Turbine Blade Coating
EB/PVD Production Systems
**EB/PVD Production Process**

Electron Beam Physical Vapour Deposition (EB/PVD) of Thermal Barrier Coatings (TBC)

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**Benefits of TBC**

- TBC absorb high thermal stress and enable higher turbine operating temperatures
  - Reduced fuel consumption
  - Higher efficiency
  - Longer turbine life-time
- TBC have a broad application range in
  - Aerospace
  - Power generating units

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**Benefits of EB/PVD**

- EB/PVD produces superior coating quality thanks to
  - Homogeneous cloud of vapour responsible for
  - Controlled thickness distribution of layers with
    - Superior dendritic structure and
    - Firmly anchored roots and
    - Smooth surface properties
- EB/PVD is exclusively approved in aerospace for high temperature turbine blades and vanes
  - The high performance electron beam evaporates metals as well as ceramics
  - Bond, diffusion and thermal barrier coatings
  - can be produced in a step by step process
  - With high deposition speeds

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The EB/PVD process is virtually exclusively approved in aerospace because of its unique structure
High Volume Production Systems

XXL Coater
Throughput of turbine blades up to 200,000 pcs/p.a. coated with YSZ*

The SL XXL Coater
with 1 Feeder
The starting model into mass production with pilot size capacity

- Large chamber volume and bigger gate valves enable coating of bigger parts
- Handling of 4 axes in 1 feeder

The modular design allows further extensions
- e.g. retrofit to a 2-feeder coater is possible

The DL XXL Coater
with 2 Feeders
Production system with two loading stations and medium size capacity

- Embedded are 40 years of experience and dozens of references
- Coating of blades and vanes

The DTL XXL Coater
with 4 Feeders
The top model of the XXL product line

- The four feeders
- Enable continuous mass production of turbine components with
- High throughput and efficiency

*Yttria Stabilized Zirkonia
The new SMART Coater — Proven components

Based on ALD’s approved standard and XXL concepts, the new SMART Coater incorporates their proven components:

- Highly reliable EB guns
- Vapour cloud management
- Controlled part movements
- Sophisticated quality control

New features:

- Short campaign times and
- Small investment costs
- High part flexibility
- Small floor space requirements / no pit
- One man operation and service
- Small volumes

Further options:

- 2 layer coating systems (2 crucibles)
- Multi layer coating systems (special crucible)
- Metal coatings
- Advanced layer monitoring
  - By integration of a Residual Gas Analyzer in coating chamber
- Advanced quality management systems
EB/PVD Systems from ALD

ALD – Solution provider with market leading EB/PVD technology

- First EB/PVD system introduced already in the 1960’s
- Dozens of systems are installed in the field
- ALD offers a complete model range
  - From XXL Coater for mass production
  - Up to SMART Coater for repair/ R&D/ pilot production

Corporate features of ALD’s EB/PVD systems

1. High coating quality by fully reproducible control over vapour cloud and parts movements
   - Computer controlled scan of the electron beam over the molten pools (ECOSYS)
   - Optimal rotating and tilting of parts in the vapour deposition cloud

2. Heating with advanced graphite heater
   - Accurate pressure control during preheating

3. Shortest down time by fast evacuating/venting cycles
   - Rough pumping by mechanical pumps
   - Fine pumping by high performance diffusion pumps
   - Dynamic seal pumping

4. Sophisticated quality control
   - Identification, pre- and post- weighing of parts
   - Recipe handling and quality reporting
   - Integration into host computer environment

5. Proven electron beam gun design for high performance and reliability
   - Double pressure stage pumping
   - Pressure control at gun pressure stage
   - High beam power thanks to proprietary HV transformers
### Typical Technical Parameters

<table>
<thead>
<tr>
<th></th>
<th>SMART COATER</th>
<th>2-FEEDER XXL COATER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total evaporation power installed:</td>
<td>1 EB-Gun 250 kW</td>
<td>2 EB-Guns, 500 kW total</td>
</tr>
<tr>
<td>Coating uniformity:</td>
<td>&lt; ± 10 % of the average deposited thickness for planar panels over the length of the coating area</td>
<td></td>
</tr>
<tr>
<td>Coating window:</td>
<td>210 x 140</td>
<td>420 x 140</td>
</tr>
<tr>
<td>Substrate temperature/Coating:</td>
<td>max. 1.000 - 1.100</td>
<td>max. 1.000 - 1.100</td>
</tr>
<tr>
<td>Substrate temperature/Preheating:</td>
<td>550 to max. 1.200 adjustable</td>
<td></td>
</tr>
<tr>
<td>Ingot Capacity</td>
<td>2 m</td>
<td>20 m</td>
</tr>
</tbody>
</table>

### Typical Dimensions

<table>
<thead>
<tr>
<th></th>
<th>SMART COATER</th>
<th>2-FEEDER XXL COATER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width, approx.:</td>
<td>7.1</td>
<td>12</td>
</tr>
<tr>
<td>Length, approx.:</td>
<td>8.4</td>
<td>20</td>
</tr>
<tr>
<td>Height, approx.:</td>
<td>4.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Weight, approx.:</td>
<td>33</td>
<td>90</td>
</tr>
<tr>
<td>Installed Power:</td>
<td>500</td>
<td>1400</td>
</tr>
<tr>
<td>Cooling water:</td>
<td>75</td>
<td>125</td>
</tr>
<tr>
<td>No of floor levels</td>
<td>Single</td>
<td>Dual</td>
</tr>
</tbody>
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