New Horizons for PLD-based Technology of 2G HTS Tapes

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FFJ background, mission, and milestones

Previous company name  SuperOx Japan LLC (July 2011 - Dec 2022)

July 2022  Owned by Faraday 1867 Holding LLC, USA

Mission  Serve the world market with high quality 2G HTS tape, in large volume, at an affordable price. **Make GAm-scale production of high quality HTS tape a reality**

Milestones

2023  
Establish world-largest 2G HTS tape production factory: full production cycle 0.4 GA-m/year

2024  
Demonstration of PLD-based production capacity up to 1 GA-m/year
Rapid growth of production in last 2 years

4mm HTS Wire Production by SOJ

SuperOx Japan ranked 87th of TOP 500 Asia-Pacific High-Growth companies (2nd in the “Industrial Goods” category) according to Nikkei Asia – Financial Times - Statista

SuperOx Japan ranked in 2022 TOP 500 Asia-Pacific High-Growth companies Ranking
Different methods for HTS production

<table>
<thead>
<tr>
<th>PLD</th>
<th>MOCVD</th>
<th>RCE</th>
<th>MOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBAD/PLD Japan/USA</td>
<td>IBAD/PLD Japan</td>
<td>IBAD, RCE/PLD USA-Japan</td>
<td>RABiTS/ MOD USA</td>
</tr>
<tr>
<td>IBAD/PLD China</td>
<td>IBAD/PLD USA</td>
<td>IBAD/ MOCVD USA</td>
<td>IBAD/MOCVD USA-Japan</td>
</tr>
<tr>
<td>IBAD/ PLD SHS</td>
<td>IBAD/ MOCVD USA</td>
<td>ISD/RCE Germany</td>
<td>IBAD/MOD, Japan</td>
</tr>
</tbody>
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CCA-2023, University of Houston, UH Hilton, Texas, USA, 3-6 April 2023
Production plans for 2023
Standard production unit (300W laser + 2 chambers)

Potential to reach 1GA-m/year capacity with 10 units

R&D success

Monthly output, kAm

2021 2022 2023

0 5000 10000 15000

0 10 20 30

Next-gen production unit (600W laser + 2 chambers)

February – received equipment, April – started operation
If R&D successful, there’s potential to reach 1 GA-m/year with only 5 units
### Excimer lasers

<table>
<thead>
<tr>
<th></th>
<th>Tube Warranty</th>
<th>Tube Expected LT</th>
<th>Windows Warranty</th>
<th>Front and Rear Optics Warranty</th>
<th>Gas Warranty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEAP 130C</strong></td>
<td>2 bn</td>
<td>4 bn</td>
<td>100 Mio</td>
<td>1.5 bn</td>
<td>≥ 30 Mio</td>
</tr>
<tr>
<td><strong>LEAP 150C</strong></td>
<td>4 bn</td>
<td>8 bn</td>
<td>100 Mio</td>
<td>1.5 bn</td>
<td>≥ 30 Mio.</td>
</tr>
<tr>
<td><strong>LEAP 300 C</strong></td>
<td>5 bn</td>
<td>10 bn</td>
<td>100 mio</td>
<td>1.5 bn</td>
<td>&gt; 50 mio</td>
</tr>
</tbody>
</table>

Several LEAP lasers operate for > 15 bn pulses !!!
Scaling up PLD major raw materials (PLD targets)

R&D focus: Optimization of target size and sputtering
Repolishing and Recycling
Production in house
Maximum production length and Ic x L performance

- Ic x L > 400,000 Am
- Tape length – 736 m;
- Average Ic = 631 A

To reach 0.4GA-m/year capacity - 1000 tapes will be required
For 1GA-m/year - 2500 tapes per year
In 20 years from 1 cm$^2$ wafers to 500 km batch
FFJ HTS tapes for fusion: large-scale supply

Min $J_e \geq 600 \text{ A/mm}^2$
5% $< \text{min}$

Av. $J_e \geq 750 \text{ A/mm}^2$

Av. $J_e \geq 980 \text{ A/mm}^2$
delivered in 2022

Actual measurement results shown
~ 1000 km of tape on plot

3000+ km of tape supplied:
statistical QA, sampling tests

R&D in progress
new chemistry
superior processing
cost reduction

CCA-2023, University of Houston, UH Hilton, Texas, USA, 3-6 April 2023
Excellent state-of-the-art in-field properties

New tape performance almost doubled compared to the standard production process

$I_c$ (20K,20T) >350A/4mm, $J_{c,e}$ (20K,20T) >1700A/mm²
Learning curve: more production → lower price

- Fusion creates demand, promotes capacity; large volume drives the cost down
- HTS price will catch LTS with another 10-fold volume increase
- Other applications will benefit (accelerator magnets, cables etc.)
FFJ occupies 2,000 m², employs 50, operates 24/7
New equipment for 2023 scale up is arriving

Chambers
Optical boxes
Chillers
Lasers

Laser Slitting

QA
Copper plating
QA

Tapestar XL HF
Special design by THEVA
- subcooling to 67K
- external field 1.0T
Currently semi-automatic
Fully automatic in the future

Automatic Quality Inspection System
Image Recognition to Find Defects

Thickness, um
Length, m

Reel-to-Reel Thickness Evaluation

UV solid state laser
Slitting speed 100 m/h
Possibility of scribing

Reel capacity: ~2,000 m x 3
Max tape speed: 90 m/h x 3

New equipment for 2023 scale up is arriving

Chillers
Optical boxes
Lasers

Laser Slitting

QA
Copper plating
QA

University of Houston, UH Hilton, Texas, USA, 3-6 April 2023

Presentation given at Coated Conductors for Applications Workshop, Houston, TX, USA, April 2023.
Multi GA-m factories vision (mid-2020’s)

Fits well into standard logistics center

<table>
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<th>Unit Area</th>
<th>Capacity (GA-m/yr)</th>
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<tr>
<td>2500 m²</td>
<td>0.5 GA-m/ year</td>
</tr>
<tr>
<td>5000 m²</td>
<td>1.0 GA-m/year</td>
</tr>
</tbody>
</table>

We are up to build more modular plants as demand unveils
Acknowledgement to FFJ team

Growing team of over 50 people from 7 countries

Creative, Young and Mobile