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300mm Wafer Fab Contamination Control

Mark Jamison, PE
HDR Architecture, Inc.

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Agenda

- What is a 300mm Wafer Fab?
- Why are they Buildings for Advanced Technology?
- Contamination Issues
- Cleanroom Environment
- Current Technology
- Where we are going from here?

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300mm Fabs

- Survey of 300mm Fab Technology
- 1000 operating fabs worldwide
 - very few are 300mm
- Operating data very scarce
- No Single design solution

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What is a 300mm Wafer Fab ?

- Latest generation fabrication plant for producing microchips
- 300mm diameter wafers (12 inch)
- Replaces previous 200mm generation



Semitech

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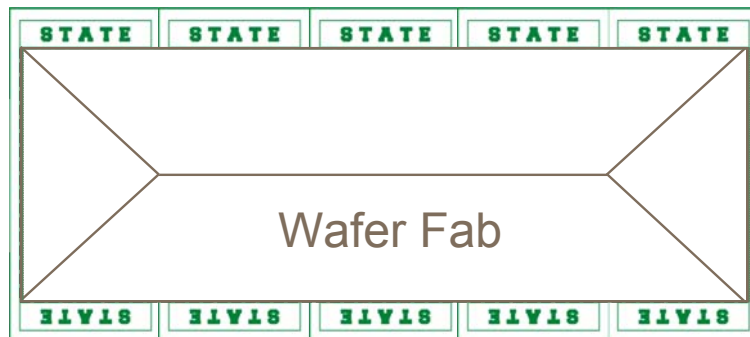
What is a 300mm Wafer Fab ?

- Huge production factories
 - up to 40,000 WSM
 - 500 process steps per wafer
- Cleanroom typically 100,000–150,000 sq. ft.
1,000,000 total sq. ft.
- High yield - >90%



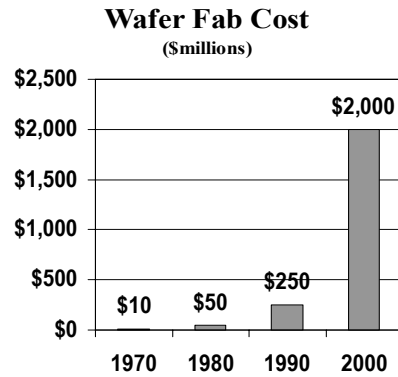
Micron

They Are Big



What is a 300mm Wafer Fab ?

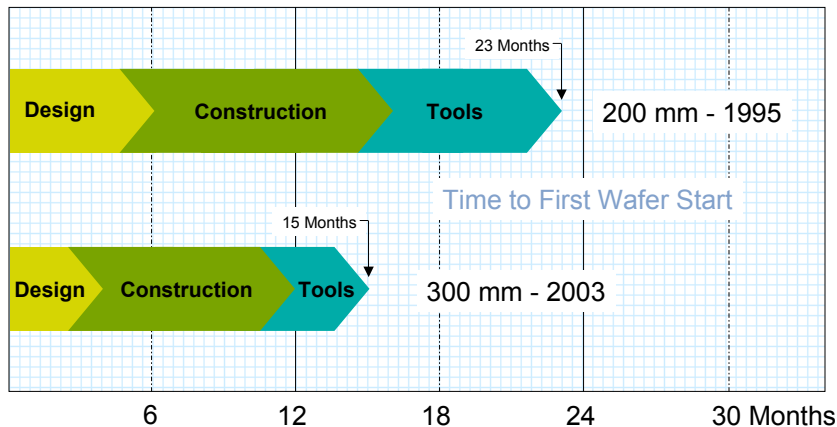
- New Fab today
\$2.0-\$2.5 billion
- 80%-85% is cost of tools
balance is the building
- Recover these costs in
3 years



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Not For The Faint of Heart

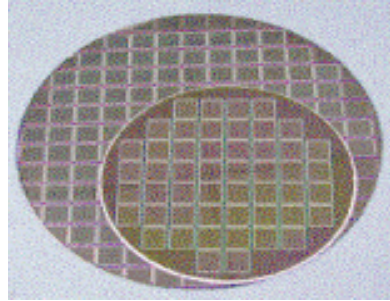


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If They're so Expensive – Why Build Them?

- Annual Revenue = \$Billions
- Wafer is 2.25 times bigger
- 2.5 times as many chips per wafer

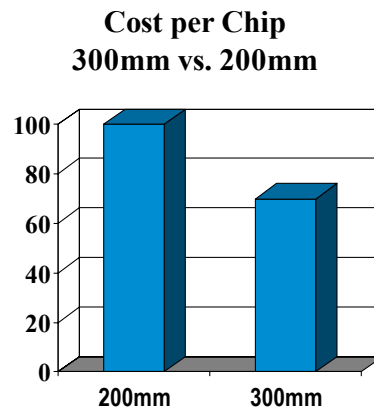


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If They're so Expensive – Why Build Them?

- Cost per wafer is higher but...
 - Cost per Chip is substantially less
 - Economy of Scale vs. 200mm



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Why Is This Important ?

- Today's Microelectronics are crossing the threshold into Nanoelectronics
 - Currently at the 130nm technology node
 - Next year will bring 90nm process
 - 65nm node is being proven in labs
- 300mm wafers are the first generation to make this transition.

Why Is This Important ?

IBM Claims World's Smallest Silicon Transistor

- Online staff -- Electronic News, 12/9/2002

IBM Corporation today said it has created a working 6nm silicon transistor, making it the smallest one of its type in existence.

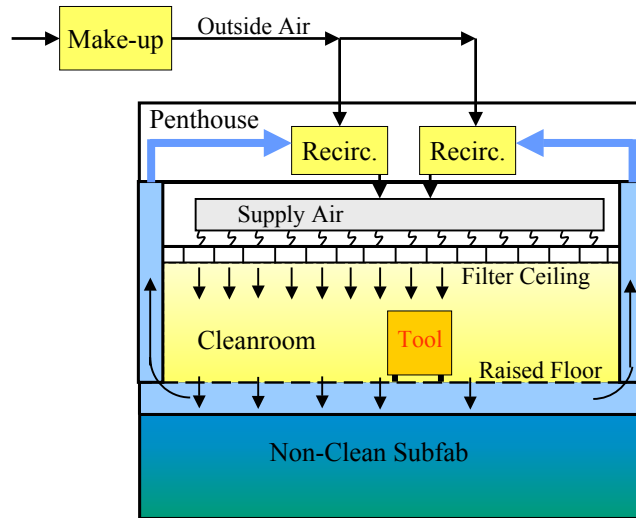
Why Is This Important ?

- The technology that is being applied to this generation of IC.
- How does this technology effect the cleanroom environment?

Cleanroom Specifications

- Filter ceiling – 100% coverage w/ gel seal grid
- Airflow – 60-90 fpm
- Temperature – 72 +/- 0.5 F critical areas
72 +/- 2 F non-critical areas
- Humidity – 50% +/- 2%RH critical areas
50% +/- 5%RH non-critical areas
- Pressurization – 0.05" WG wrt corridor
- Class 0.1 as-built condition
- Class 1 operating

Traditional Cleanroom

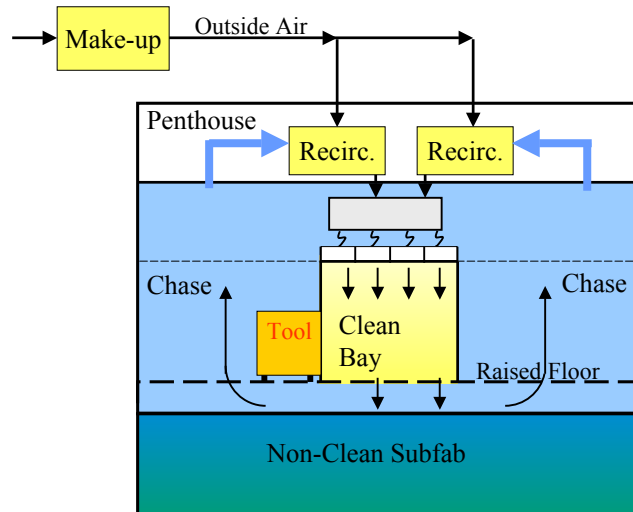


Ballroom With Non-Clean Subfab

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Traditional Cleanroom



Bay and Chase With Non-Clean Subfab

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Cleanroom Zone Isolation

- HVAC isolation between process zones

For Example:


Photolithography	CVD / Diffusion
CMP / Wet Etch	Exotic Metals
Support	

Types of Contamination

- Temperature instability 
- Humidity instability
- Vibration 
- Static discharge 
- EMI / RFI 

We will focus on Airborne contamination

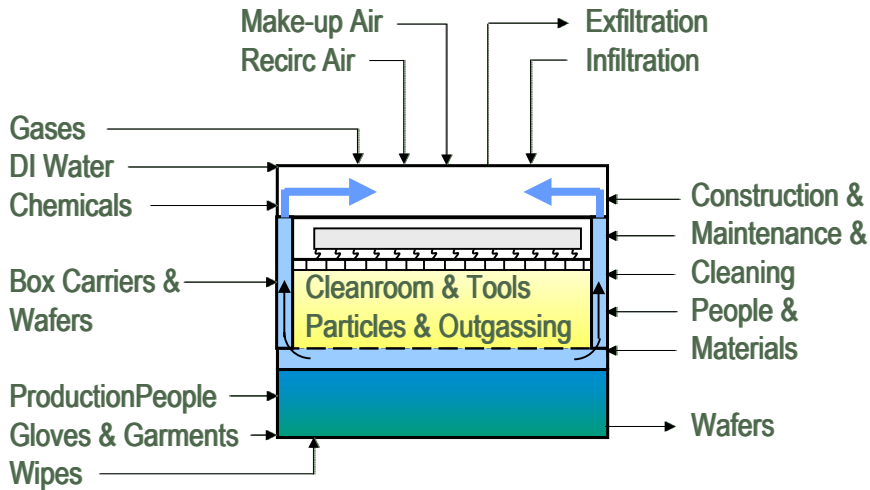
Types of Contamination

- Particulates 
- Bacteria
- Metallic Ions – sodium, potassium, chloride
- Airborne Molecular Contamination
 - Acid vapor
 - Water vapor
 - Hydrocarbons
 - Other gas

Effects of Contamination

- Yield reduction – killer particles
- Early device failure
 - Uncontrolled doping
 - Modified electrical properties
- Degradation of fabrication equipment
 - Stepper optics hazing

Sources of Contamination



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Measuring Contamination

- The goal is to build Cleanrooms to limit manufacturing defects and other impacts
- Standards define the cleanliness of the cleanroom
- In the Old Days, Things were simple

Federal Standard 209B - 1976

Class Name	Class Limits (particles/ft ³)	
	>0.5 μ m	5 μ m
100	100	
10,000	10,000	65
100,000	100,000	700

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Measuring Contamination

Federal Standard 209E

Class Name	Class Limits	
	>0.5 μ m	5 μ m
	Particles/Volume	Particles/Volume
English	(ft ²)	(ft ²)
1	1.0	-
10	10.0	-
100	100	-
1,000	1,000	7.00
10,000	10,000	70.0
100,000	100,000	700.0

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Measuring Contamination

Federal Standard 209E

Class Name	Class Limits				
	0.1 μ m	0.2 μ m	0.3 μ m	0.5 μ m	5 μ m
	Particles/Volume	Particles/Volume	Particles/Volume	Particles/Volume	Particles/Volume
English	(ft ²)	(ft ²)	(ft ²)	(ft ²)	(ft ²)
1	35	7.50	3.00	1.00	-
10	350	75.0	30.0	10.0	-
100	-	750	300	100	-
1,000	-	-	-	1,000	7.00
10,000	-	-	-	10,000	70.0
100,000	-	-	-	100,000	700

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Measuring Contamination

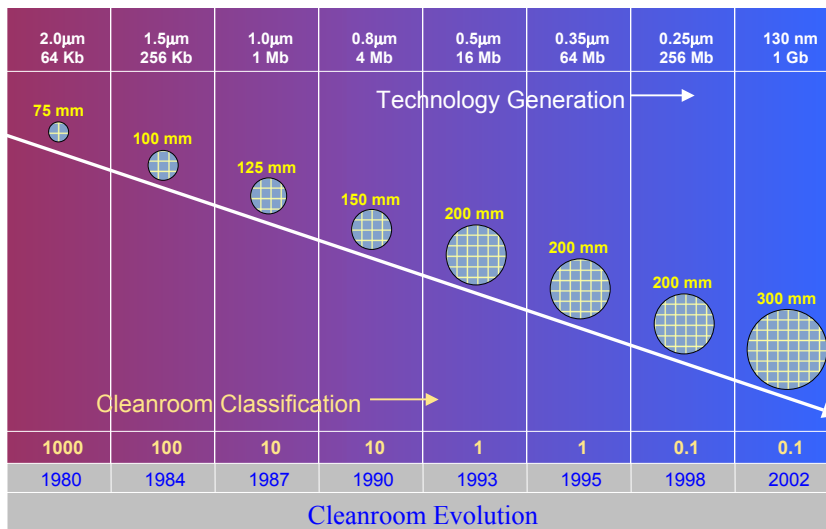
Federal Standard 209E

Class Name		Class Limits									
		0.1µm		0.2µm		0.3µm		0.5µm		5µm	
		Particles/Volume		Particles/Volume		Particles/Volume		Particles/Volume		Particles/Volume	
SI	English	(m ³)	(ft ³)	(m ³)	(ft ³)	(m ³)	(ft ³)	(m ³)	(ft ³)	(m ³)	(ft ³)
M 1		350	9.91	75.7	2.14	30.9	0.875	10.0	0.283	-	-
M 1.5	1	1240	35	265	7.50	106	3.00	35.3	1.00	-	-
M 2		3500	99.1	757	21.4	309	8.75	100	2.83	-	-
M 2.5	10	12,400	350	3650	75.0	1060	30.0	353	10.0	-	-
M 3		35,000	991	7570	214	3090	87.5	1000	28.3	-	-
M 3.5	100	-	-	26,500	750	10,600	300	3530	100	-	-
M 4		-	-	75,700	2140	30,900	875	10,000	283	-	-
M 4.5	1000	-	-	-	-	-	-	35,300	1000	247	7.00
M 5		-	-	-	-	-	-	100,000	2830	618	17.5
M 5.5	10,000	-	-	-	-	-	-	350,000	10,000	2470	70.0
M 6		-	-	-	-	-	-	1,000,000	28,300	6180	175
M 6.5	100,000	-	-	-	-	-	-	3,500,000	100,000	24,700	700
M 7		-	-	-	-	-	-	10,000,000	283,000	61,800	1750

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How Did We Get Here ?



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Measuring Contamination

Federal Standard 209E

Class Name		Class Limits									
		0.1µm		0.2µm		0.3µm		0.5µm		5µm	
		Particles/Volume		Particles/Volume		Particles/Volume		Particles/Volume		Particles/Volume	
SI	English	(m ²)	(ft ²)	(m ²)	(ft ²)	(m ²)	(ft ²)	(m ²)	(ft ²)	(m ²)	(ft ²)
M 1		350	9.91	75.7	2.14	30.9	0.875	10.0	0.283	-	-
M 1.5	1	1240	35	265	7.50	106	3.00	35.3	1.00	-	-
M 2		3500	99.1	757	21.4	309	8.75	100	2.83	-	-
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M 3		35,000	991	7570	214	3090	87.5	1000	28.3	-	-
M 3.5	100	-	-	26,500	750	10,600	300	3530	100	-	-
M 4		-	-	75,700	2140	30,900	875	10,000	283	-	-
M 4.5	1000	-	-	-	-	-	-	35,300	1000	247	7.00
M 5		-	-	-	-	-	-	100,000	2830	618	17.5
M 5.5	10,000	-	-	-	-	-	-	350,000	10,000	2470	70.0
M 6		-	-	-	-	-	-	1,000,000	28,300	6180	175
M 6.5	100,000	-	-	-	-	-	-	3,500,000	100,000	24,700	700
M 7		-	-	-	-	-	-	10,000,000	283,000	61,800	1750

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Measuring Contamination

- International Standard
- Replaced Federal Standard 209E (Nov. 2001)
- Added classifications

ISO 14644-1

ISO Classification	Class Limits (particles / m ³)						Fed 209 Class
	0.1µm	0.2µm	0.3µm	0.5µm	1µm	5µm	
ISO Class 1	10	2	10				(0.01)
ISO Class 2	100	24	102	4			(0.1)
ISO Class 3	1000	237	1020	35	8		1
ISO Class 4	10,000	2370	10,200	352	83		10
ISO Class 5	100,000	23,700	102,000	3520	832		100
ISO Class 6	1,000,000	237,000		35,200	8320	29	1000
ISO Class 7				352,000	83,200	2930	10,000
ISO Class 8				3,520,000	832,000	29,300	100,000
ISO Class 9				35,200,000	8,320,000	293,000	

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What Has This Meant For The Cleanroom ?

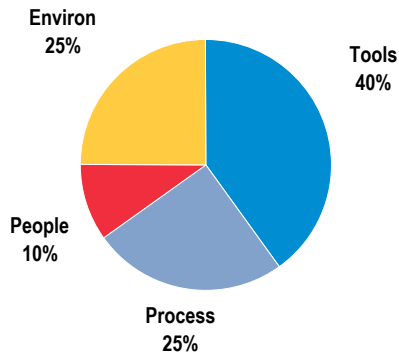
We've declared war on contamination

Fighting Contamination

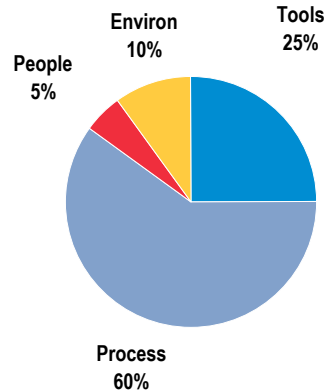
- High efficiency PTFE filters (99.9995% or better)
- Non-outgassing, easily cleanable materials
- Chemically treated carbon filters for AMC
- Static dissipative floors
- Room pressurization
- Cleanroom Certification
- Cleanroom protocols & Gowning

Sources of Contamination

Class 10 Cleanroom



Class 1 Cleanroom



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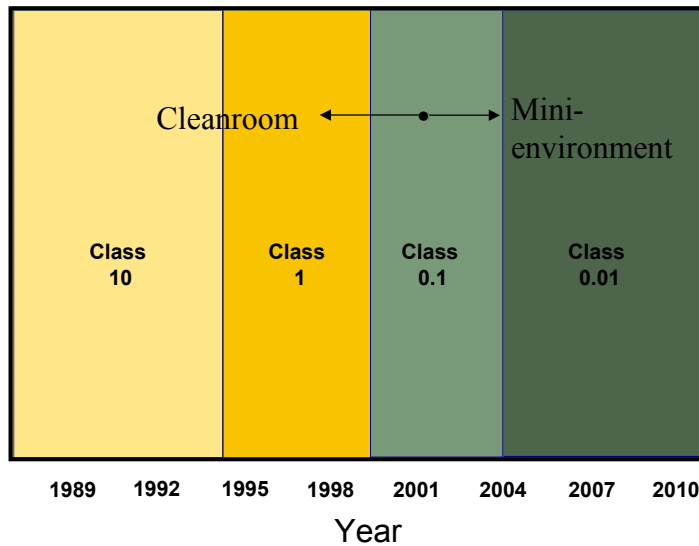
Cleanroom Trends

- Contamination control
- Tighter temp control
- Process cooling water for heat removal
- AMC filters
- High efficiency dc motors on FFUs
- High efficiency vane axial fans
- **Wafer Isolation Technology**

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Isolation Technology



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Wafer Isolation



- Enabling technology below 90nm
- Wafer is never exposed to the fab cleanroom environment
- Front Opening Unified Pod
- FOUP
- Next generation will offer inert gas purge

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Wafer Isolation

- SMIF Load Port
- Interface between FOUP and Tool



Asyst Load Port

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Integrated Minienvironment

- Contain individual tools
- Fan Filter Units
- Better than class 1 environment

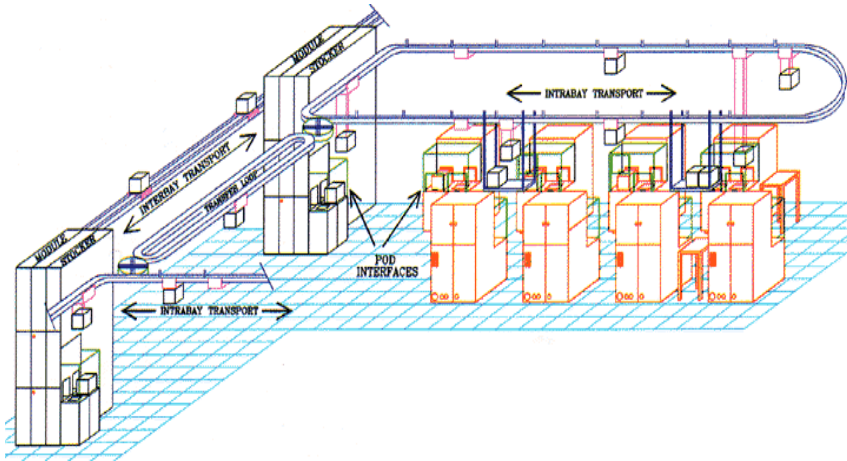


Asyst Minienvironment

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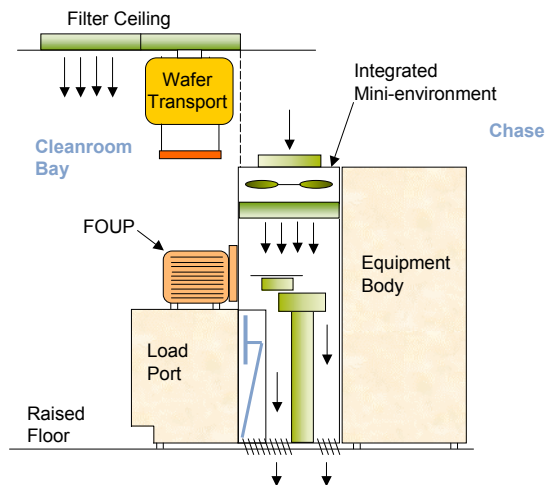
Material Handling Systems



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Wafer Isolation



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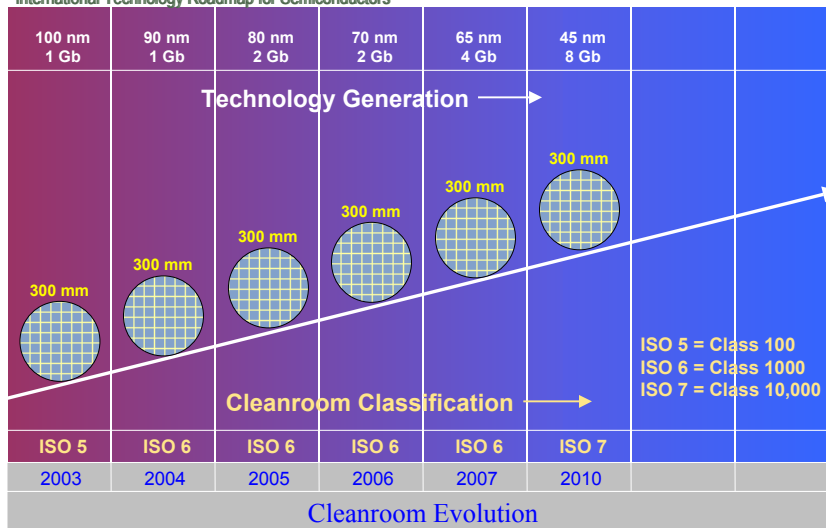
Cleanroom Trends

- Wafer Isolation helps resolve issues with:
 - Particulate Contamination
 - Temperature control
 - Airborne Molecular Contamination
- If the wafer never sees the cleanroom –

Why have one?

Where are we Going ?

International Technology Roadmap for Semiconductors



Cleanroom Implications

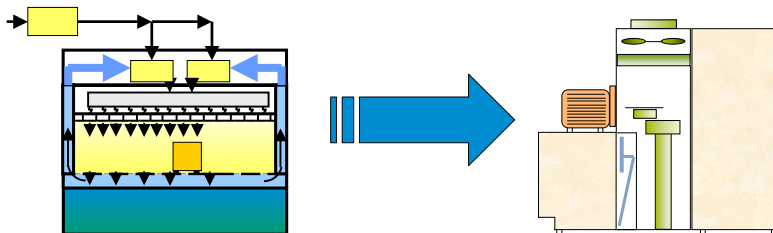
- Extreme Wafer Isolation – Inert Environment
- Reduced classification
 - Reduced airflow
 - Reduced capital cost of building
 - Reduced gowning requirement
 - Reduced operating costs for cleanroom
- Heat Removal is a problem
Limits airflow reduction

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The Transition

- Expensive, Complex Cleanroom
- Expensive Complex Production Tool

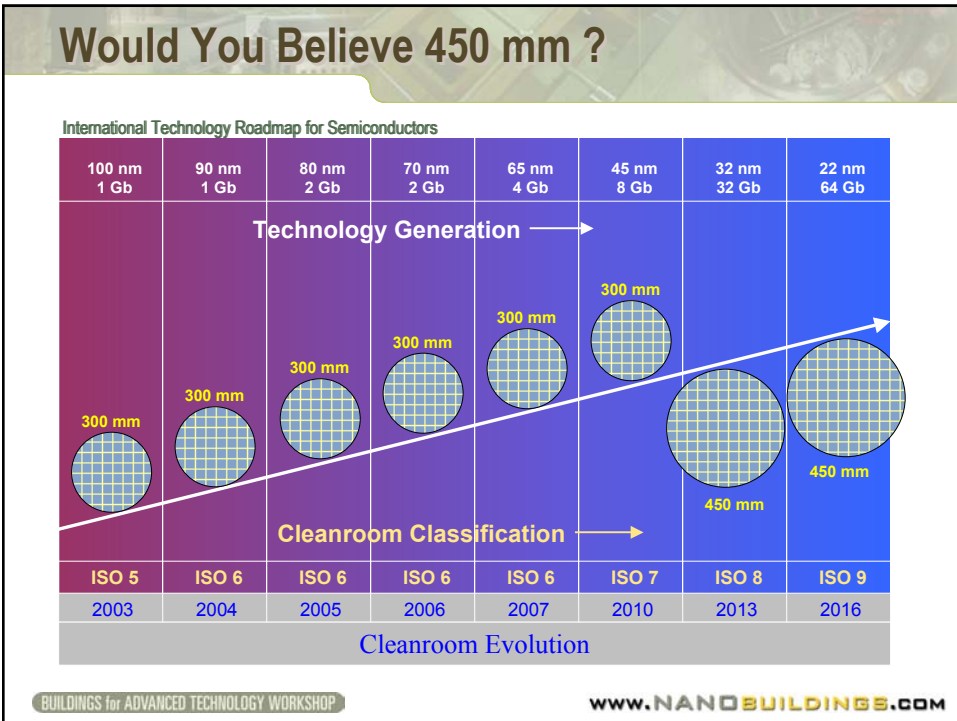


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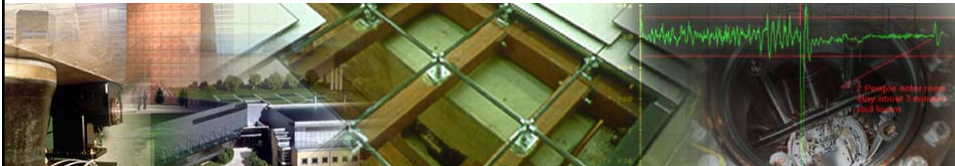
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What's Next ?

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