Mass Production of GEM foils in Korea

July 6, 2018 @ ICHEP 2018, Seoul
Inkyu Park (University of Seoul) on behalf of MECARO
Company Overview

- **Company name**: Mecaro Co., Ltd.
- **CEO**: Lee, Jae Jeong
- **Date of establishment**: November 2000
- **Capital**: USD 4.61M (4.97 Billion Won)
- **Business area**: Development, manufacture and sales of semiconductor equipment related parts and chemicals
- **Main product**: Precursor and heater block for semiconductor
- **No. of employees**: 220 (as of December 31, 2017)
- **Capital**: USD 4.61M (4.97 Billion Won)
- **Location**
  - **Head office**: 103-14, Sandan-ro, Pyeongtaek-si, Gyeonggi-do, Republic of Korea (Songtan Industrial complex, Mogok-dong 439-5)
  - **2nd business location**: 261, Wonnamsandan-ro, Wonnam-myeon, Eumseong-gun, Chungcheongbuk-do, Republic of Korea (717 Wonnam Industrial Complex, Sangdang-ri)
  - **3rd business location**: 26-1, Daeyang-ro, Mokpo-si, Jeollanam-do, Republic of Korea (Ceramic center Production support building 105-1, Yeonsan-dong)
- **Homepage**: www.mecaro.com

Shareholders (as of December 31, 2017)

- **Largest Shareholder and others** (60.8%)
- **Major shareholders** (More than 1%) (10.7%)
- **Minor shareholder** (28.5%)
- **Total No. of outstanding shares**: 9,931,140

Revenue Trend

[Unit: 100 million won]

- 2000: 35
- 2006: 68
- 2007: 78
- 2008: 105
- 2009: 151
- 2010: 180
- 2011: 214
- 2012: 220
- 2013: 230
- 2014: 347
- 2015: 481
- 2016: 1,060

About MECARO
Wonnam technopark, Korea
Main products summary

- **Precursor** - chemicals used in thin film deposition in semiconductor manufacturing processes
- **Heater block** - a functional part that uniformly supplies thermal energy to a silicon wafer

**Pre-process**
- Wafer
- Diffusion
- Photo
- Etch
- CVD/ALD

**Post-process**
- Sawing
- Diebond
- Wirebond

**Precursor**
- Cap. Dielectric film (Cp-Zr/ZM40)
- Cap. Electrode (TiCl4)
- Low temperature Oxide (HCDS)
- α-Carbon (1-Hexene)

**Heater Block**
- Heater Block
- Susceptor
- Shower Head
Industry-leading R&D infrastructure and systematic structure
Securing high technological capability through continuous R&D investment

R&D personnel and organization status

Total number of employees 220

R&D 25.9%

Development of R&D personnel
[Unit: person]

<table>
<thead>
<tr>
<th>Year</th>
<th>Precursor development team</th>
<th>New business group</th>
<th>System development team</th>
<th>Research institute</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>19</td>
<td>57</td>
</tr>
<tr>
<td>2015</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>7</td>
<td>57</td>
</tr>
<tr>
<td>2016</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>17</td>
<td>57</td>
</tr>
<tr>
<td>2017</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>57</td>
</tr>
</tbody>
</table>

Major intellectual property rights
(patent rights: 22 cases, pending: 6 cases)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Content</th>
<th>Registration date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precursor</td>
<td>New organo-metallic compound containing zirconium metal and manufacturing method</td>
<td>2013.05.06</td>
</tr>
<tr>
<td>Heater Block</td>
<td>Chemical vapor deposition pedestal heater block</td>
<td>2009.12.29</td>
</tr>
<tr>
<td>Solar cell</td>
<td>CIGS thin film manufacturing method</td>
<td>2011.10.04</td>
</tr>
<tr>
<td>New business</td>
<td>Vaporizer for substrate processing equipment</td>
<td>2016.02.01</td>
</tr>
</tbody>
</table>
Expand to adjacent high value-added business utilizing core technology capability

**GEM technology**
- The principle of generating an electron avalanche by forming an electric field inside a small spherical fine hole
- State-of-the-art semiconductor technology application for processing hundreds of thousands of long spherical fine holes in a single piece of GEM foil (500x1000mm) for detecting particles with high precision.
- Secured price competitiveness by simplifying the production process, that allows mass-production of GEM

**CIGS thin film solar cell**
- Compared to existing PVD method, it consumes fewer raw materials and is easy to enlarge
- System construction cost is only 1/3 to 1/5 of PVD
- Suitable for mass production of flexible CIGS due to development of relative low-temperature process technology
- The result of our precursor synthesis technology and heater block manufacturing technology

Explore new engines
Mecaro produces GEM Foil to Korea CMS.
Korea CMS is participating to upgrade Muon system of CMS during LS2 and LS3 period.
<table>
<thead>
<tr>
<th></th>
<th>Single-mask</th>
<th>Double mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Cheap</td>
<td>Expensive</td>
</tr>
<tr>
<td>Mask alignment</td>
<td>No need (film)</td>
<td>Crucial (Glass only)</td>
</tr>
<tr>
<td>Pros &amp; Cons in size</td>
<td>Large size capable</td>
<td>Limited in size</td>
</tr>
<tr>
<td>Production method</td>
<td><img src="chart1" alt="Single mask diagram" /></td>
<td><img src="chart2" alt="Double mask diagram" /></td>
</tr>
<tr>
<td>Production process</td>
<td>Complicate</td>
<td>Simple</td>
</tr>
<tr>
<td>Production time</td>
<td>Long</td>
<td>Fast</td>
</tr>
<tr>
<td>Labor cost</td>
<td>Expensive</td>
<td>Cheap</td>
</tr>
</tbody>
</table>
Production chain

DFR Film laminator → Large Bipolar Exposure → DFR Film Developer → Cu layer etcher

Inspection & QC → Cleaner & Dryer → PI etching machine → Cleaner & Dryer

All facilities completed in 2013~2017
Large Bipolar Exposure
Quality control

Optical Inspection

Leakage current measurement

QC Long (24-hour leakage current measurement) assured before packaging and shipment.
• Outer hole sizes are 68 ~ 72 um. (design goal = 70um)
• Inner hole size are 48 ~ 52 um. (design goal = 50 um)
An example of GEM product
Readiness for order

Stacking 5 GEMs

Packing for a set of 5 GEMs
Various GEM products

135 x 175 mm²

300x300 mm²
Summary: GEM Foil Roadmap

- **2013Y**
  - ✓ Technical License agreement with CERN

- **2014Y – 2017Y**
  - Developed with **double side photolithography method**
  - ✓ 5x5cm/10x10cm/30x30cm: Developed in 2014
    - → 10x10cm: Developed and completed Quality Test with **CERN CMS** in 2014
      - **High gain & good uniformity obtained**
  - ✓ Provide GEMs to Institute for Basic Science (IBS) and some universities in 2016
  - ✓ **CMS GE1/1 (Large Size)**: Started to develop in 2016 and delivered in 2017
    - Successful Quality Test by **CERN CMS** in 2017

- **2018Y – 2023Y**
  - ✓ Developing application products of GEM detector in 2018
  - ✓ **35x43cm**: Produced to Institute for Basic Science in 2018
  - ✓ **CMS GE2/1**: Schedule to produce **456** Foils to **CERN CMS** from 2018 to 2021
  - ✓ **CMS ME0**: Schedule to produce **666** Foils to **CERN CMS** from 2021 to 2023
Future Plan for GEM

Our aim is to innovate to bring GEM’s new technology to people with our all capabilities, which significantly improves people’s life.


- **GEM Foil : Provide to CERN**
  - GE21 / ME0
  - About 1100 EA

- **Detector for Physics Experiment**

- **Medical Radiation Imaging**

- **Radioactive Waste Detector**

- **GEM Neutron Detector**

Visit the MECARO exposition booth in ICHEP2018 July 5-7 (COEX)
MECARO visit on July 7 (Sat)

The bus will leave at 9:00 am sharp in front of the main gate of ICHEP site.

09:00 - 10:30: Move to MECARO (expected transportation time is about 100min)
10:30 - 11:00: Reception
11:00 - 12:00: Visit to the MECARO GEM production site
12:00 - 12:30: CMS-KCMS-MECARO meeting and Q&A
12:30 - 14:00: Lunch
14:00 - 15:30: Return to ICHEP.
Thank you!

Head office
103-14, Sandan-ro, Pyeongtaek-si, Gyeonggi-do, Republic of Korea | Tel (031) 646-4400 | Fax (031) 663-4479

Eumseong office
261, Wonnamsandan-ro, Eumseong-gun, Chungcheongbuk-do, Republic of Korea | Tel (070) 4613-2700 | Fax (070) 8250-8232

Mokpo office
26-1, Daeyang-ro, Mokpo-si, Jeollanam-do, Republic of Korea | Tel (061) 270-5093 | Fax (061) 278-7811