SF$_6$ Emissions Abatement Strategy in Taiwan

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Outline

- Uses of SF$_6$ in Taiwan
  - Electric power industry,
  - Semiconductor industry,
  - TFT-LCD industry,
  - Magnesium industry,
- Taiwan's SF$_6$ Emissions Reduction
- Future work
- Conclusions
SF6 Used in Electric Power Sector

GIL (Gas Insulation Line)

GIS (Gas Insulation Switchgear)

GCB (Gas Circuit Breaker)
Share of SF₆ Emission in Electric Power

- GIS: 40%
- GIL: 14%
- GCS: 1%
- GCB: 40%
- Other: 5%
SF6 Emissions Reduction Strategies for Electric Power Systems

- Environmental management system
  - Taipower is ISO 14000 certified.
  - SF$_6$ gas recovery for servicing SF6 equipments

- To survey SF$_6$ emission
  - Taiwan EPA provides the Electric power industry with personal training
  - To introduce the international protocol on global atmosphere,
  - The emission reduction of SF$_6$
  - The SF$_6$ recovery equipment and demonstration
TFT-LCD and Semiconductors Use \( \text{SF}_6 \)

1. CVD chamber cleaning

2. Dry-etching processes.
TSIA ESH Committee Organization

ESH Committee

Secretary

Working Group

Consultant
ITRI

PFC Reduction
Chem. Management
Energy Saving
ESH Database Performance indicator
Tool/Facility ESH Guideline

TSIA: (Taiwan Semiconductor Industrial Association)
TSIA-PFC Emission Data

PFCs: $C_2F_6, CF_4, CHF_3, SF_6, NF_3, C_3F_8, C_4F_8$

MTCE


(Year)
SF₆ Gas Emission by TSIA

- 2000: 0.20
- 2001: 0.20
- 2002: 0.15
- 2003: 0.13
TTLA Member Distribution

TTLA: Taiwan Thin Film Transistor – Liquid Crystal Display Association

- Quanta Display Inc.
- HannStar Display Corp.
- AU Optronics Corp
- Toppoly Optoelectronics Corp.
- CHI MEI Optoelectronics Corp.
- ChungHwa Picture Tubes Ltd.
- Prime View Int'l Co. Ltd.
- Industrial Technology Research Institute

Taiwan
SEP Committee devotes itself to studying and finding solutions for the safety and environmental related issues of Taiwan TFT-LCD industry. The SEP Committee also participates in international safety and environmental protection related organizations and activities.
TFT-LCD Industry Use PFCs

The PFCs of TTLA total emissions is 0.274MMTCE in 2003
TTLA PFCs Abatement strategy

- Join World TFT-LCD Association, achieve the PFCs emission reduction goal for Taiwan, Japan and Korea
- Sign with Taiwan EPA the voluntary memorandum for PFCs emission reduction
  - Taiwan EPA will assist TTLA on reporting and checking of the PFCs emission amount and provide
  - TTLA agrees to choose 2002 as the base year for PFCs emission reduction
  - Use the PFCs emission intensity 0.0335 tonnes carbon equivalent/square meter substrate area used
- Implement reduction measures on the use and emission of PFCs.
The Technologies of reduction PFCs emission

- **PFC Emissions Calculation**
  - Calculating annual PFC emissions and constructing reduction strategy

- **Local Scrubber Installation**
  - Using effective local scrubber and improve its performance

- **Process Optimization**
  - Optimizing the PFC usage inside the process chamber

- **Gas Substitution**
  - Using gases with less global warming effects
PFC Emissions Calculation
IPCC Tier 2C Method

PFC emissions = (1 - h)[PFC_i (1 - C_i)(1 - A_i) + (B_i * PFC'_i)(1 - A'_i)]

h = residual PFC in the gas cylinder = 0.1
PFC_i = purchased PFC amount
PFC'_i = PFC used in the process tool (= PFC_i * C_i)
C_i = usage ratio of PFC in the process tool (rf. IPCC published value)
B_i = ratio of PFC converted to CF_4 (rf. IPCC published value)
A_i = DRE value of local scrubbers (rf. IPCC published value)
A'_i = DRE value of local scrubbers for CF_4 (rf. IPCC published value)
Drop-in replacement trends for Gas Substitution

C1 → C2 → C3 → C4
CF₄ → C₂F₆ → C₃F₈ → C₄F₈

decreasing PFC emissions

NF₃ → C₄F₈O

decreasing gas usage

Trends based on the decreasing stability of the compounds with increasing F, and so their more efficient conversion to atomic fluorine, the active cleaning species

DATA SOURCE:
International Seminar on PFC Emission control in Taiwan 2003
Optimization of NF₃ Remote Clean
Process Optimization

- Control Item
  - NF₃ Flow rate
  - Pressure

- Characteristics of remote NF₃ Clean:
  - 99.7% destruction of NF₃
  - Faster process
  - No direct ion bombardment in CVD chamber

- Goal: reduce NF₃ use
Local Scrubber Installation

- The calculation of PFCs Emission is based on IPCC Method Tier 2c
- Local Scrubber DRE (destruction rate efficiency) to be 90%
  - Fueled combustion
  - Plasma
  - Catalytic devices
- The other local scrubbers DRE is 0%
  - Thermoelectric
Local Scrubber
Guardian Combustion

DRE=97% for NF3 *(Solid-State Technology (in Taiwan version), May/June, 2004)*
Local Scrubber
SCDS (thermal catalyst)

System for PFC Decomposition

DRE>99% for CF4, C2F6, SF6
(Solid-State Technology, Sep. 2004)
Abatement Performance Evaluation of a Local Scrubber

Process Gases (SiH4, NF3)

Local Scrubber

N2

CH4

Air

Exhaust

FTIR/RGA

Pump

Pump
### Applications of Magnesium in Taiwan

<table>
<thead>
<tr>
<th>Industry</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Notebook PC</td>
<td>Casing &amp; Interior framework</td>
</tr>
<tr>
<td>2. Consumer Electronic</td>
<td>Camcorder, Digital camera, PDA, MD, LCD projector, Internet appliance</td>
</tr>
<tr>
<td>3. Communication</td>
<td>Mobile phone</td>
</tr>
<tr>
<td>4. Automotive</td>
<td>Engine cover, Airbag housing, Steering wheel</td>
</tr>
<tr>
<td>5. Bicycle Industry</td>
<td>Fork Slider, Pedal, Frame, Crane, Hub, Stem</td>
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</tbody>
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*Industrial Technology Research Institute, Energy & Resources Laboratories*
TMA SF$_6$ Abatement strategy

- There are 15 companies in TMA (Taiwan Magnesium Association) use SF$_6$ on 2002
- Taiwan EPA is working with TMA to assess substitute gases in hope to reduce the use and emission for SF$_6$.
- Current substitute gases in priority include SO$_2$, HFC-134a and other cover gases
Conclusion

- SF₆ emission from Industrial is less than 0.1% of greenhouse gases in Taiwan
- Taiwan semiconductor industry and TFT-LCD industry are committed to greenhouse gas reduction target
- Power industry and magnesium aluminum alloy industry are working with EPA to recover SF₆ and assessing substitute gases in hope to reduce the use and emission for SF₆.
- Taiwan will continue to develop saving energy and improve manufacturing process to reduce the use and emission for SF₆