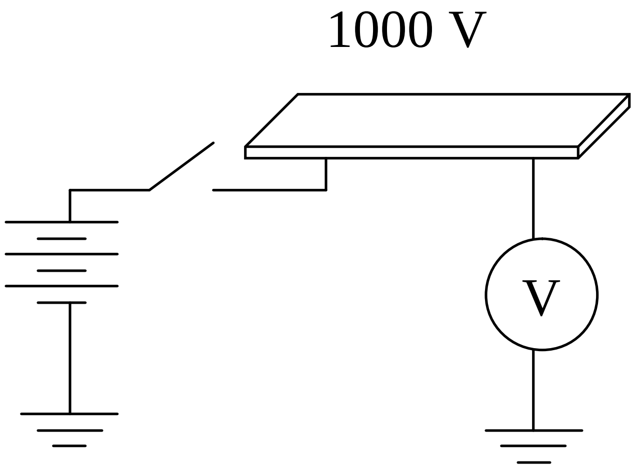
AIR IONIZATION SYSTEMS

Pulsed DC systems use positive and negative emitter points that are turned on and off alternately to create clouds of positive and negative ions. Cycle timing and polarity can be adjusted to provide the required balance and level of static control needed in a specific environment



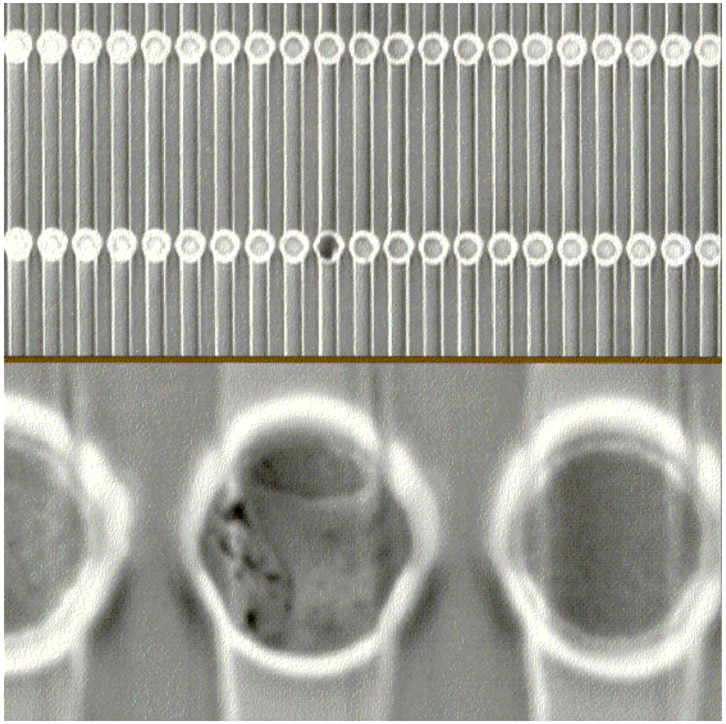
CHARGED PLATE MONITOR

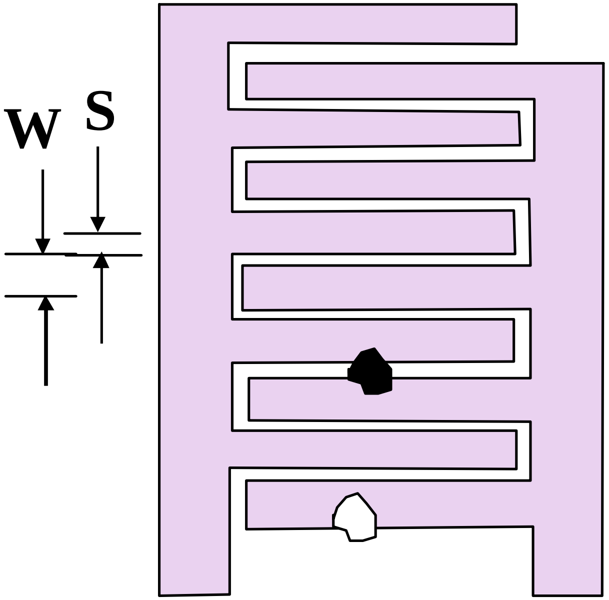
A charged plate monitor is an instrument that has an isolated conductive plate (~ 4 inches square) that can be charged to 1000 volts and the time it takes to discharge to 10% (100 volts) is determined. In normal air at 60% humidity the decay may take 12 hours. An ionization system can reduce the decay time to less than one minute.



DEFECT TEST STRUCTURES

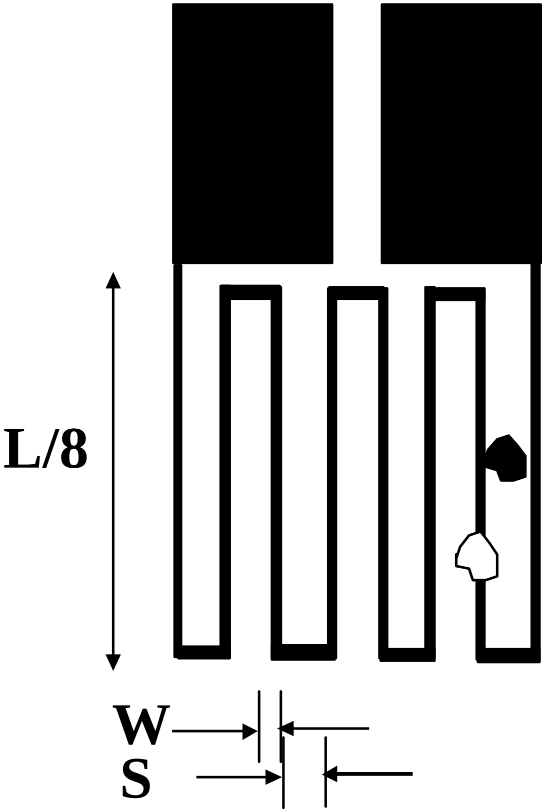
Via chain is sensitive to contact cut problems.





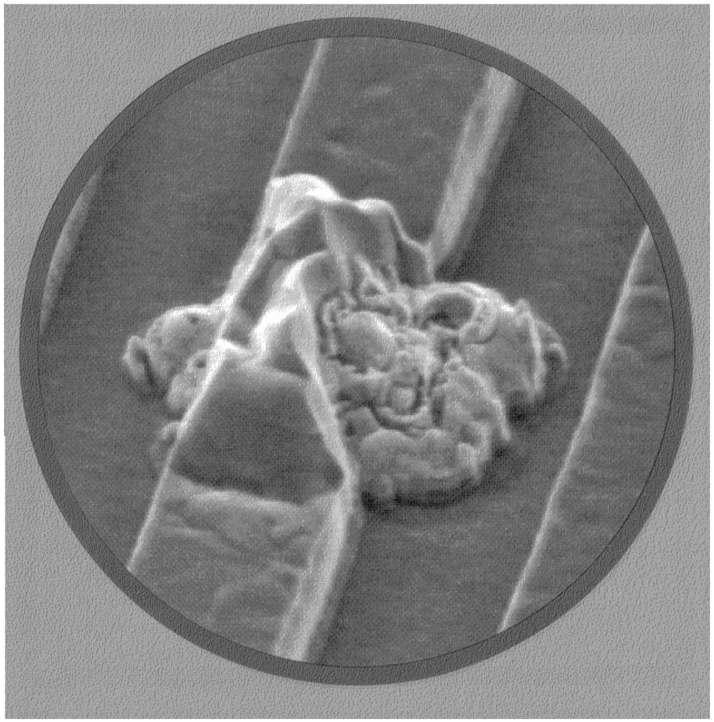
Comb Structure is sensitive to Shorts and less sensitive to opens if W > S

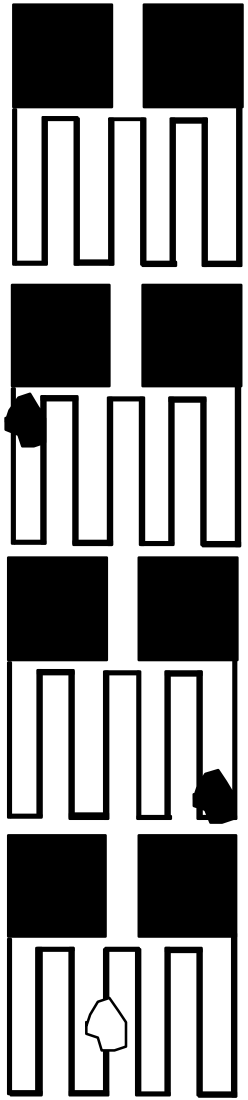
DEFECT TEST STRUCTURES



R= (Rhos)X(L/W)

Serpentine Structure is sensitive to opens and less sensitive to shorts if S > W





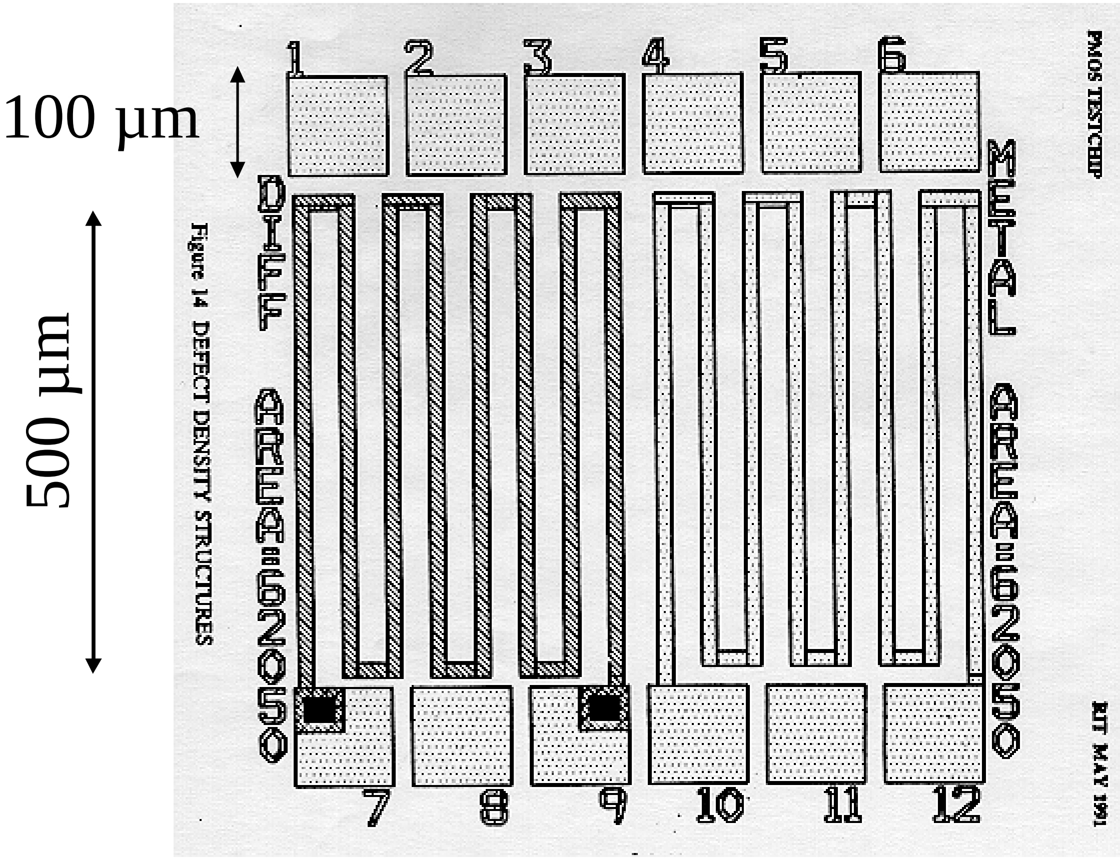
No Defects
R = R1

Short
R << R1

Short
R <= R1

Open
R >> R1

METAL AND DIFFUSION SERPENTINE



Line width = 15 µm
Line Space = 30 µm
L/W = 269
Area Covered by metal = 62050 μm^2

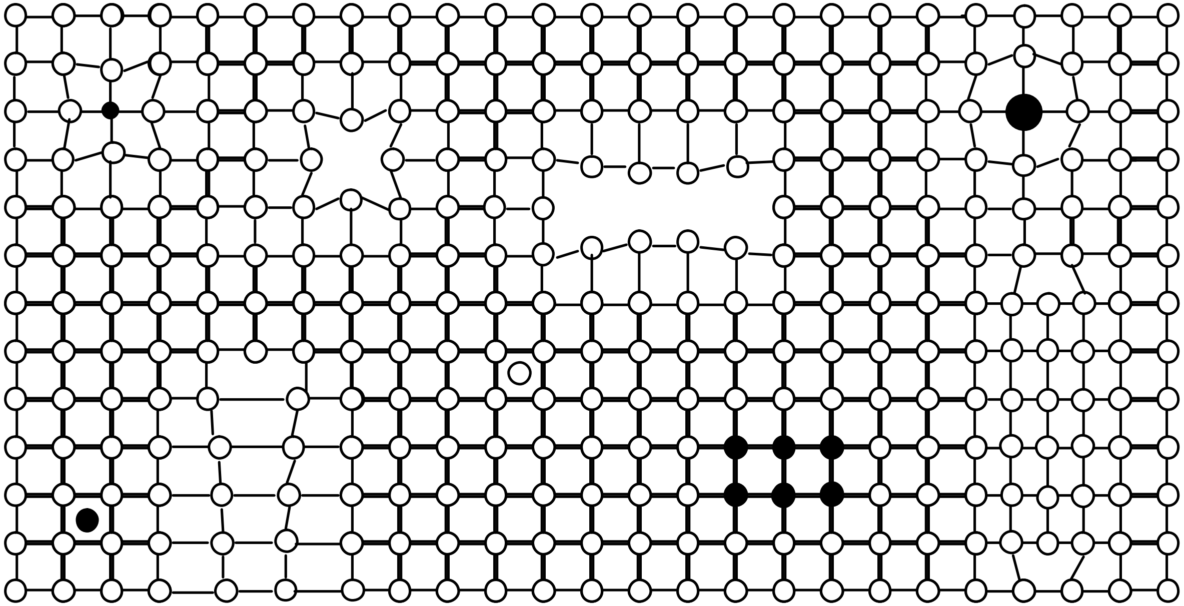
R = Rhos L/W

Defect density (in #/cm^2) = (# defective x 1612) / (# tested)

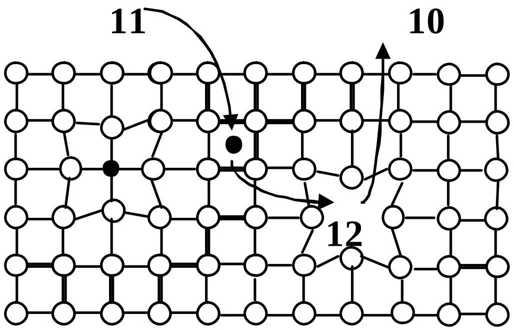
DEFECT TEST DATA FROM 1994 AT RIT

SERPENTINE	METAL			POLY		
LINE WIDTH (µm)	3	6	9	2	4	6
SPACE (µm)	9	18	27	4	12	18
AREA (µm^2)	27117	23820	24147	31088	27920	23820
DEFECTS FOUND	34	2	1	ALL	32	2
DEVICES MEASURED	53	53	53	53	53	53
YIELD	36%	96%	98%	0%	40%	96%
DEFECTS/cm^2	2366	158	78	INFINITE	2162	158
COMB	**METAL**			**POLY**		
LINE WIDTH (µm)	9	18	27	6	12	18
SPACE (µm)	3	6	9	2	4	6
AREA (µm^2)	25389	24396	22788	26160	25056	26448
DEFECTS FOUND	1	0	1	3	3	3
DEVICES MEASURED	53	53	53	53	53	53
YIELD	98%	100%	98%	94%	94%	94%
DEFECTS/cm^2	70	0	83	216	207	219

CRYSTAL DEFECTS



1. interstitial impurity
2. edge dislocation
3. self-interstitial
4. precipitate of substitutional atoms
5. small dislocation loop formed by agglomeration of self-interstitials
6. substitutional impurity, widening lattice
7. vacancy
8. dislocation loop formed by agglomeration of vacancies
9. substitutional impurity, compressing lattice



10. Schottky defect
11. interstitial arriving from surface
12. Frenkel defect

INFLUENCE OF CRYSTAL DEFECTS ON DEVICES

Leakage Currents in PN Junctions

  Precipitates, Dislocations

Collector-Emitter Leakage in BJTs

  Precipitates, Dislocations

Minority Carrier Lifetime

  Point Defects, Point-Defect Clusters

Gate Oxide Quality, Oxide leakage, Oxide Breakdown Voltage

  metallic contamination, defect density on surface, oxygen precipitates at the surface

Threshold Voltage Control

  surface state density

BASIC GETTERING PRINCIPALS

1. Suppress Nucleation of More Crystal Defects by Controlling Thermal Stresses and resultant dislocations.

2. Remove Existing Crystal Defects by High Temperature Annealing or Creation of Oxygen Denuded Zones at the wafer surface, removing Oxygen precipitates near the surface.

3. Remove Point Defects by Gettering (capturing contaminates at locations away from device locations)

Yield Improvements Can Be Made

REDUCTION OF MOBILE METAL CONTAMINATES

Cu, Ni, Au, Fe are highly mobile and diffuse long distances at moderate temperatures, find defects and are captured

Cu can diffuse 600 um in 1 min at 900 C

Fe can diffuse 100 um in 1 min at 1000 C

Low Temperature Processes introduce fewer impurities from the furnace.

HCl Cleaning of Furnace Tubes

Double Wall Furnace Tubes

Eliminate Metal Tweezers

Replace Stainless Steel with Silicon, Carbon and Aluminum Parts

EXTRINSIC GETTERING

HEAVY PHOSPHOROUS DIFFUSION OF THE BACKSIDE OF THE WAFER WILL CAUSE DEFECTS THAT CAN CAPTURE METAL CONTAMINATES

MECHANICAL DAMAGE TO BACKSIDE OF THE WAFER, ABRAISON, SANDBLASTING

LASER DAMAGE

ION IMPLANT DAMAGE

DEPOSITION OF POLYSILICON ON BACK OF WAFER

INTRINSIC GETTERING

STARTING WAFERS WITH 15-19 PPMA OXYGEN CONCENTRATION

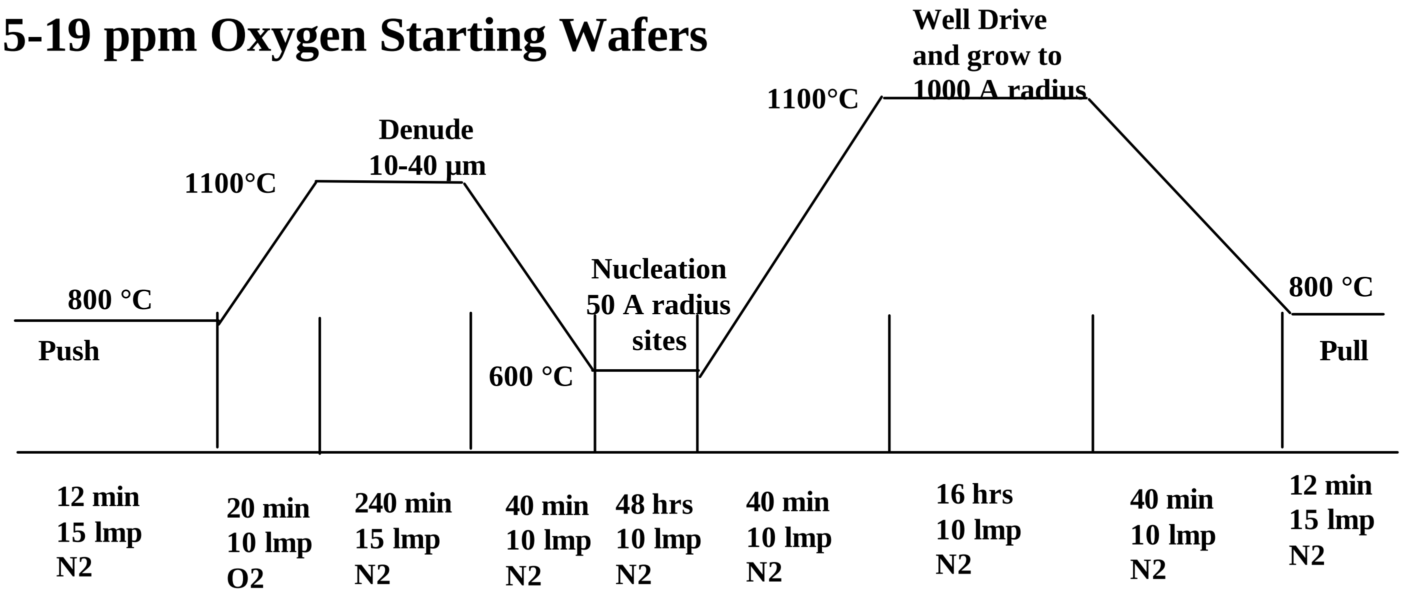
1. DENUDED ZONE FORMATION - HIGH TEMPERATURE STEP TO REDUCE OXYGEN CONCENTRATION NEAR WAFER SURFACE

2. NUCLEATION OF $SiO2$ CLUSTERS - LOWER TEMPERATURE STEP

3. PRECIPITATE GROWTH AND GETTERING - HIGH TEMPERATURE STEP FOR GROWING $SiO2$ CLUSTERS AND FORMING DISLOCATION LOOPS, GETTERING SITES

INTRINSIC GETTERING

15-19 ppm Oxygen Starting Wafers



15-20 ppm Oxygen Starting Wafers

T1 = 1100 C, t1 = 240 min., give 10-40 um Denuded Zones

T2 = 600 C, 4 to 64 hours, nucleate 50 A radius sites

T3 = 1100 C, 4 to 16 hours, Grow 1000 A radius sites

FURNACE CONTAMINATION

Contamination from high temperature furnace operation

Furnace tube used for p-type or n-type diffusion will dope bare wafers simply by transfer of dopant molecules from the furnace wall to the wafers.

In the case of Boron, B2O3, Boric Oxide, from spin on glass and glass transferred from solid sources

In the case of Phosphorus, P2O5, melts at 360 C and is a gas at high temperatures. This glass is a vapor at 900 C and can move from surface to surface and dope a bare silicon substrate.

REMEDIES FURNACE CONTAMINATION

Ceramic Liners

Chlorine

Procedures to Prevent Contamination

CONTAMINATION IN VACUUM SYSTEMS

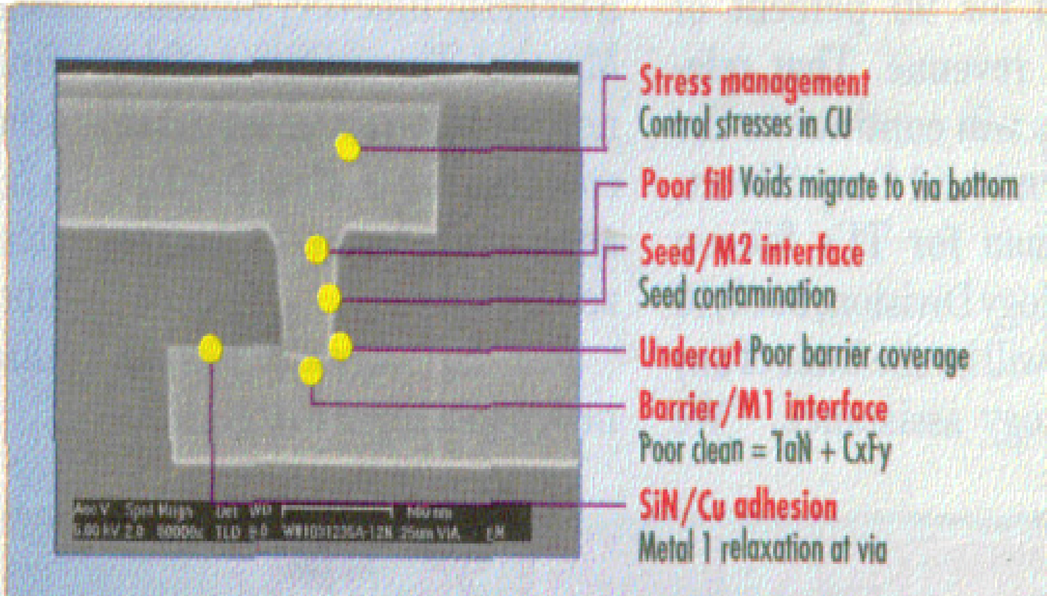
When solids are heated they will go to the liquid state (Hg is already liquid at room T) at the melting point. Solids will also go to the gas state at the correct combination of temperature and pressure. This is the vapor pressure and is often given as a function of temperature. As pressure is decreased the temperature at which solids will vaporize lowers and if this temperature is below the melting point then the material will sublime (go to gas state without going through the liquid state) In our LPCVD systems and sputtering systems temperatures around 400 C and pressures below 1x10-5 Torr are common. At these temperatures and pressures many metals sublime and can be a source of contamination for the next users of the system. For example Zinc is a component of brass, cadmium is used to plate steel screws, sulfur and selenium are used in stainless steel ver-#303. These materials all sublime at 400 C and 1x10-5 Torr and will contaminate the equipment as a result.

MELTING POINT & VAPORIZATION PRESSURE DATA FOR VARIOUS MATERIALS

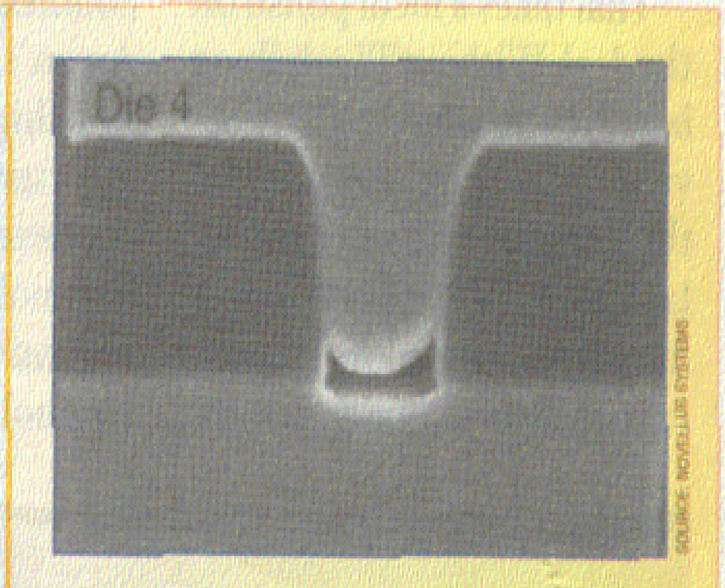
Material	Melt Point	Temp@ Vapor Pressure		
		10^{-8}	10^{-6}	10^{-4}
Al	660	677	812	1010
Arsenic	814	107	152	210
Barium	725	545	627	735
Beryllium	1278	710	878	1000
Bismuth	271	330	410	520
Boron	2100	1278	1548	1797
Boron Nitride	2300	-	-	1300
Cadmium	321	64	120	180
CdS	1750			550
CdTe	1098			450
Chromium	1890	837	977	1177
Gallium	30	619	742	907
GaAs	1238			

Material	Melt Point	Temp@ Vapor Pressure		
		10^{-8}	10^{-6}	10^{-4}
Ge	660	677	812	1010
Gold	1062	807	947	1132
Hafnium Oxide	2812	-	-	2500
Iron Oxide	1425			
Nickel	1453	927	987	1262
Platinum	1769	1292	1492	1747
Selenium	217	89	125	170
Silver	961	574	617	684
Tantalum	2996	1960	2240	2590
Titanium	1668	1067	1235	1453
Tungsten	3410	2117	2407	2757
Zinc Oxide	1975			
Ziconium	1852	1477	1702	1987

Via Failure



A slew of detailed process problems can lead to via failures.



SOURCE: NOVELLUS SYSTEMS

Vias can pull away from the metal layer.

REFERENCES

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2. “Silicon Processing for the VLSI Era”, Wolf and Tauber, Ch.2. Crystalline Defects, Thermal Processing and Gettering, Lattice Press, CA.
3. SEMATECH Cost of Ownership Presentation, July 1993.
4. VLSI Technology, Ch. 14 - “Yield and Reliability”, Sze.
5. “Yield Analysis Software Solutions”, Semiconductor International, January 1996,Pg 79.
6. “Equipment Generated Particles: Ion Implantation”, Semiconductor International, September 1991.
7. Controlling Process Equipment Contamination in the 90’s”, Semiconductor International, October 1993.
8. “Designing Particles Out of the Deposition Process - Titanium Nitride Films”, 1991 IEEE/SEMI International Semiconductor Manufacturing Science Symposium.
9. Self-Analysis of CCD Image Sensors Using Dark Current Spectroscopy, W.C.McColgin, J.P.Lavine, C.V.Stancampiano, J.Kyan, D.N.Nichols, Eastman Kodak Research Laboratories, Rochester, New York.
10. Resist Implant Problems: Some Solved, Others Not”, Semiconductor International, June 1992.
11. Ion Systems, 1005 Parker Street, Berkeley A 94710, ionsys@ion.com.

HOMEWORK - YIELD

1. Calculate the defect density for the following examples:

(a) 256K DRAM with die size 0.4 cm by 0.4 cm and Yield of 75%
(b) 1M DRAM with die size of 1.4 cm by 0,4 cm and Yield of 55%,
(c) 4 M DRAM with die size of 1.4 cm by 1.4 cm and Yield of 20%.

2. What defect density will be needed to give a 85% Yield on 16M devices with area four times the 4 M DRAM in problem 1.

HW - READING QUESTIONS - DEFECTS

This homework refers to the following articles and abstracts:

1. “Self-Analysis of CCD Image Sensors using Dark Current Spectroscopy”, Eastman Kodak Company.
2. “Controlling Process Equipment Contamination in the 90’s”, Semiconductor International” October, 1993.
3. “Equipment Generated Particles: Ion Implantation”, Semiconductor International, September 1991.
4. “Designing Particles Out of the Deposition Process - Titanium Nitride Films”, IEEE/SEMI International Semiconductor Manufacturing Science Symposium, July 1991.
5. “Yield Analysis Software Solutions”, Semiconductor International, January 1996.

Generate a set of two questions and answers that illustrate the main points of each article. (total of 10 questions with answers)