ERC TeleSeminar

Standardization of ESH Metrics for Semiconductor Manufacturing Equipment

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INTERNATIONAL SEMATECH

Outline

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- Project Objective
- Terms & Definitions
- Tool ESH Metrics
- Measurement
- Tool Energy Consumption
- Definitions
- Approach
- ISMT tools
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- Summary

Facility ESH Metrics

- **Goal:** **Quantitative comparison of the normalized ESH performance of world wide SC sites. Identify focus areas for improvements.**

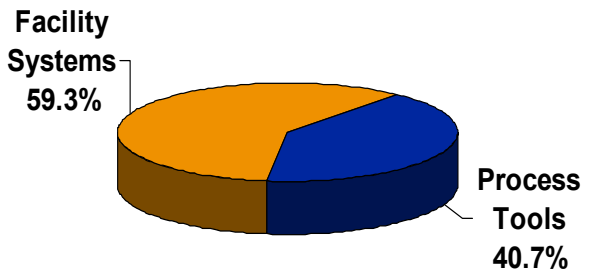
- **Example:** **SIA 5 site-environmental metrics normalized to product of total cm2 of wafers manufactured X mask layers.**
  - Total water supplied
  - Hazardous Waste
  - VOC Emissions
  - Total Reportable TRI Chemical Usage
  - Total Electrical Usage

Project Objective

Establish a Tool-Specific ESH Metrics Database for 200mm & 300mm tools

Why?

- **Insufficient data is available to compare 300mm versus 200mm tools for ESH performance**
- **Identify areas to focus research on tool ESH improvements**
- **Site Energy Consumption**



Terms and Definitions

- **Baseline process and associated designed throughput (Reference: SEMI S2-0200 & ISMT Application Guide)**
- **Normalized to per wafer pass**
- **For energy and water consumption, specify idle and process**
- **Tool energy consumption: "Utility Consumption Characterization Protocol for Semiconductor Tools ", Doc # 00043939A-ENG**

ESH Metrics (1)

Metric	Unit	Normalizing Factors	DM	Supplier
1. Energy consumption when idle	Kilowatt	N/A	X	X
2. Energy consumption when in process	Kilowatthour	Per wafer pass	X	X
2a. peak current	A, amperage	N/A	X	X
2b. inrush current	A, amperage	N/A	X	X
2c. connected load	KVA	N/A	X	X
2d. power factor	N/A. (between 0 and 1)	N/A	X	X
3. DI water consumption when idle	Liters/min	N/A	X	X
4. DI water consumption when in process	Liters/cm2	Per wafer pass	X	X

1. DM = Device manufacturers
2. X = ability for device manufacturers or equipment suppliers to provide ESH metric data.

ESH Metrics (2)

Metric	Unit	Normalizing Factors	DM	Supplier
5. hazardous waste generation	Kg/cm2	Per wafer pass	X	X
5a. Aqueous waste	Kg/cm2	Per wafer pass	X	X
5b. Liquid non - aqueous waste	Kg/cm2	Per wafer pass	X	X
5c. Solid waste	Kg/cm2	Per wafer pass	X	X
6. Process chemical consumption (list by chemcial)	Kg/cm2	Per wafer pass	X	X
7. Specialty gas consumption	Kg/cm2	Per wafer pass	X	X
8. Bulk gas consumption	Kg/cm2	Per wafer pass	X	X
9. VOCs	Kg/cm2	Per wafer pass	X	X
10. PFCs	CE Kg/cm2	Per wafer pass	X	X
11. HAPs	Kg/cm2	Per wafer pass	X	X
12. Pac kaging	Kg /tool [the weight of non -divertible waste per piece of equipment]	Per piece of equipment delivered		X

1. DM = Device manufacturers
2. X = ability for device manufacturers or equipment suppliers to provide ESH metric data.

ESH Metrics (3)
Safety, Health & Operational

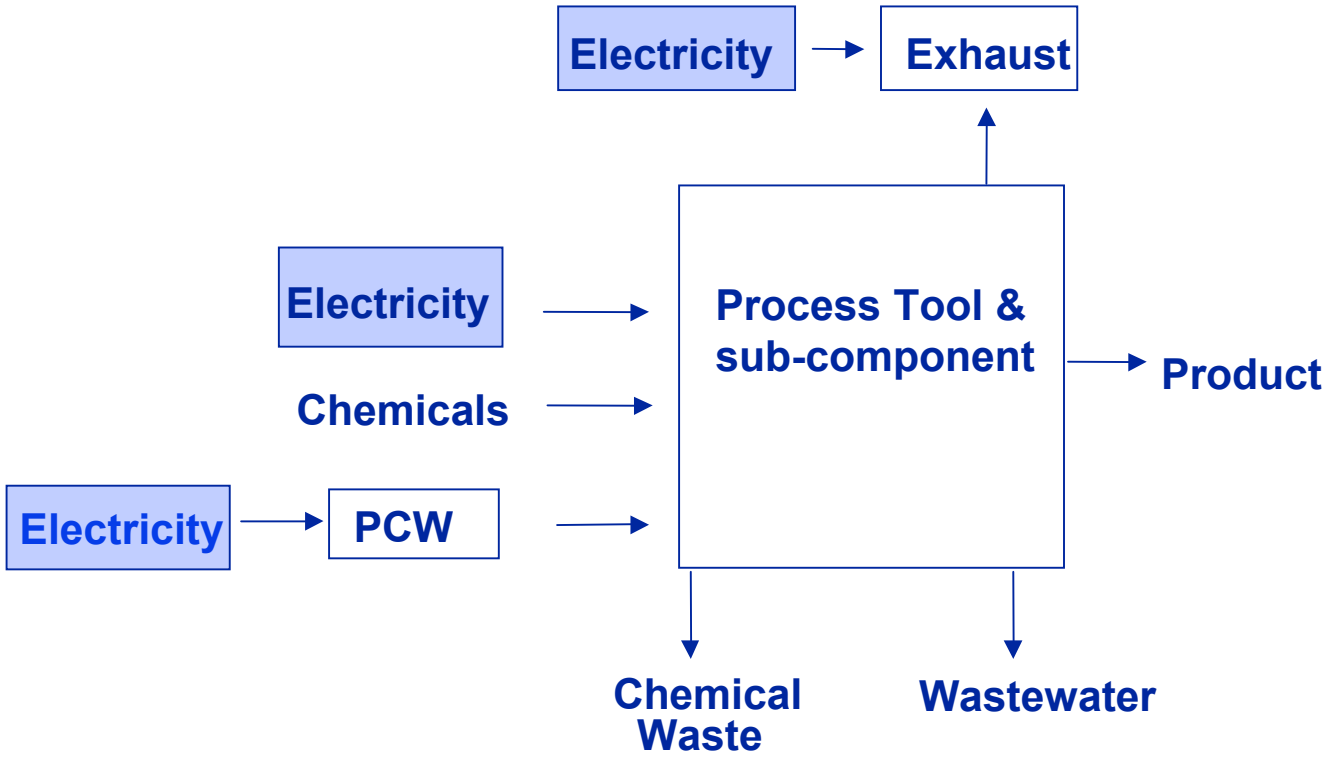
Metric	Unit	Normalizing Factors	DM	Supplier
13. S2 non - conformances	Number of non - conformances in S2 report	Per piece of equipment at delivery	X	X
14. S8 non - conformances	Number of non - conformances in S8 report	Per piece of equipment at delivery	X	X
15. Hazard ous Tasks	Quantity of hazardous tasks requiring PPE	Per year per piece of equipment	X	X
16. Maintenance	hours/ yr	Per year (in the past 12 month)	X	

1. DM = Device manufacturers
2. X = ability for device manufacturers or equipment suppliers to provide ESH metric data.

Measurement

- **Tool energy consumption:** **"Utility Consumption Characterization Protocol for Semiconductor Tools", Doc # 00043939A-ENG**
  (http://www.sematech.org/public/resources/stds/300mm/guide.htm)
- **Water consumption:** **ultrasonic flow meter or equivalent**
- **VOC, PFC, HAP emission:** **"Guidelines for Environmental Characterization of Semiconductor Equipment", Doc # 01104197A-XFR**
  (http://www.sematech.org/public/resources/stds/300mm/guide.htm)
- **Others:** **Document how the data was obtained. If by estimation, document the calculation.**

Tool Energy Consumption



Definitions (1)

Term	Description
Baseline process	A representative process for which a significant number of end users actually use this tool. [SEMATECH Application Guide 2.0 for SEMI S2-93 and SEMI S8-95]
Energy consumption	Including the electricity/power consumption of (1) process tools and process tool subcomponents such as pumps, radio frequency (RF) power supplies (2) process cooling water (3) exhaust.
	Please refer to Technology Transfer document 00043939A-ENG "Utility Consumption Characterization Protocol for Semiconductor Tools" (http://www.sematech.org/public/resources/stds/300mm/guide.htm)
DI water consumption	The use of mobile ultrasonic flow meters allows for non-intrusive measurements of UPW flow rates. The flow meter sensors, or transducers, are attached to the outside of the UPW feed or waste water lines and require no interference with normal tool operat

Definitions (2)

Term	Description
Hazardous waste generation	By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special E
Aqueous waste	Primarily liquid waste that goes to wastewater treatment system
Liquid non-aqueous waste	Primarily liquid waste that does not go to wastewater treatment system, e.g., waste photoresist, H2SO4 collected for off-site recycling
Process chemical	Liquid chemicals except DI water . All chemicals used should be listed.
Specialty gas	Gases other than bulk gases, e.g., AsH3, PH3, Cl2, NF3, etc . May specify by chemicals for comparison purposes
Bulk gas	Gases supplied with bulk volume, including N2, O2, Ar, and H2.

Definitions (3)

Term	Description
VOCs	Volatile organic compound, any organic compound that participates in atmospheric photochemical reactions except those designated by EPA as having negligible photochemical reactivity [US-EPA, www.epa.gov/trs/index.htm]
PFCs	Per-fluoro-compound, including CF4, CHF3, C2F6, C3F8, C4F8, NF3, SF6 so far based on the agreement by WSC (World Semiconductor Council). It is calculated to be carbon equivalent weight, CE Kg.
HAPs	Hazardous air pollutants, Chemicals that cause serious health and environmental effects. Health effects include cancer, birth defects, nervous system problems and death due to massive accidental releases such as occurred at the pesticide plant in Bhopal, India. Hazardous air pollutants are released by sources such as chemical plants, dry cleaners, printing plants, and motor vehicles (cars, trucks, buses, etc.) [US-EPA, www.epa.gov/trs/index.htm]

Also refer to "Guidelines for Environmental Characterization of Semiconductor Equipment", Doc # 01104197A-XFR (http://www.sematech.org/public/resources/stds/300mm/guide.htm)

Definitions (4)

Term	Description
Hazardous Tasks	Tasks associated with hazards. Hazard is defined as a "condition that creates or contributes to an increased risk that an event causing death or serious bodily harm will occur." [W. Scott Railton, OSHA Compliance Handbook, May 1992, page 65. ISBN: 0-86587
Maintenance	Hours of tool downtime due to ESH maintenance or retrofit activities.
Idle	The state when the tool is fully powered on and ready to process wafers but is not actually running a process. If there are different stages of idle mode (e.g. minimum/baseline idle and maintenance/high-flow idle for CMP tools), then average consumption s
Peak	The highest level of consumption of the utility by the equipment during normal use.
CE	Carbon equivalent

Approach:

- **16 Tool ESH Metrics to be collected for representative 200mm & 300mm tool sets**
  - **Implant**
  - **Etch**
  - **Wet decks, etc.**

- **ESH Working Group to Benchmark Data:**
  - **ITRS roadmap**
  - **200mm vs 300mm**
  - **Member company comparison**
  - **Tool Supplier comparison**
  - **Confidentiality protected**

International SEMATECH Fab (ATDF)
Initial tool sets in Tool ESH Metrics Database

Measurements performed in November 2001

- **CVD (PECVD)**
- **Wet Bench (single wafer process)**
- **Implanter (can process 200mm & 300mm wafer, only running 200mm in 2001 because no other 300mm tools to support)**

Results from ATDF – Implanter (1)

Tool		Implanter	Implanter	Implanter	Implanter
Baseline Process		AsH3	AsH3	PH3	BF3
Recipe Details		< 50 keV	< 150 keV	< 200 keV	< 50 keV
Associated Throughput	Wafer per hour	20	15	22	76
Wafers Procesed		25	1	5	5
Metric	Unit				
1. Energy consumption when idle	Kilowatt	27.87	27.87		
2. Energy consumption when in process	Kilowatt-hour	34.4154	2.8259		
2a. peak current	A, amperage	92.84 (ph C)	124.7 (ph C)		
2b. inrush current	A, amperage	92.84 (ph C)	124.7 (ph C)		
2c. connected load	KVA	29.96	42.52		
2d. power factor	N/A.	0.931	0.949		
3. DI water consumption when idle	Liters/min	NA	NA	NA	NA
4. DI water consumption when in process	Liters/cm2	NA	NA	NA	NA

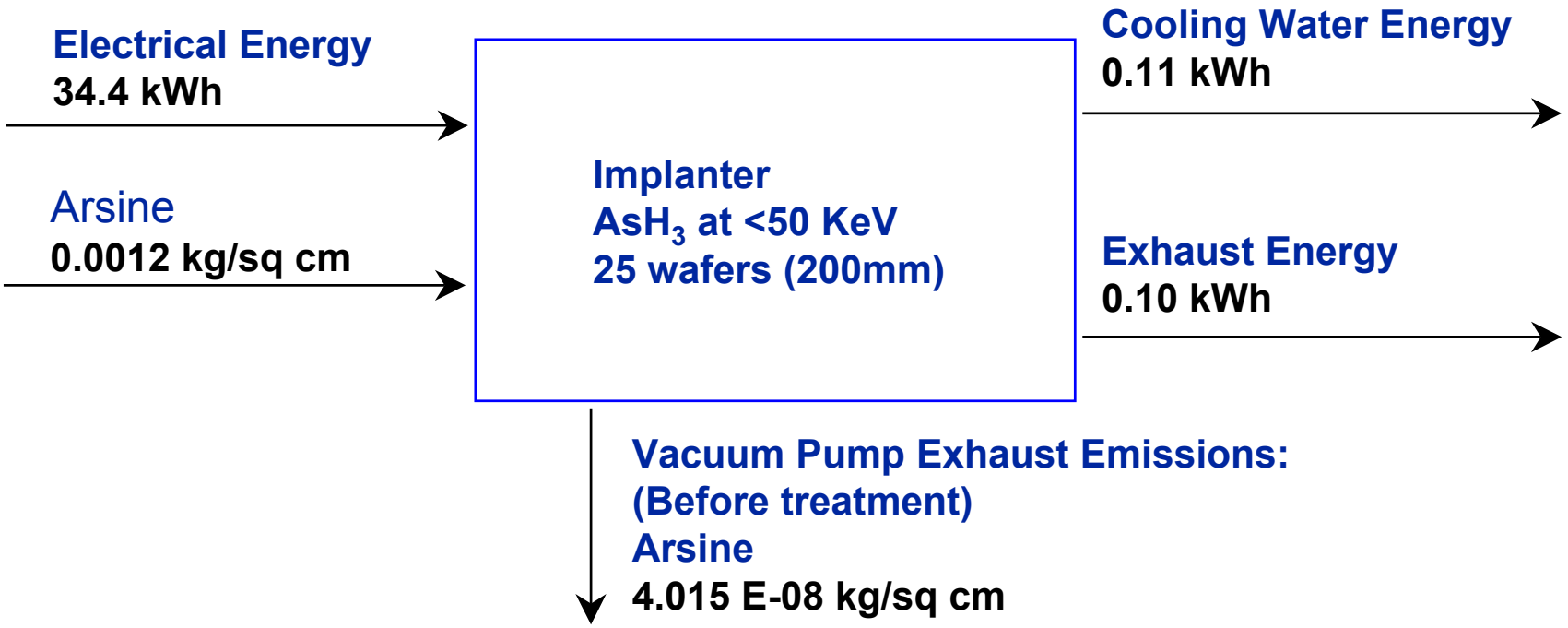
Results from ATDF – Implanter (2)

Tool		Implanter	Implanter	Implanter	Implanter
Baseline Process		AsH3	AsH3	PH3	BF3
Recipe Details		< 50 keV	< 150 keV	< 200 keV	< 50 keV
Associated Throughput	Wafer per hour	20	15	22	76
Wafers Procesed		25	1	5	5
Metric	Unit				
5. hazardous waste generation					
5a. Aqueous waste	Kg/cm2	NA	NA	NA	NA
5b. Liquid non-aqueous waste	Kg/cm2	NA	NA	NA	NA
5c. Solid waste	Kg/cm2	no data			
6. Process chemical consumption	Kg/cm2				
7. Specialty gas consumption	Kg/cm2				
8. Bulk gas consumption	Kg/cm2				

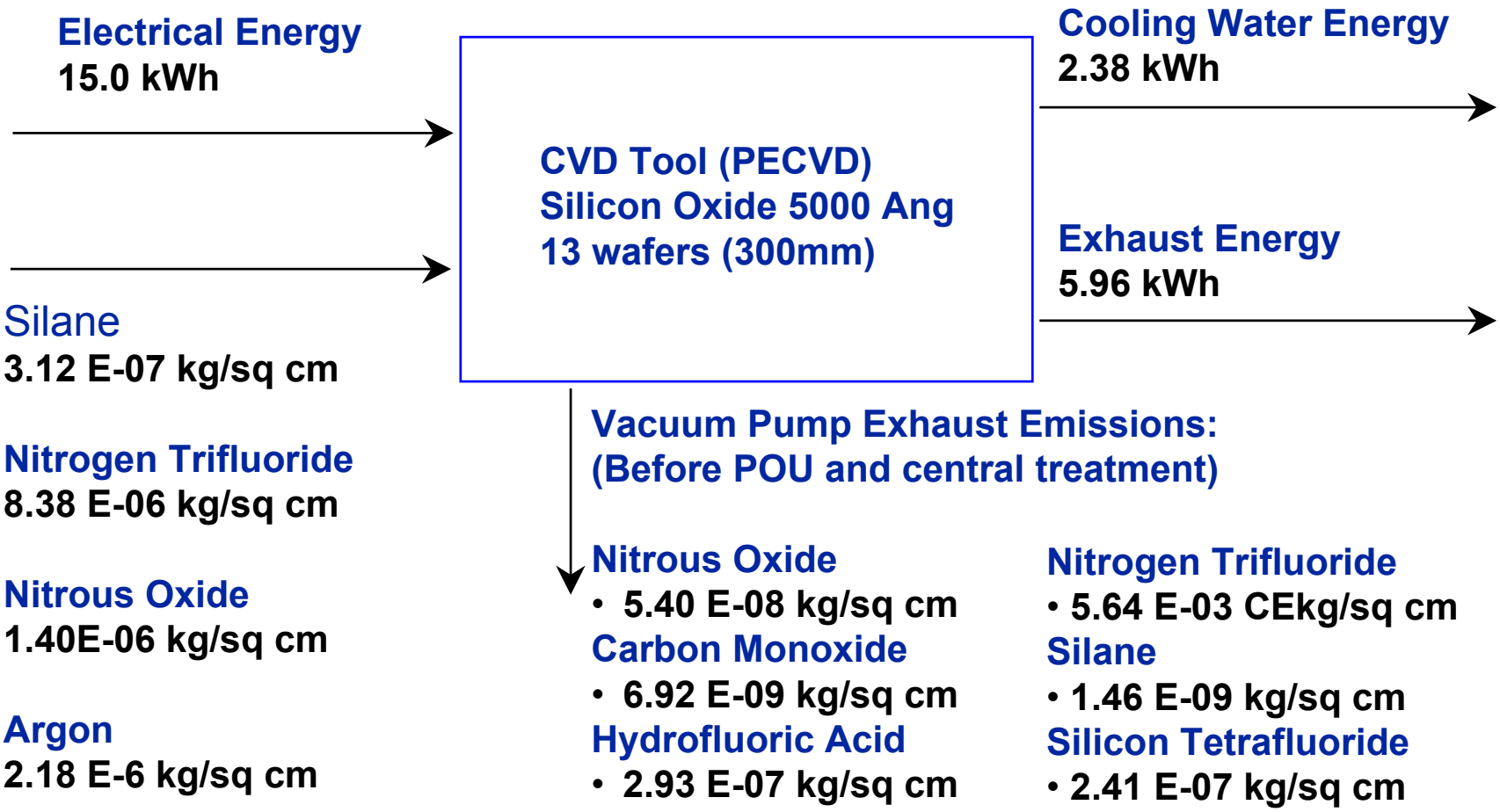
Results from ATDF – Implanter (3)

Tool		Implanter	Implanter	Implanter	Implanter
Baseline Process		AsH3	AsH3	PH3	BF3
Recipe Details		< 50 keV	< 150 keV	< 200 keV	< 50 keV
Associated Throughput	Wafer per hour	20	15	22	76
Wafers Procesed		25	1	5	5
Metric	Unit				
9. VOCs emission	Kg/cm2	NA	NA	NA	NA
10. PFCs emission	CEKg/cm2				
11. HAPs emission					
BF3	Kg/cm2				
AsH3	Kg/cm2	4.0157E-08			
PH3	Kg/cm2			1.30723E-08	8.40378E-09
N2O	Kg/cm2				
CO	Kg/cm2				
HF	Kg/cm2				1.77128E-09

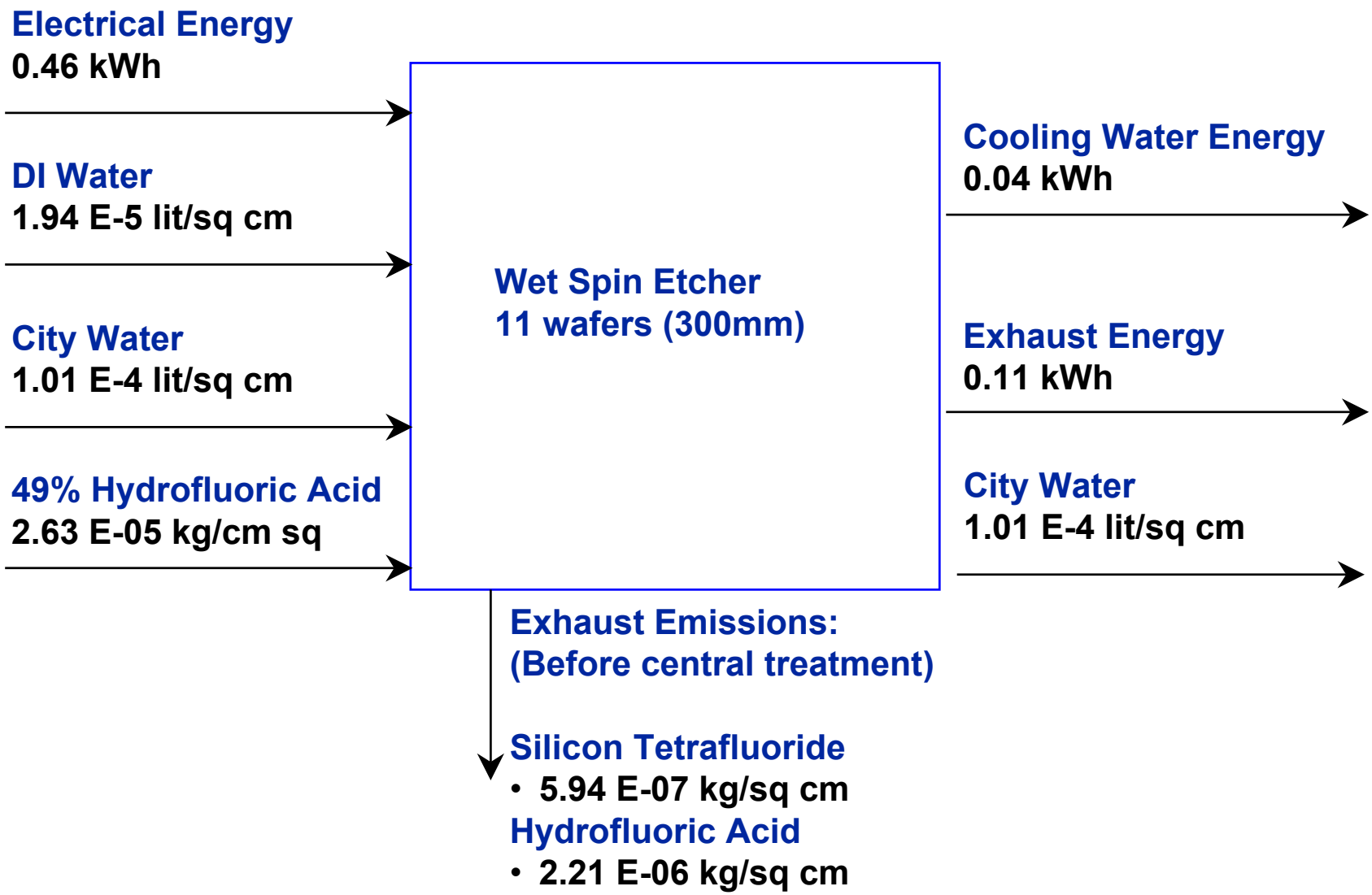
Results - Implanter



Results – CVD Tool



Results – Wet Spin Etcher



Summary

- Identified ESH parameters
- Agreed on units and normalizing factors
- Now building tool database
- Goal is to improve ESH performance of semiconductor tools