What is the customer looking for?

Capacity, Capability & Commitment
Capacity

Size

Engineering Capacity

Production Capacity
$55M in 2012 Abatement Revenue

287 direct employees

>3,500 installed base

Head Quarters, Dongtan Industrial Complex

Jincheon Manufacturing Plant - 88,000 ft²
Engineering Capacity

>5 concurrent development projects

Head Quarters

Scrubber R&D Lab
Manufacturing Capacity

>100 scrubbers per month

Scalable to 300 units in 2 months
Wide Range of Technologies

Technology Innovations
GST Abatement Product Line

- **FACILITY LEVEL**
  - PFC ABATEMENT (CATALYST & RTO)
  - PROJECT RCO and Zone PFC Scrubber

- **BURN-WET**
  - DRAGON / DRAGON DUO

- **HIGH CAPACITY**
  - BURN-WET
  - GALLANT

- **DRY**
  - SDS-500

- **PLASMA-WET**
  - Durian

- **PUMP & ABATEMENT**
  - EXCELLION

- **HEAT-WET**
  - ISIS-I,II,III,IV

- **WET & WET-EP**
  - SWS-500 / AQUA EP

GST Confidential
GST Product Performance Target

- GST strives to provide *best practical abatement solutions* to semiconductor industry.

- GST Abatement Efficiency and Emissions Target
  - Toxic: < TLV
  - Flammable: < ¼ LEL
  - PFC DRE: > 95%
  - NOx Emissions: < 50 ppm
  - CO Emissions: < 50 ppm
  - Other parameters: THC, odor, etc.
“Heat-Wet” Type: ISIS

ISIS-II

- HVM (high volume manufacturing) proven
  - Well suited for semiconductor deposition processes
  - Powder tolerant design with large reactor volume
- High abatement efficiency
  - Steam generator option for Cl₂ and F₂
  - SiC high temperature heaters
- Low NOx and CO
  - Lower operating temperature than “Burn-Wet” type
  - No fuel
- Various capacity models available
  - ISIS-I ~ ISIS-IV
ISIS-I & II Hardware
ISIS Hardware – Entry & Reactor

- 4 independent inlets
- 4 x 40mm entry
- CDA / Steam
High Performance SiC Heater

- SiC Heater 5.5kW × 6
- INCONEL600 Heater Housing

Fig. 1 Characteristics of resistance and temperature

Characteristic value (Rt/Ro):
- Ro......Resistance value at 1000°C
- Rt......Resistance value at each temperature
Quench section view between PM

- Reactor side:
  - Inconel shield
- Wetted path:
  - Teflon coated stainless steel
Air Curtain Cleaning System

Reactor view between PM

Sleeve N2  40LPM

Sleeve N2  0LPM
“Dry” Type – SDS Single & Twin

SDS

- HVM (high volume manufacturing) proven
  - Implant application
  - Low utility consumption
  - Simple construction

- High abatement efficiency
  - Various adsorbent media available
Media Capacity & DRE

- Abatement efficiency: Effluent concentration to non-detection level
- Media operation limits for full capacity utilization:
  - Maximum 0.02 m/second (0.02 m/second at 150 slm)
  - Maximum 2% target gas concentration (typical operating range < 1%)

<table>
<thead>
<tr>
<th>Media</th>
<th>Key Composition</th>
<th>Target Gas</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULTIMA-Sorb</td>
<td>Cu(OH)2</td>
<td>AsH3</td>
<td>100 l/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PH3</td>
<td>100 l/l</td>
</tr>
<tr>
<td>Sorbent A-1</td>
<td>Ca(OH)2</td>
<td>BF3</td>
<td>55 l/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>40 l/l</td>
</tr>
<tr>
<td>Sorbent A-2</td>
<td>FeCl3</td>
<td>Cl2, BCl3, HBr, HCl, F2, HF</td>
<td>50 l/l</td>
</tr>
<tr>
<td>Sorbent A-7</td>
<td>Ca(OH)2</td>
<td>HCl, HF</td>
<td>200 l/l</td>
</tr>
</tbody>
</table>
### Break-through Detection

<table>
<thead>
<tr>
<th></th>
<th>Hydride Series</th>
<th>Acid Series</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Gases</strong></td>
<td>AsH3, PH3, etc.</td>
<td>Cl2, F2, BF3, etc.</td>
</tr>
<tr>
<td><strong>Composition</strong></td>
<td>Metal Oxide &amp; Salt</td>
<td>Metal Oxide &amp; Salt</td>
</tr>
<tr>
<td><strong>Before Exposure</strong></td>
<td>![Before Image]</td>
<td>![Before Image]</td>
</tr>
<tr>
<td><strong>After Exposure</strong></td>
<td>![After Image]</td>
<td>![After Image]</td>
</tr>
<tr>
<td></td>
<td><strong>Reaction with Chloride</strong></td>
<td><strong>Reaction with Fluoride</strong></td>
</tr>
</tbody>
</table>
Durian

- HVM (high volume manufacturing) proven
  - Ideally suited for semiconductor etch PFC abatement
  - Low utility consumption

- High abatement efficiency
  - N2 plasma
  - Ceramic reactor
  - No fuel

- Energy savings operation ready
N2 Plasma
Catalyst Aided

- GST exclusive PFC catalyst lowers the decomposition temperature
  - For example, CF4 may be abated at <750°C

- RCO – Facility Level PFC Abatement
  - Combination of heat recovery and catalyst technology
  - Ultra-low energy consumption
  - >20 process tool coverage

- Zone Scrubber – Subfab Level PFC Abatement
  - Coverage for entire bay (10 etch tool effluents)
  - Energy efficient
  - <20 process tool coverage
Catalyst facilitates reaction by hydrolyzing PFC’s to HF and CO₂ at temperatures well below typical thermal oxidation

- \( \text{C}_2\text{F}_6 + 3\text{H}_2\text{O} \rightarrow \text{CO} + \text{CO}_2 + 6\text{HF} \)
- \( \text{CO} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2 \)

Decomposition PFC’s without Catalyst
- \( \text{CF}_4 \rightarrow 1120^\circ\text{C} \)
- \( \text{C}_2\text{F}_6 \rightarrow 842^\circ\text{C} \)
- \( \text{SF}_6 \rightarrow 800^\circ\text{C} \)
- \( \text{NF}_3 \rightarrow 300^\circ\text{C} \)

Decomposition PFC’s with Catalyst
- \( \text{CF}_4 \rightarrow 410^\circ\text{C} \)
- \( \text{C}_2\text{F}_6 \rightarrow 425^\circ\text{C} \)
- \( \text{SF}_6 \rightarrow 350^\circ\text{C} \)
- \( \text{NF}_3 \rightarrow 200^\circ\text{C} \)
Catalyst Performance

- Applicable for semiconductor PFC gas species

Temperature, °C

Conversion, %

- NF$_3$
- CHF$_3$
- SF$_6$
- CF$_4$
- C$_2$F$_6$
- C$_3$F$_8$
- c-C$_4$F$_8$

[PFC] = 1,000 ppm
[H$_2$O] = 3.5 %
Catalyst Performance (influent concentration)

- **Al₂O₃ based catalyst (M/Al₂O₃)**
- **Metal**: Ti, Zr, Co, Ni additives

Effect of concentration on SF₆ Light-off curve.

- [SF₆] = 1,000 ppm
- [SF₆] = 5,000 ppm
- [SF₆] = 10,000 ppm

Graph: Catalyst Performance (influent concentration)
Catalyst Performance (temperature & space velocity)

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>75.6</td>
</tr>
<tr>
<td>650</td>
<td>99.9</td>
</tr>
<tr>
<td>700</td>
<td>99.9</td>
</tr>
</tbody>
</table>

Space Velocity: 2500 h⁻¹, SF₆: 1500ppm, TOS: 5hr

<table>
<thead>
<tr>
<th>GHSV (h⁻¹)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>99.6</td>
</tr>
<tr>
<td>2000</td>
<td>99.9</td>
</tr>
<tr>
<td>3000</td>
<td>98.9</td>
</tr>
</tbody>
</table>

Temperature: 650°C, SF₆: 1500ppm, TOS: 5hr
Lab - Catalyst Performance Testing

**Temperature Effect**

- 650 °C-Cool: 96.2%
- 650 °C-Hot: 98.1%
- 700 °C: 99.7%
- 750 °C: 100.0%
- 650 °C: 98.4%

GHSV = 3000 h⁻¹
SF6: 1500 ppm

**SF6 Removal efficiency**

- Temp. = 650 °C
- GHSV = 3000 h⁻¹
- SF6: 3200 ppm
- HF: 1.6 ppm
- HCl: 93 ppm

- 1. SF6
- 2. SF6 + HF
- 3. SF6 + HF + HCl
- 4. SF6 +HCl
- 5. SF6
Pilot - Catalyst Performance Testing

<table>
<thead>
<tr>
<th>Specification</th>
<th>Burn &amp; Catalyst &amp; Wet Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>1CMM</td>
</tr>
<tr>
<td>Dimension</td>
<td>2500W X 2000D X 3000H</td>
</tr>
<tr>
<td>Utility</td>
<td></td>
</tr>
<tr>
<td>LNG</td>
<td>30LPM</td>
</tr>
<tr>
<td>H₂O</td>
<td>2 LPM</td>
</tr>
<tr>
<td>Power</td>
<td>220V, 8KW</td>
</tr>
</tbody>
</table>
PFC RCO/Zone System Block Diagram

Influent → Pre-Treatment (Wet) → Thermal Treatment (w Catalyst) → Post-Treatment (Wet) → Effluent

Bypass
“Burn-Wet” Type: DRAGON

Dragon LE/HE/HEX

- HVM (high volume manufacturing) proven
  - Ideally suited for semiconductor deposition processes
  - Virtually zero unscheduled downtime with DUO
  - Low utility consumption

- High abatement efficiency
  - Fuel provides reagent
  - Higher temperature compared to “Heat-Wet” type

- Dual stage combustion for low NOx and CO
  - Stage 1: Fuel rich for low NOx and high CO
  - Stage 2: 2\textsuperscript{nd} combustion for CO conversion

- Energy savings operation ready
Burn-Wet Improvement: Dragon LE

- **Dual Stage Combustion**
  - Higher temperature operation range
  - Separate control for NOx and CO

  **Stage 1**
  - O2 lean environment
  - Higher temperature operation vs. Gen 1

  **Stage 2**
  - O2 rich environment
  - 2\textsuperscript{nd} stage combustion for CO conversion

- **Benefits**
  - Wide range of application
  - Low NOx emissions

LNG+O\textsubscript{2}+CDA

Stage 1

Stage 2
Separate Control for CO

- Fuel/O2 Mix Settings: LNG 20 slm, O2 5 slm, Mix CDA 90 slm
- Stage 2 CDA for CO to CO2 conversion
GST Reactor Types

- Multi-stage Combustion Reactor (for Dragon LE & HE)
  - Independent control of NOx and CO
  - >99% NF3 DRE with <10 ppm NOx emissions

- Pre-heat Reactor (for Dragon HEX)
  - Heat recovery for >30% energy savings
  - CF₄ abatement capability
SWS-500

- HVM (high volume manufacturing) proven
  - Acid gas abatement
  - Low capital and low utility consumption

- Original “scrubber” for semiconductor industry
Larger “Wet” Type – Aqua & Aqua EP

Aqua

- HVM (high volume manufacturing) proven
  - Acid gas abatement
  - Low capital and low utility consumption

- Larger Capacity
  - 40~60 m³/min
  - EP option for fine particulate removal
Continuous Improvement

Service
Regional Support

- **North America**
  - **BAZM Solutions**
    Brian Kingston
    +1 408 887 6132
    sales@bazmsolutions.com
  - **GST America**
    Jason Smith
    +1 916 969 9829
    Jason_smith@gst-in.com

- **Head Quarters**
  - **GST – Project Management**
    SM Shim
    +82 10 9491 2675
    smshim@gst-in.com
  - **GST – Sales & Marketing**
    Jay Jung
    +1 408 338 7263
    jay_jung@gst-in.com
GST strives to provide **BEST PRACTICAL ABATEMENT** solutions

- Full product portfolio
- World wide reach
- Premier semiconductor abatement company
- GST stands behind our products and customers

GST is pleased to offer subfab solutions for North America customers

- Evaluations / qualifications
- Joint development and custom engineering
- Invitation to tour GST facilities and install base
Thank you
# Application Matrix - Deposition

<table>
<thead>
<tr>
<th>Process</th>
<th>Process Gas</th>
<th>Typical Concerns</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>PECVD SiH4</td>
<td>SiH4 / NH3 / N2O</td>
<td>Flammable effluent mix</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td>Hot N2 Heater jackets</td>
</tr>
<tr>
<td></td>
<td>NF3</td>
<td>Incompatible gases (clean and dep)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PECVD TEOS</td>
<td>TEOS / TEB / TEPO</td>
<td>Flammable effluent mix</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td>Hot N2 Heater jackets</td>
</tr>
<tr>
<td></td>
<td>NF3</td>
<td>Incompatible gases (clean and dep)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low k CVD</td>
<td>TMS / mDEOS / BCHD</td>
<td>Byproduct build-up and clogging</td>
<td>Dragon - HE</td>
<td>ISIS-II</td>
<td>Hot N2 Heater jackets</td>
</tr>
<tr>
<td></td>
<td>NF3</td>
<td>Flammable effluent mix</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incompatible gases (clean and dep)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SACVD, HDPCVD</td>
<td>TEOS / O3 / others</td>
<td>Byproduct build-up and clogging</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td>Hot N2 Heater jackets</td>
</tr>
<tr>
<td></td>
<td>NF3</td>
<td>Flammable effluent mix</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incompatible gases (clean and dep)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>SiH4 / WF6</td>
<td>Byproduct build-up and clogging</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td>Hot N2 Heater jackets</td>
</tr>
<tr>
<td></td>
<td>NF3 or ClF3</td>
<td>Flammable effluent mix</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incompatible &amp; reactive gases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitride</td>
<td>DCS / NH3</td>
<td>Byproduct build-up and clogging</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td>Hot N2 Heater jackets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flammable effluent mix</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Application Matrix - Etch, Implant, etc.

<table>
<thead>
<tr>
<th>Process</th>
<th>Process Gas</th>
<th>Typical Concerns</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poly</td>
<td>SiH4 / PH3 / CIF3</td>
<td>Highly toxic and flammable effluent</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incompatible &amp; reactive gases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductor Etch</td>
<td>Cl2 / BC13 / HBr / SF6 / CF4 / CHF3</td>
<td>Byproduct build-up and clogging</td>
<td>Durian</td>
<td>SWS-500</td>
<td>Hot N2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Toxic and corrosive effluent mix</td>
<td></td>
<td>Dragon – HE</td>
<td>Heater jackets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td>ISIS-II</td>
<td></td>
</tr>
<tr>
<td>Dielectric / Silicon Etch</td>
<td>NF3 / CF4 / SF6 / CHF3</td>
<td>Toxic and corrosive effluent mix</td>
<td>Durian</td>
<td>SWS-500</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 and GHG</td>
<td></td>
<td>Dragon-HEX</td>
<td></td>
</tr>
<tr>
<td>Implant</td>
<td>AsH3 / PH3 / BF3</td>
<td>Highly toxic and flammable effluent</td>
<td>SDS-500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epi</td>
<td>DCS / PH3 / AsH3 / SiH4 / H2</td>
<td>Highly toxic and flammable effluent</td>
<td>Dragon - LE</td>
<td>ISIS-II</td>
<td>Hot N2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High volume of flammable gases</td>
<td></td>
<td></td>
<td>Heater jackets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Byproduct build-up and clogging</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet bench</td>
<td>NH4OH / HCl / HF</td>
<td>Large exhaust volume</td>
<td>Aqua - EP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NH4OH and HCl fume byproduct</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>