Micron semiconductor plant Clay, NY

Environmental impacts

10 December 2023

CENTRAL NEW YORK SOLIDARITY COALITION

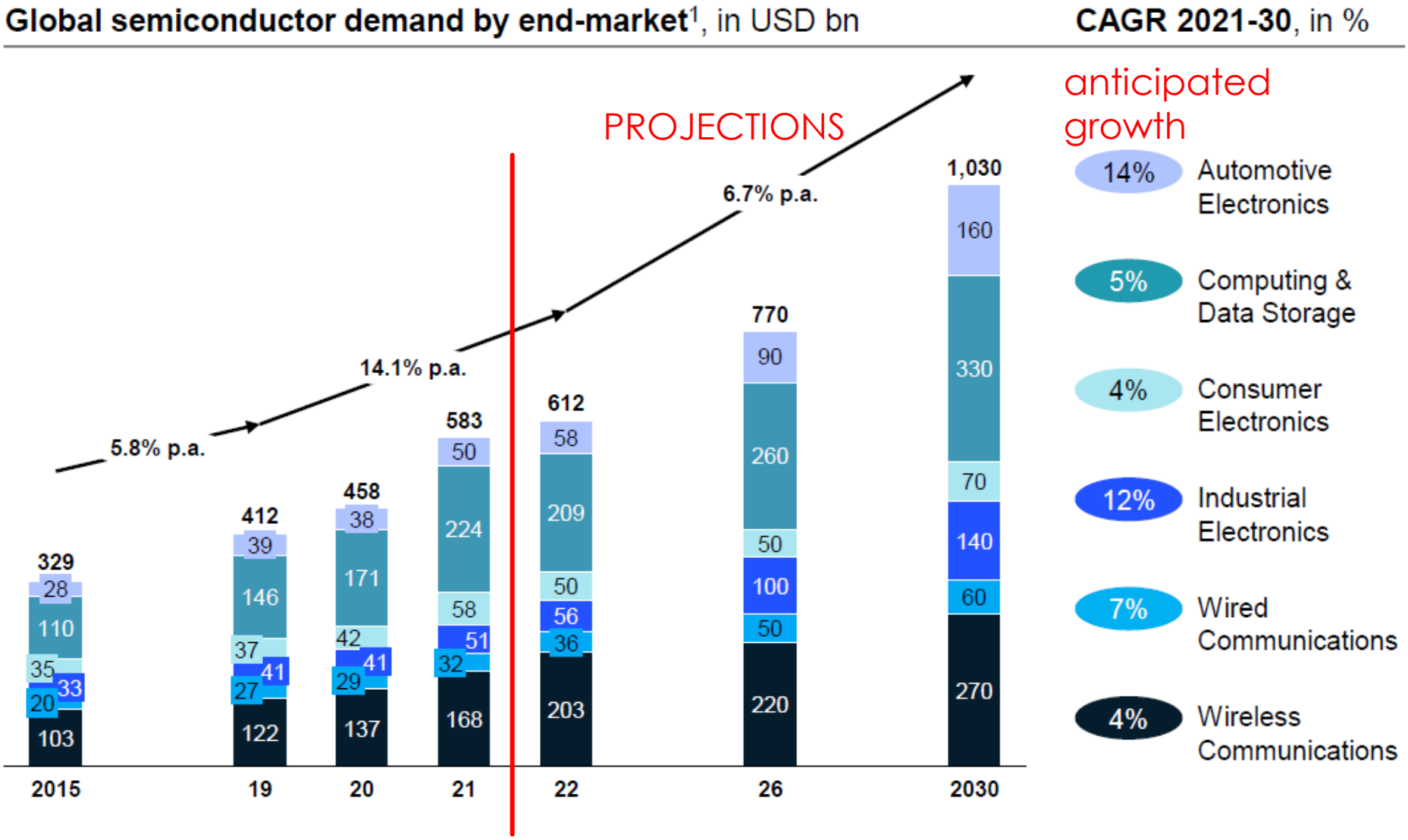
Don Hughes, PhD

Major topics

- Chemicals
- Water usage and treatment
- Natural gas
- Electricity

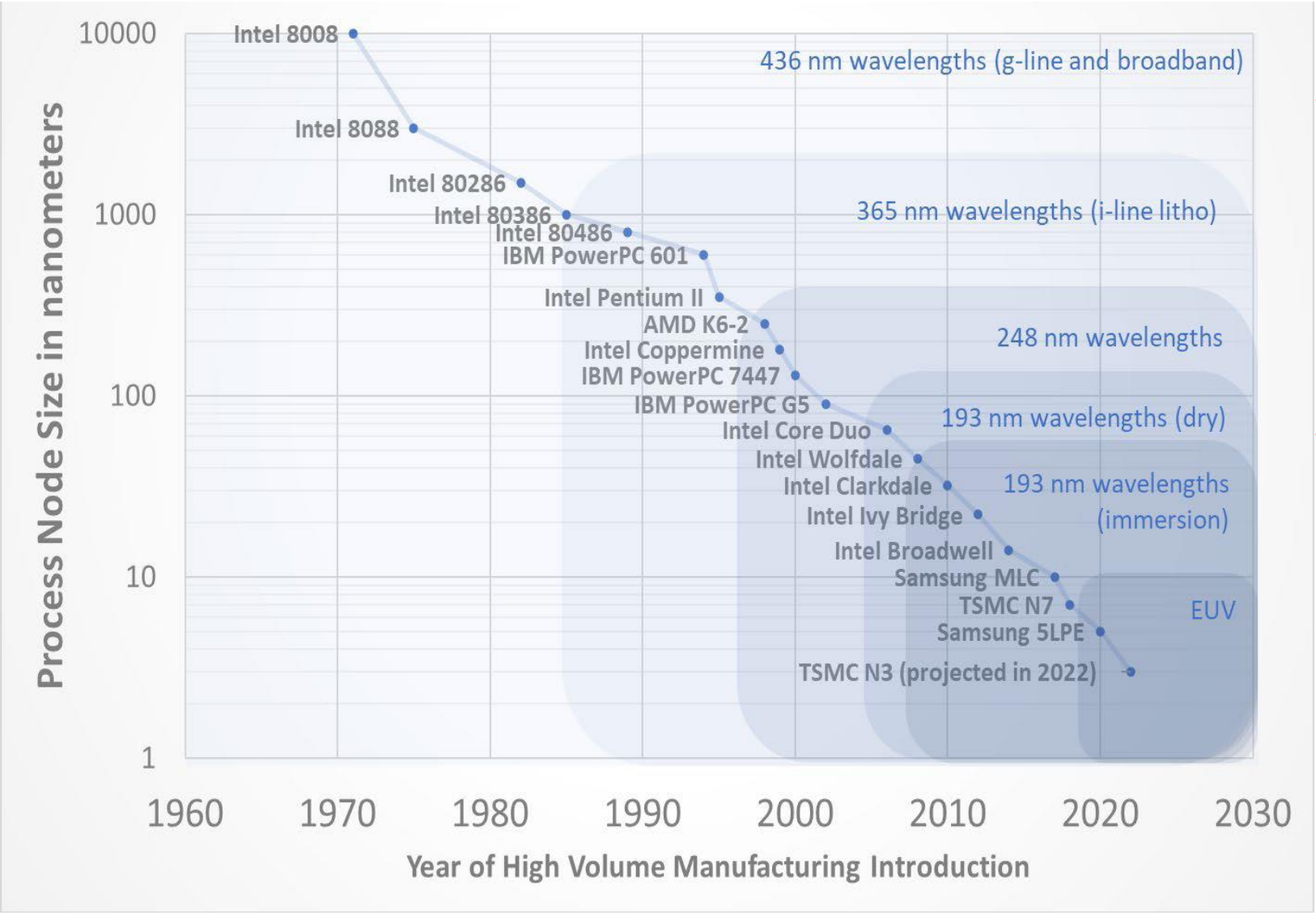
First....a look at chip fabrication

Source: World Semiconductor Trade Statistics (WSTS) 2021.
Updates: total sales = $556 billion (2021); $574 billion in 2022. Semiconductor Industry Association (SIA)



1. Includes ASP increase of 2.0% p.a. for 2022-30

Evolution of semiconductors using photolithography



Visible light

near-UV

far-UV

extreme-UV

How big is a nanometer?

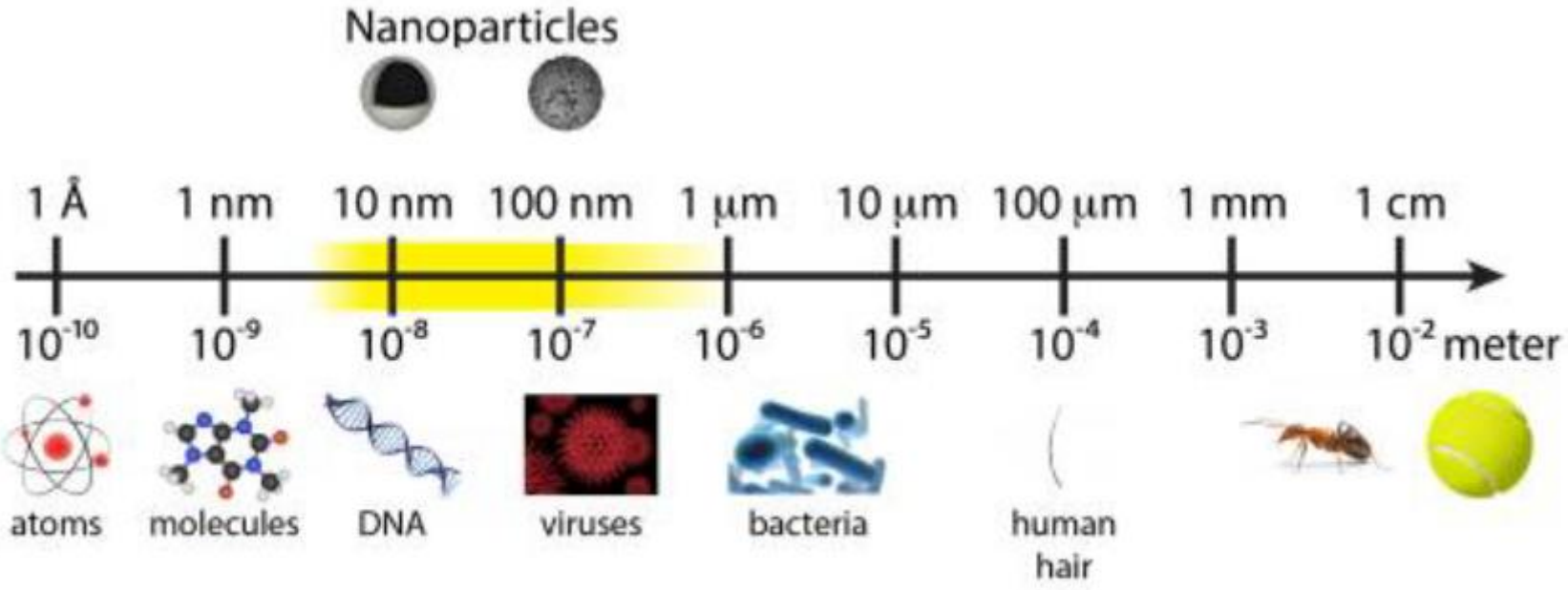
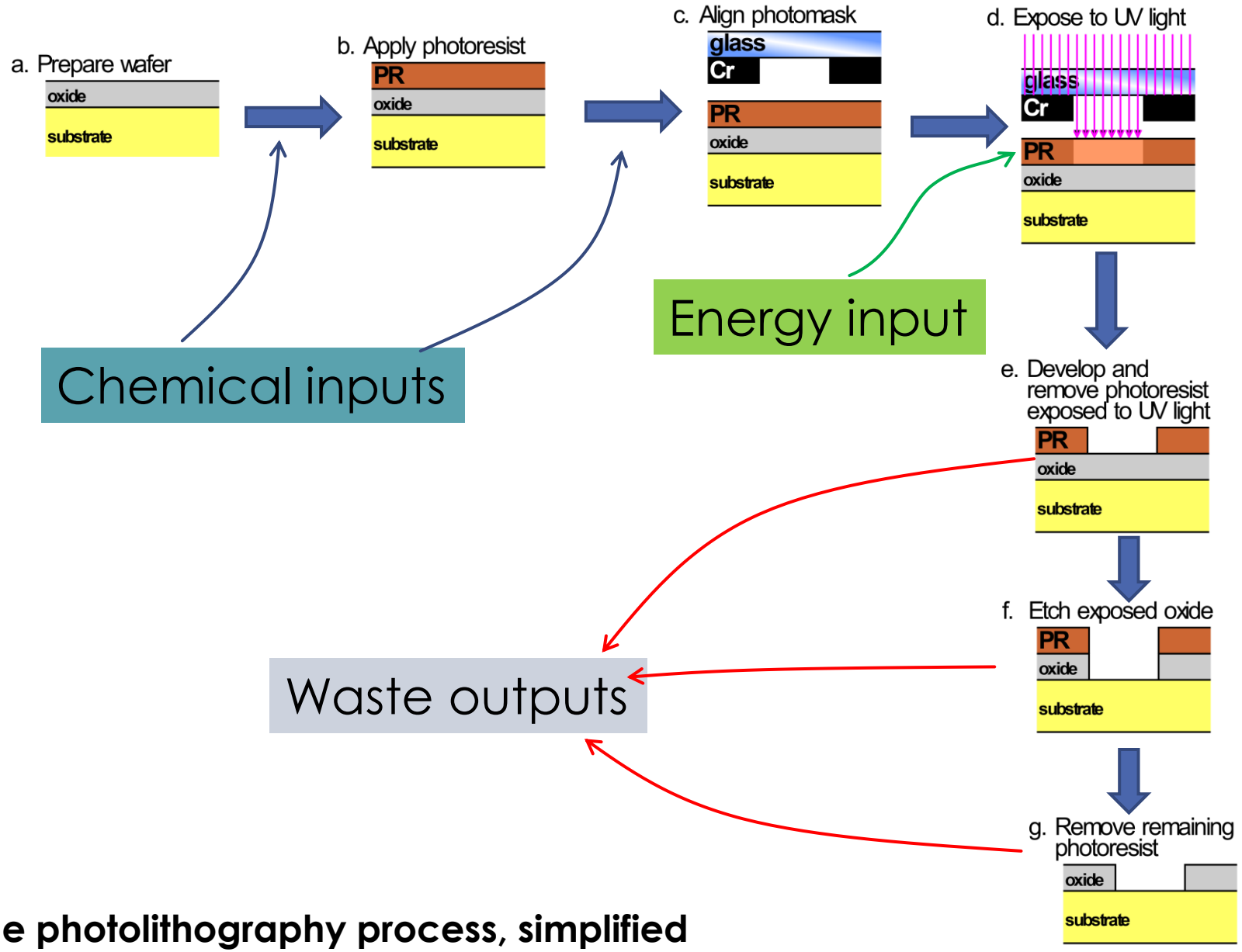


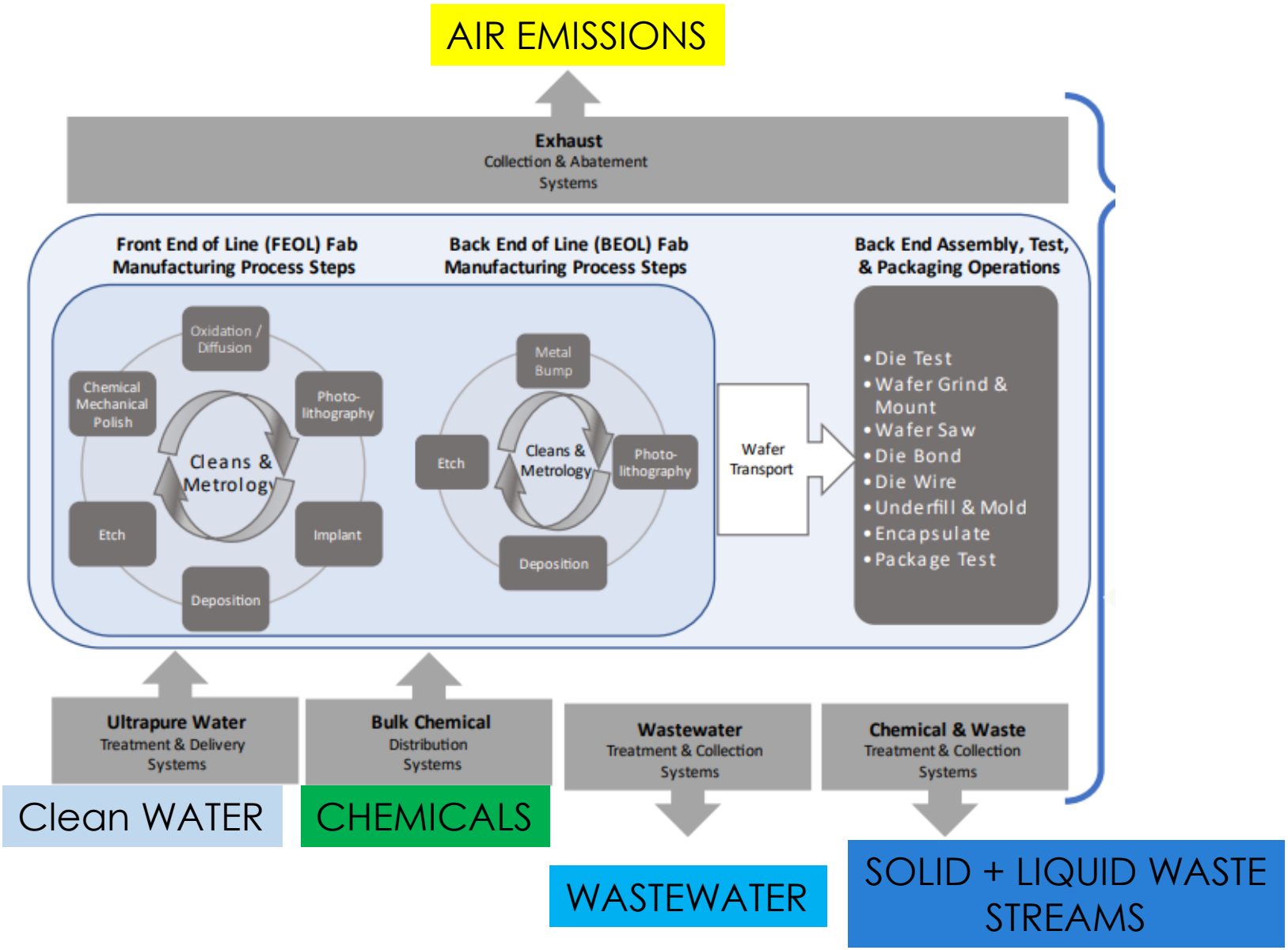
Figure 19: Micron size comparison (API 2020); (Bloemen 2015).



The photolithography process, simplified

Extreme ultraviolet lithography machine at Albany NanoTech Complex.

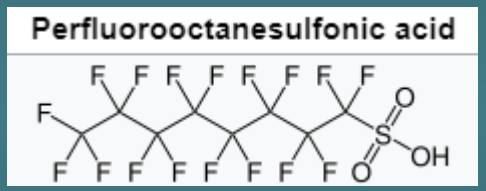
Glenn Coin | gcoin@syracuse.com Published: Sep. 18, 2023



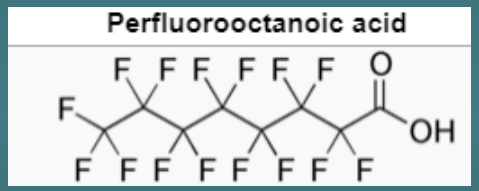
General overview of semiconductor manufacturing process steps, operations and systems evaluated by Semiconductor PFAS Consortium working groups.

Chemicals: PFAS

- PFAS = per- and polyfluoroalkyl substances
- chemicals that contain two or more fluorine atoms bonded to a carbon or hydrocarbon backbone"



PFOS



PFOA

PFOS and PFOA are frequently detected in foods, water, air, precipitation, and soils in the Great Lakes ecosystem[1]

both eliminated from semiconductor mfr. in early 200s

[1] Gewurtz et al., 2013, 2019; U.S. EPA, 2019

PFAS: What are the concerns?

1. **Highly persistent and mobile** within the environment
2. **Bioaccumulative** in animals, plants, people
3. **Health Effects**

Current peer-reviewed scientific studies have shown that exposure to certain levels of PFAS may lead to:

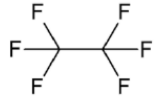
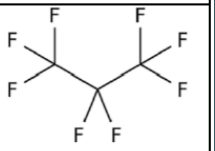
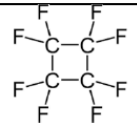
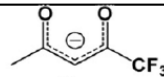
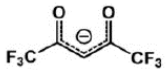
- Reproductive effects such as decreased fertility or increased high blood pressure in pregnant women.
- Developmental effects or delays in children, including low birth weight, accelerated puberty, bone variations, or behavioral changes.
- Increased risk of some cancers, including prostate, kidney, and testicular cancers.
- Reduced ability of the body's immune system to fight infections, including reduced vaccine response.
- Interference with the body's natural hormones.
- Increased cholesterol levels and/or risk of obesity.

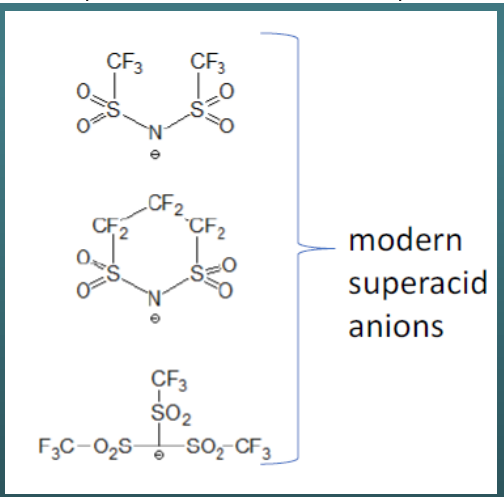
Source: US Environmental Protection Agency. https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas

Uses of PFAS for chips:

- **Photolithography** - A crucial phase in the process of manufacturing semiconductors, of transferring a component or circuit pattern by applying a photoresist and exposure.
- **Wet Chemistry** - Liquid substances used in processes such as wet etching, cleaning, chemical mechanical planarization, surface modification treatment, and other liquid applications in chip manufacturing.
- **Plasma etch and deposition** - Gases used in plasma etching and chamber cleaning, and metalorganics used in deposition.
- **Heat Transfer Fluids** - Coolants used in the manufacture of semiconductors, during the testing of devices, and in equipment such as chillers.
- **Assembly, Test, Packaging, and substrate material uses** - Materials used to test and attach individual semiconductor devices into chip packages.
- **Pump Fluids & Lubricants** - To provide smooth

generation of particles and outgassing (under

PFC gas	Hexafluoroethane (C_2F_6)/ PFC-116	
PFC gas	Octafluoropropane (C_3F_8)/ PFC-218	
PFC gas	Octafluorocyclobutane (C_4F_8)/freon-C-318	
Organometallic precursor ligands	tfac (1,1,1-trifluoro-2,4-pentane-dionate)	
Organometallic precursor ligands	hfac (1,1,1,5,5,5-hexafluoro-2,4-pentane-dionate)	



Source: The Impact of a Potential PFAS Restriction on the Semiconductor Sector. Report No. 2022-0737 Rev. 0 Prepared by **RINA Tech UK Limited** | April 2023.

Semiconductor Industry Association PFAS Consortium

- In many instances, ***PFAS are the only substances known currently to offer the necessary technical performance*** in semiconductor production.
- If manufacturers are no longer able to invest in innovations relying on PFAS, ...***significant disruption to the technology roadmap*** as manufacturers attempt to develop the next materials and equipment, which would be **a lengthy and demanding process with no certainty of success**.
- These impacts pose an ***enormous competitive disadvantage*** for semiconductor producers based in jurisdictions where there are PFAS restrictions compared to their non-affected competitors.

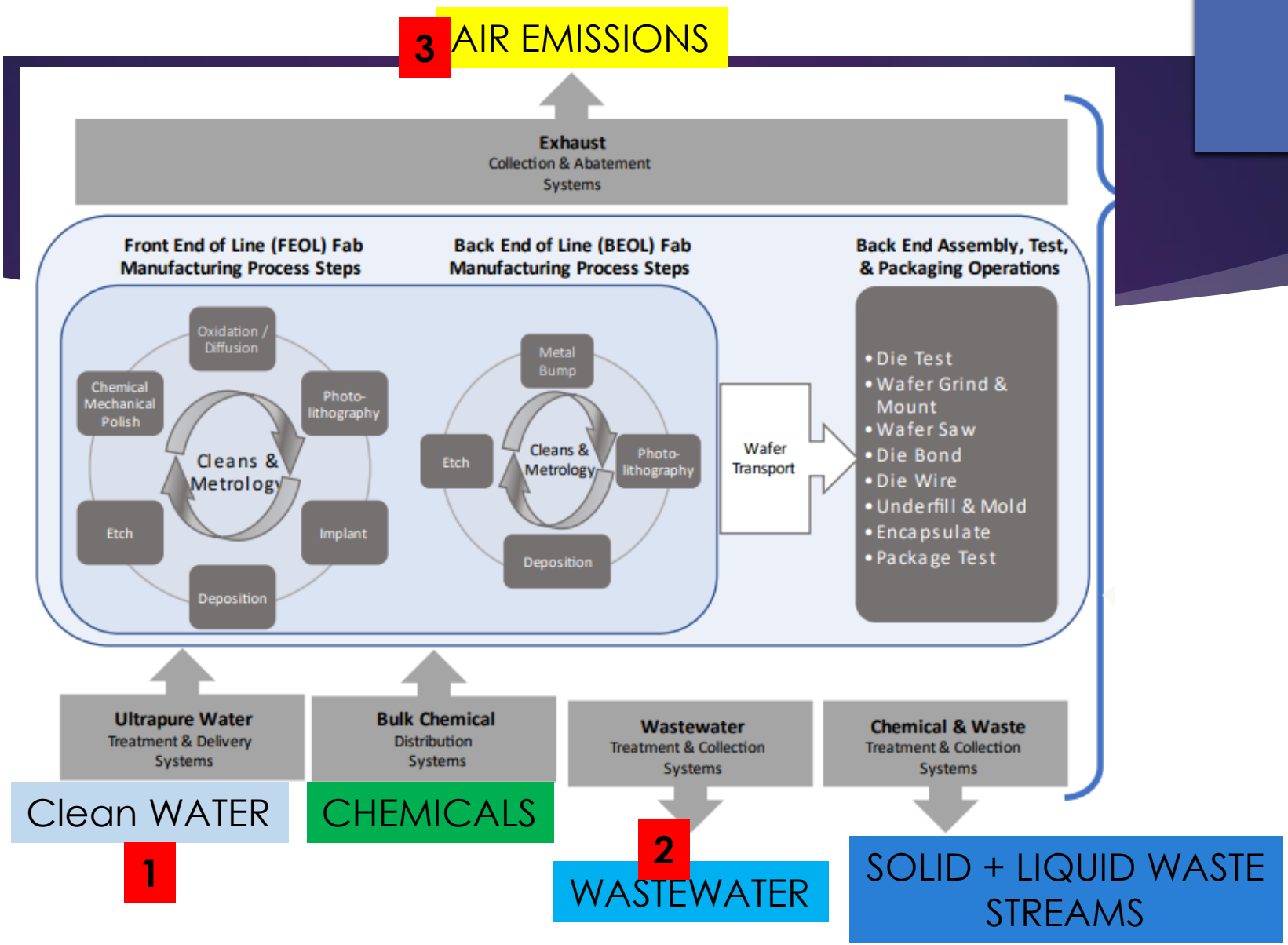
(emphasis added)

Source: The Impact of a Potential PFAS Restriction on the Semiconductor Sector. Report No. 2022-0737 Rev. 0 Prepared by **RINA Tech UK Limited** | April 2023.

What USEPA is doing re: PFAS (2023)

- Set drinking water limits for PFOA and PFOS = **4 parts per trillion**
- Updating rules for
  - Steam Electric Power Generating
  - Meat and Poultry Products
  - Organic Chemicals, Plastics & Synthetic Fibers
  - Metal Finishing and Electroplating
- "Not pursuing further action for the Electrical and Electronic Components Category (40 CFR part 469) at this time." A study was conducted in 2021. Regulations last revised in 1983.

Source: https://www.epa.gov/eg/current-effluent-guidelines-program-plan



General overview of semiconductor manufacturing process steps, operations and systems evaluated by Semiconductor PFAS Consortium working groups.

1 Water supply: Onondaga County Water Authority

- **L. Ontario** = primary source

up to 48 million gallons per day

- Fab 1: use existing supply pipeline (from Oswego to Syracuse)
- Fabs 2 – 4: Build new pipeline parallel to existing & build new treatment facilities.
- Cost ~ over $200 million


L. Ontario water intake
OCWA pipeline
Micron plant
County WWTP
OSWEGO COUNTY
ONONDAGA COUNTY
Oneida Lake
Onondaga Lake
Cross Lake
Syracuse
Syracuse-Hancock International Airport
Oswego River
Oneida River

2 Wastewater pretreatment

- If it is necessary to remove PFAS-containing materials from a fab's wastewater, they should ideally be **intercepted and/or treated close to their source**, where flows are typically lower and concentrations higher.
- Typical fab effluents ~ 12,000 to 23,000 m^3/day
  [3 – 6 million gal/day]
- **Removing low concentrations of PFAS-containing materials from a final effluent discharge** point that operates at a high flow will be **very expensive and, in some cases, infeasible.**

Source: The Impact of a Potential PFAS Restriction on the Semiconductor Sector. Report No. 2022-0737 Rev. 0 Prepared by **RINA Tech UK Limited** | April 2023.

Wastewater treatment:

- Estimated flow: 8 – 20 MGD

- Onon. County to pay about $200 million to upgrade the Oak Orchard Wastewater Treatment Plant

- Micron to spend $200 million on road and infrastructure improvements

Conveyance Improvements Estimated to be needed:

- **Industrial wastewater pumping station** on Micron property west of Caughdenoy Road.
- Four (4) 30-inch force mains for industrial wastewater from PS to WWTP
- One (1) 36-inch force main for **reclaimed water** supply
- From the Micron Campus to the pumping station: four (4) new 30-inch diameter industrial wastewater lines under Caughdenoy Road

Final Treatment @ Oak Orchard sewage

- PFAS will not breakdown in a sewage treatment plant.
- **PFAS have been found at elevated levels in sewage sludge.**
- **PFAS that do not partition to sludge will either:**
  - **be discharged into local waterway**
  - **be emitted into the air**

Source: The Impact of a Potential PFAS Restriction on the Semiconductor Sector. Report No. 2022-0737 Rev. 0 Prepared by **RINA Tech UK Limited** | April 2023.

3

Air emissions

- Micron to incinerate off gases at 1000 - 2000+ °F using natural gas

"greenhouse gas (GHG) and volatile organic compound (VOC) abatement systems"

PFAS = very powerful GHGs

Source: Meeting with Micron, Nov. 2023.

Electricity

- "Micron has a public commitment to achieve 100% renewable electricity for all its US operations by the end of CY25. Micron is considering all forms of renewable electricity to achieve our goals." Beth Elroy, Micron Vice President – Global EHS & Sustainability
- Includes nuclear?

- Fabs 1 & 2: 480 MW (power ~500,000 homes)
- Fabs 3 & 4: 480 MW (power ~500,000 homes)
- Total = 16 billion kilowatt-hours of electricity per year.
- Micron will increase demand in NY state by 11%.

Sources of Renewable Electricity

- Solar: Need 3 square miles of PV collectors + battery storage (summer)
- Wind: Need > 1,000 3MW wind turbines (winter)
- Hydropower: good luck!

Nuclear power:

- Ninemile point 1: 613 MY (operational Dec. 1969)
- Ninemile point 2: 1,277 MY (operational March 1988)

Energy leaders warn: NY electric grid must grow for Micron and other new big users

- Updated: Nov. 30, 2023, 6:24 p.m.|
- Published: Nov. 30, 2023, 6:00 a.m.

- NY Independent System Operator report:
- "many factors introduce greater uncertainty in the forecast of energy use in New York State and, thus, greater risk to the reliability of the grid in the future."

Staff writer Tim Knauss, Post-Standard/Syracuse.com

in summary...major concerns

PFAS

- extremely diverse class of compounds
- integral to semiconductor manufacture
- significant human health and environmental risks
- potent GHGs
- difficult to regulate & to treat

Electric requirements

- Micron = 11% increase electric demand in NYS
- renewable commitment – v. difficult to attain

Source: Meeting with Micron, Nov. 2023.