

# Industrial Process Technical Advisory Group

September 17, 2014

# Greenhouse gases

- **Carbon Dioxide**
  - Major Sources: Burning of vegetation and fossil fuels
  - 100 year global warming potential = 1
  
- **Methane**
  - Major Sources: Production of fossil fuels, agriculture, landfills
  - 100 year global warming potential = 25
  
- **Nitrous Oxide**
  - Major Sources: Agriculture, wastewater treatment, fossil fuel combustion
  - 100 year global warming potential = 298
  
- **Fluorinated Gases**
  - Major Sources: Semiconductors, electrical manufacturing, ozone depleting substance replacement
  - 100 year global warming potential = 1,000 – 24,000

# Industrial Process – Initial Data

Source	2011	2012
Freescale EB site	62,897 mtCO2e	58,107 mtCO2e
Freescale OH site	53,809 mtCO2e	59,528 mtCO2e
Samsung Austin	406,859 mtCO2e	322,024 mtCO2e
Spancion	92,188 mtCO2e	93,050 mtCO2e
Austin White Lime	271,216 mtCO2e	301,907 mtCO2e
<b>TOTAL</b>	<b>886,969 mtCO2e</b>	<b>834,616 mtCO2e</b>

Source: EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT)  
<http://ghgdata.epa.gov/ghgp/main.do>

# Breakdown of Emissions from EPA

## ■ Semiconductor

- Stationary Combustion – Natural Gas
- Process Emissions
  - Nitrous Oxide
  - Sulfur Hexafluoride, Fomblin, Krytox, NF3, Perfluorocyclobutane, Octofluorocyclopentene, PFC-14, PFC-116, HFE-7200, HFE-7500, HT-110, HT-135, HT-170, HT-200, FC-40, HFC-23, HFC-41, PFC-218, FC-3283

## ■ Lime

- Stationary Combustion in Kilns - Coal & Natural Gas
- Process Emissions
  - $\text{CaCO}_3 + \text{Heat} \rightarrow \text{CaO} + \text{CO}_2$

# Questions to the Semiconductor Industry

- What are your actual emissions?
- What actions have you been taking to reduce emissions and how much do they cost?
- What is your future potential for reduction and what is planned?

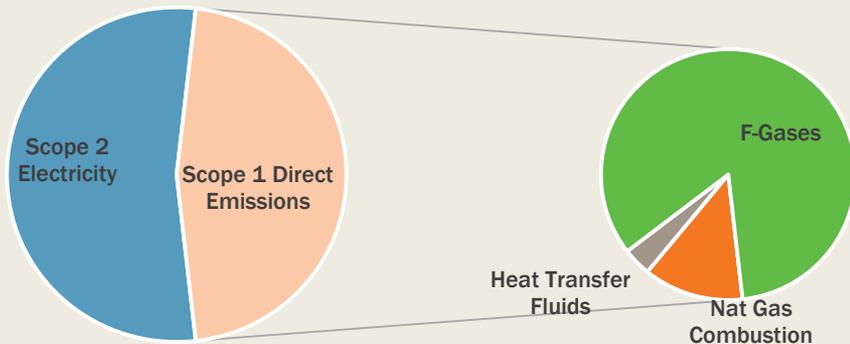
# Spancion

- 93,000 mt CO<sub>2</sub>e reported in 2012
- 2013 actual emissions over 100,000 mtCO<sub>2</sub>e
  
- Potential for CF<sub>4</sub> abatement
  - Could eliminate 33,000 mtCO<sub>2</sub>e
  - \$100 / ton to abate
  - Total cost \$3.5 Million
  - Emissions would be reduced to 59,000 mtCO<sub>2</sub>e
  
- Next
  - Not a Title V source, required to report and no federal regulations to destroy or reduce
  - Facility is old and very challenging to retrofit at this point

# Samsung

- Over the Title-V air permit threshold of 100,000 tons per year
- Required to abate certain pollutants
- New Facility, designed for capture and destruction
- Abatement on vast majority of units in the facility
- Estimated 60% reduction, likely much higher
- Do not report destruction because it is costly to measure
- Process gas emissions reported = 227,000 mtCO<sub>2</sub>e in 2013 are likely 90,000 mt CO<sub>2</sub>e or less.
- Next: More measurement, tracking, and reduction

# Freescalé Baseline GHG Emissions Data

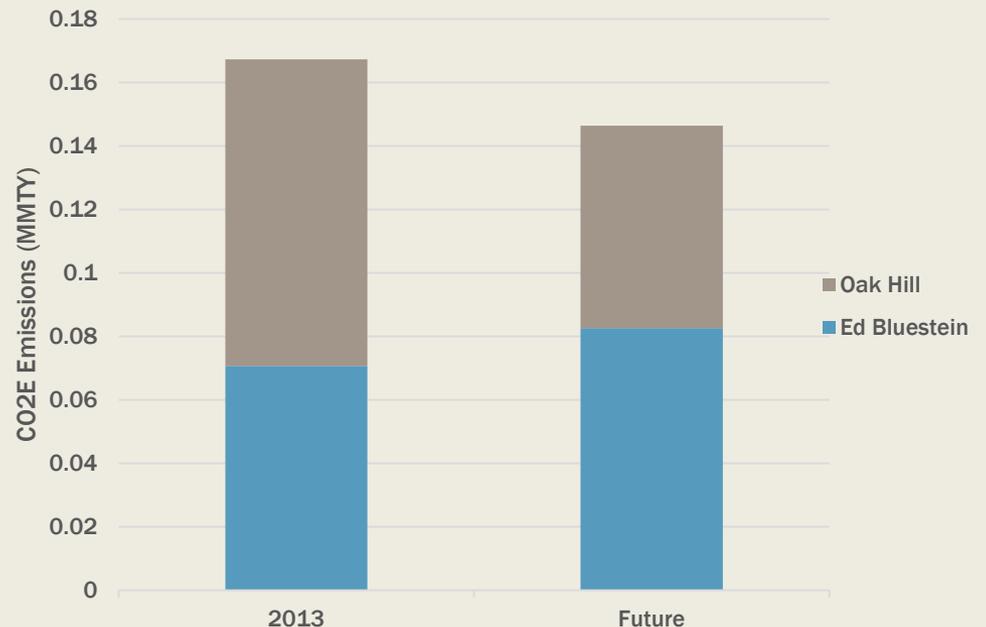


## Direct Emissions – 46% of Total

- 83% Process Gasses
- 13% Combustion
- 4% Heat Transfer Fluids

## Future Emissions

- Includes some predicted increases due to tool sets coming online
- Includes abatement on key CVD platforms at Oak Hill Fab



# Freescal Austin GHG Reduction Strategies

- Remote Plasma System retrofits (Ed Bluestein)
- Alternative Heat Transfer Fluids (Ed Bluestein)
  
- Abatement of CVD (Oak Hill)
  - 67,233 MT of CO<sub>2</sub>e reduction per year
  - Investment to-date \$2.7MM
  
- RPS retrofits and Abatement are roughly cost-equivalent
  - ~\$250k per tool installed (4 chamber CVD system)
  - ~\$44 for every CO<sub>2</sub>e MT/year reduction

# Freescal - Future Options

## ■ Etch Abatement

- Several deep silicon etch platforms with high SF<sub>6</sub> and C<sub>4</sub>F<sub>8</sub> usage
- Etch real-estate is difficult to acquire. Multi-tool abatement systems with redundancy would be needed to reduce footprint.
- Similar cost as CVD abatement within 20%

## ■ Other

- Process optimization based on end-point detection for chamber cleans.
- Switch to alternate etch/chamber clean gasses with lower GWPs

# What's Next?

- These reductions have a direct cost
  - F-Gas destruction from all Austin Semiconductor facilities  
= 300,000 metric tons \* \$70 / ton = \$21,000,000
- GHG Regulation will eventually occur
  - Drive investments to destroy fugitives
  - Drive innovations for gas replacement
- The Freescale and Spansion plants are past their useful life already, closing or replacement plants with new technology are on the horizon