

Understanding Fluorine (F₂) Gas Emissions and Control

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Presentation Topics

- **NF3**

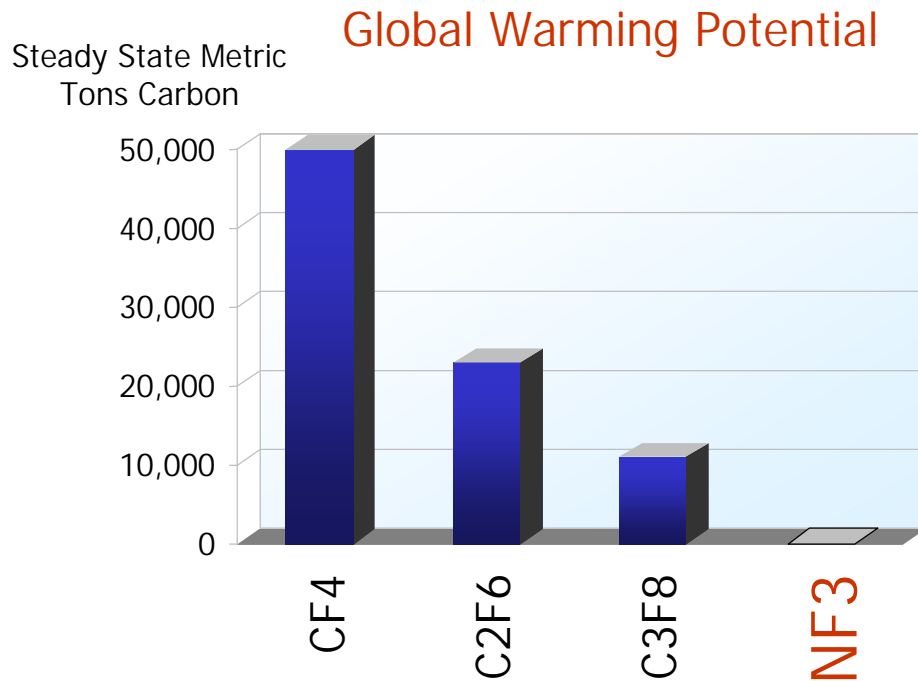
- Advantages
- Liabilities
- Future

- **Fluorine Gas**

- Formation
- Impacts
- Measurement
- Abatement

Is there room for improvement?

Advantages of NF3 Cleans

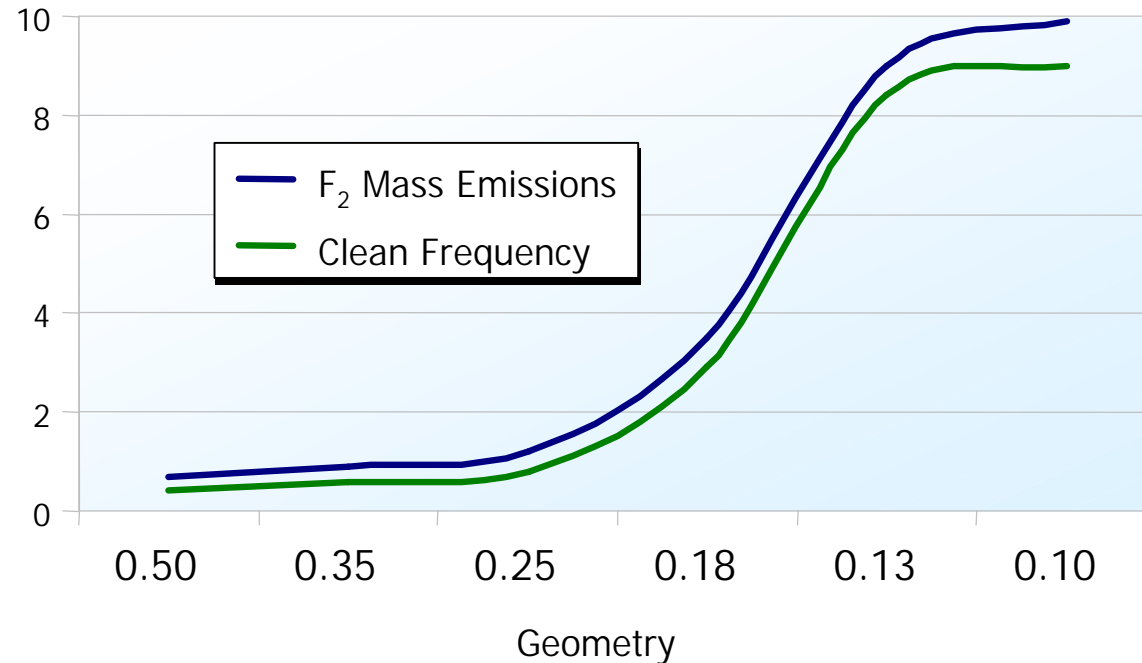


Source: Solid State Technology, July 1996

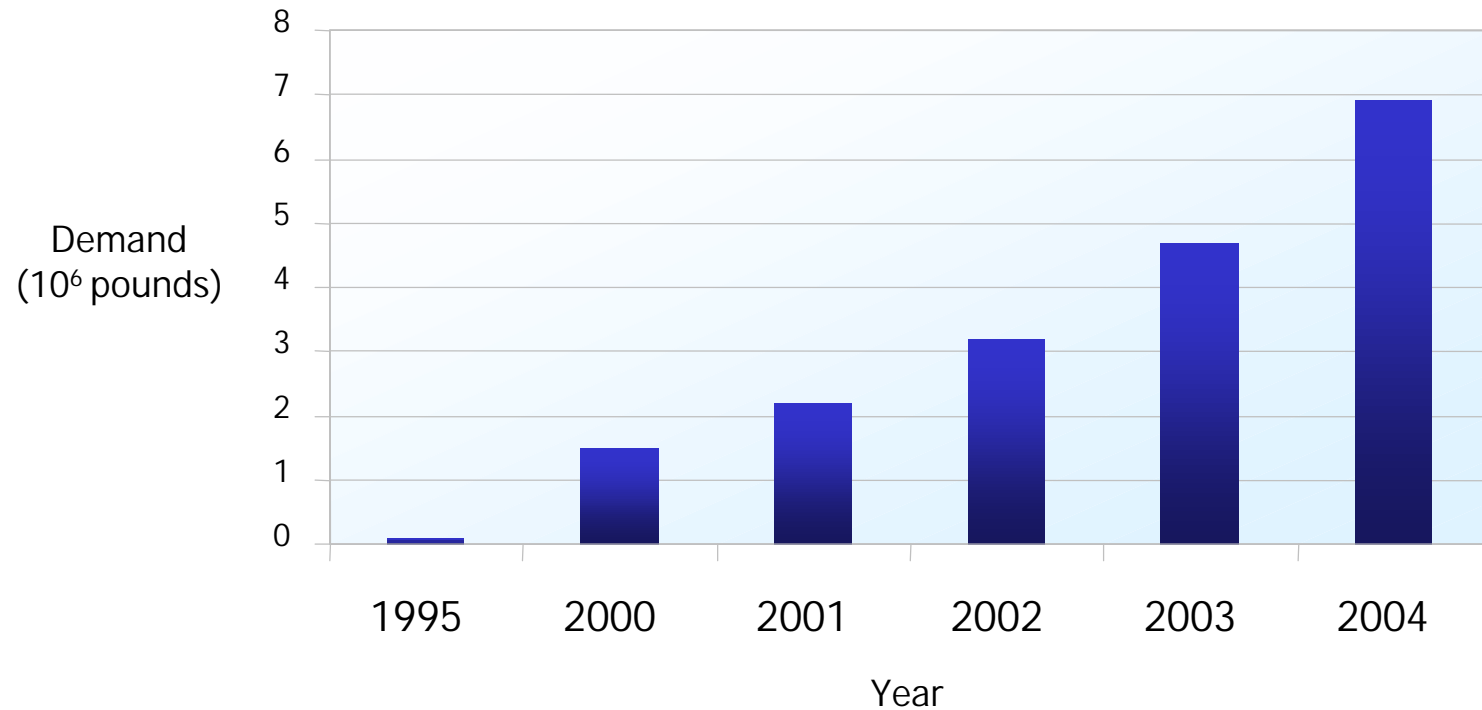
- **4 to 12 Times Faster**
- **Greater Conversion**
 - 70 to 90% Insitu
 - >99% Remote
- **Reduced Global Warming Impact**

Liabilities of NF_3 Cleans

- **Fluorine Gas Emissions**
- **Geometry Size Drives Usage**



Increasing Global NF_3 Demand



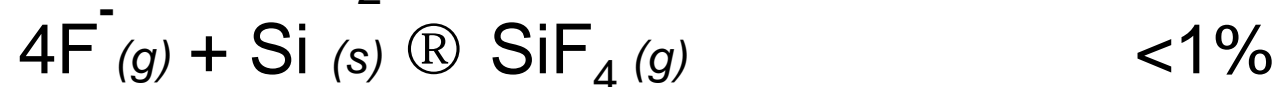
Source: SEMI - Industry Research & Statistics,
November 2000

F₂ Formation & Fate

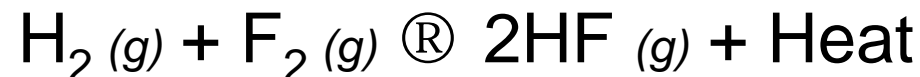
- **Remote Plasma Chamber**



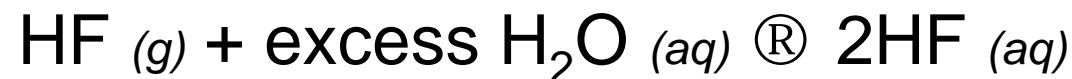
- **Between Chamber and Pump**



- **Abatement Conversion**



- **Liquid Scrub**

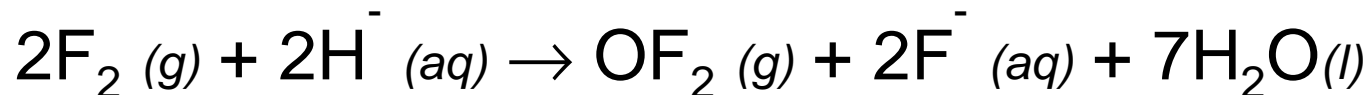


OF₂ Formation Mechanisms

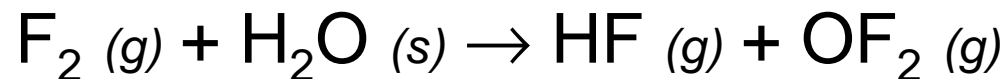
- **Adding Electrical Energy**



- **Passing Fluorine Through >1 Molar Aqueous Alkaline**



- **Passing F₂ over Cooled Ice**



Sources:

Encyclopedia of Inorganic Chemistry, vol 3, p 1236, 1994

Journal of the American Chemical Society, 57(1):246-248, 1935

Journal of the American Chemical Society, 106(15):1754-1757, 1987

Impacts to Operations

- **Degradation of FRP Ducts**
- **Odor Complaints - Threshold is 0.02 to 0.08 ppmv**
- **Exposure Symptoms - Low TLV of 1.0 ppmv**
- **Yield Impacts - F₂ is Strongest Known Oxidizer**
- **Corrosion of Abatement Equipment**

Desired Characteristics of a Chemical Sensor

- **Responsive to Fluorine**
- **Components Compatible with Fluorine**
- **Not Cross Sensitive to other Common Species (HF, SiF₄, Silane, Hydrogen, etc.)**
- **High Sensitivity**
- **Continuous**

Measurement Methods

- **Mass Spectrometer**
 - + Continuous and able to see other species
 - Equip degradation and stability
- **Electrochemical Cells**
 - + Continuous and Low Cost
 - Poisoning, cross sensitivity, and stability
- **Colorimetric Tubes**
 - + Simple and Low Cost
 - Not Continuous, cross sensitivity, and poor quantitaion

Measurement Methods

(continued)

- **URS Technology**

- + ?

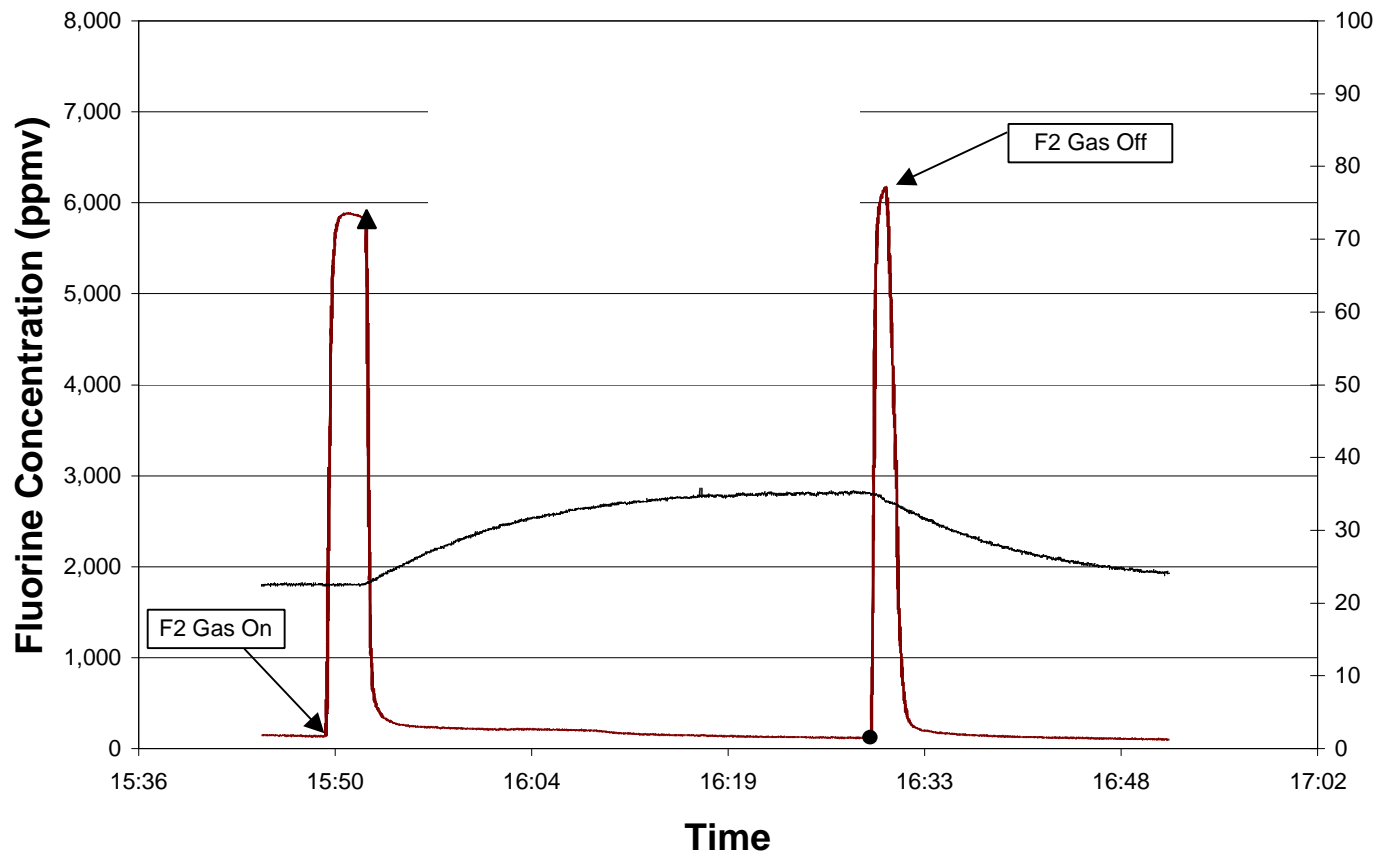
- ?

- **Impinger Trains**

- + Simple and Low Cost

- Not Continuous, cross sensitivity, and long sample duration

Fluorine Gas - DRE Demonstration

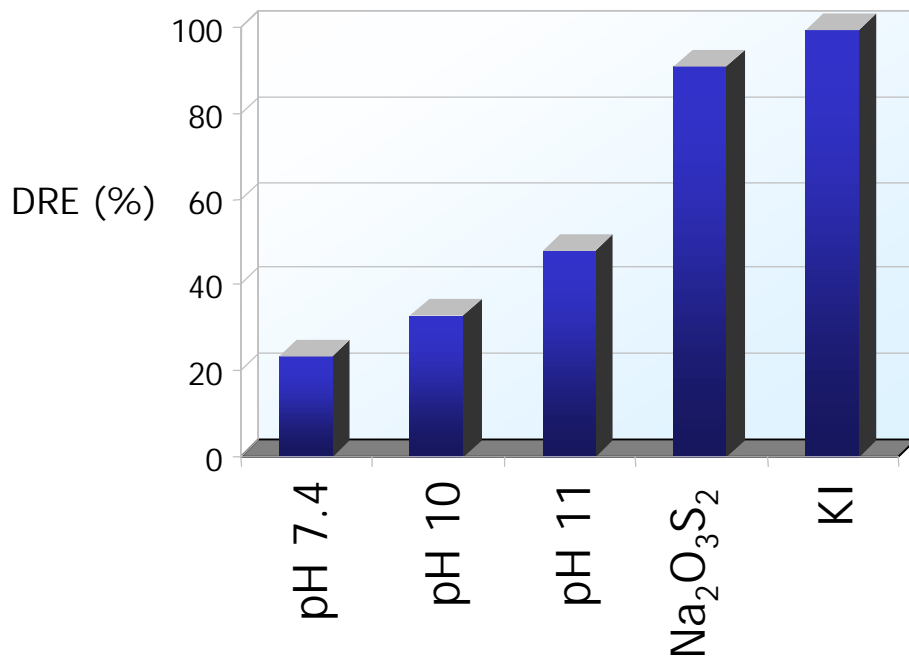


Desired Characteristics of an Abatement System

- **Treats Both Fluorine and Process Gases**
- **Components Compatible with Fluorine**
- **Minimal Footprint**
- **Minimal Maintenance**
- **Minimal Utility Usage**
- **Minimal Installation Costs**

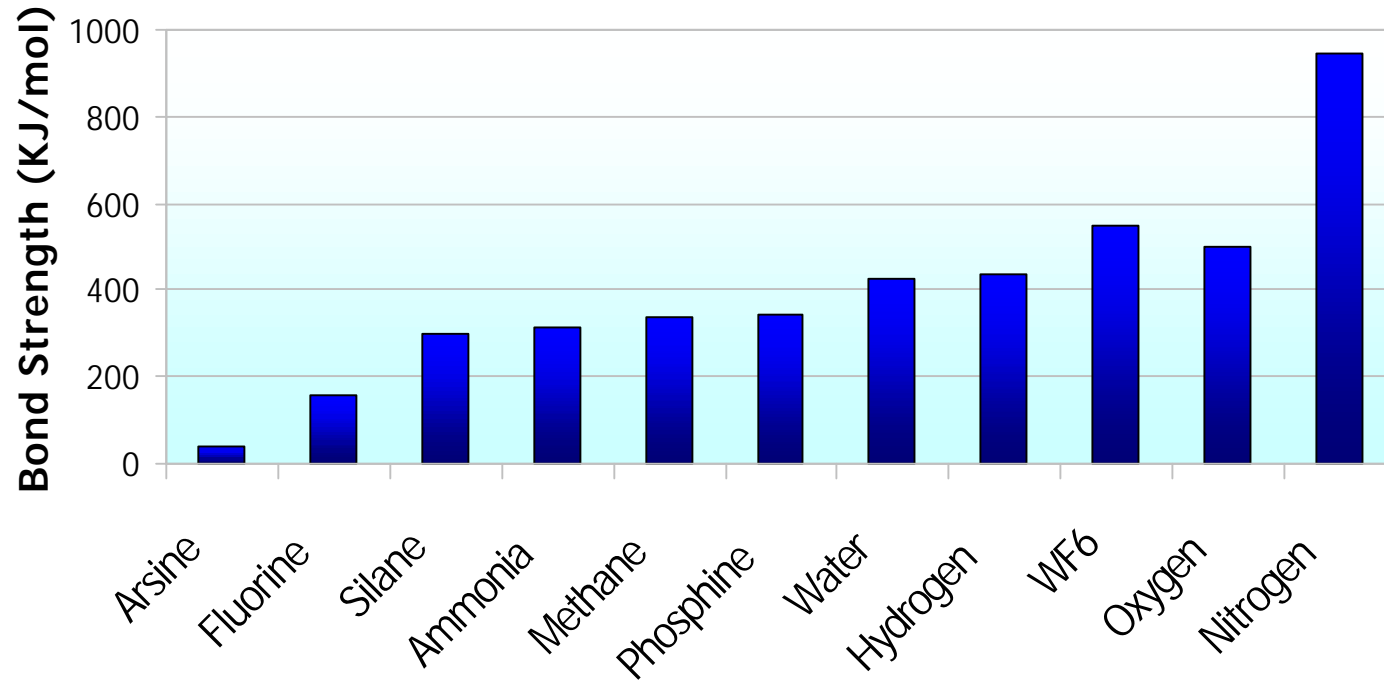
F₂ & Acid Scrub Performance

F₂ DRE for Liquid Scrub



- **Poor Performance for Standard Configurations**
- **Elevated pH has Minimum Impact on DRE**
- **Secondary Chemical Addition is Problematic**
- **Potential for Evolution of F₂ back to the Gas Phase**

Bond Strength



Source: Handbook of Chemistry & Physics,
63rd Edition

Ineffective Solutions

- **Short Contact Time Combustion**
- **Water Ring Pumps**
- **Ambient Temperature Resins**
- **Heated Salts**
- **Nitrogen Dilution**

How is F₂ currently abated?

Conventional Approach:

- **Thermal Oxidation with Water Contact Cooling**

Conclusions

- **NF3 Usage will Increase Dramatically**
- **Fluorine Gas Emissions Across the Industry are Increasing**
- **An Ideal Measurement System is in Development**
- **Current Abatement Strategies are Adaptions of PFC Designed Equipment**

Questions

Contact

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