Motivation
- γ-titanium aluminides show superior mechanical properties at high temperatures
- Large scale application of these alloys is still hindered by high material cost
- TiAl is currently produced by VAR from titanium sponge, aluminium and master-alloys
- Challenges in today’s production include homogeneous alloying and the high price of materials
  - An alternative processing route was designed and has reached pilot scale, starting from readily available, cheap raw-materials.

Flowchart

- Raw materials: TiO₂ pigment, alloying oxides, Al powder, booster
- Aluminothermic reduction
  - Liquid, homogeneous metal-melt
- In-line-casting
- Raw γ-TiAl electrode
- Calcium feed
- Deoxidation by PESR
- Deoxidized γ-TiAl ingot: Ø 160 mm, 50 kg

PESR results

- Characterisation of obtained ATR electrodes

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>wt.% Ti</td>
<td>46.58</td>
<td>44.73</td>
<td>47.46</td>
<td>47.48</td>
<td>47.38</td>
<td>47.49</td>
<td>47.96</td>
<td>48.35</td>
</tr>
<tr>
<td>wt.% Al</td>
<td>27.41</td>
<td>28.20</td>
<td>26.75</td>
<td>27.30</td>
<td>23.35</td>
<td>27.43</td>
<td>27.13</td>
<td>26.30</td>
</tr>
<tr>
<td>wt.% Nb</td>
<td>16.66</td>
<td>16.26</td>
<td>17.34</td>
<td>17.16</td>
<td>17.04</td>
<td>17.16</td>
<td>17.33</td>
<td>17.08</td>
</tr>
<tr>
<td>wt.% C</td>
<td>0.17</td>
<td>0.092</td>
<td>0.122</td>
<td>0.071</td>
<td>0.12</td>
<td>0.076</td>
<td>0.087</td>
<td>0.075</td>
</tr>
<tr>
<td>wt.% O</td>
<td>1.69</td>
<td>2.57</td>
<td>1.36</td>
<td>1.19</td>
<td>1.85</td>
<td>1.14</td>
<td>0.69</td>
<td>1.34</td>
</tr>
<tr>
<td>pow H</td>
<td>132</td>
<td>75</td>
<td>39</td>
<td>68</td>
<td>108</td>
<td>90.5</td>
<td>59</td>
<td>56</td>
</tr>
</tbody>
</table>

Modelling for PESR control

- slag system: CaF₂ - CaO – Ca₂Al₂O₄
- deoxidation and formation of CaO

\[
\text{[TiO]} + \text{[O]} + \text{[Ca]} \rightarrow \text{[Ti]} + \text{[CaO]} + \text{[CaF₂]}
\]

- slag temperatures ~1700°C, strong reducing conditions, fluorine melt
- no possibility at present for on-line measurement of Ca and/or O activity
- control of slag chemistry by modeling using equilibrium calculations and mass balancing

Conclusions
- IME proves a concept for direct TiAl production starting with aluminothermic reduction of pigment.
- Oxygen uptake during ATR could easily be reduced from 16,000 ppm to 2000 ppm by PESR
- Process optimisation by adjusting Ca-feed aims on final oxygen contents of <500 ppm
- Inevitable Ca uptake amounts to 1000 ppm and has to be removed by final VAR
- TiAl cost can be reduced by factor 2-3

Contact: Prof. Dr.-Ing. B. Friedrich
IME Process Metallurgy and Metal Recycling
RWTH Aachen University
Intzestr. 3, 52056 Aachen, Germany
Phone: +49 (0)241 80 95850
e-mail: bfriedrich@ime-aachen.de