Recycling of silicon from photovoltaic production sludge

**Motivation:**
- Global warming and CO₂-emission lead to a stronger usage of alternative energies like the photovoltaic.
- Over 90% of present solar cells are manufactured on the basis of crystalline silicon.
- SoG-Si production capacities are limited and prices high up to 200 US$ / kg (spot market).
- The wafer cutting process generates approx. 34% of Si losses in form of fine Si-powders in a sludge → high financial losses.

**Process idea:**

**Sludge**
(Si / SiC / metallic impurities / coolant lubricant)

- **Physical conditioning**
- **Leaching with hydrochloric acid**
  → Fe, Cu, Zn
- **Pelletising**
  Binder: sodium silicate
  Additive: SiO₂
- **Melting**
  Aggregate: EAF
  Crucible: graphite
  Additive: CaO
- **Refining of silicon**
  Techniques: evaporation, gas purging, crystallisation

**Result:**
- Turning a waste to product - utilisation of the sludge as "new" feedstock for production of upgraded silicon.

**Sludge characterisation**

<table>
<thead>
<tr>
<th></th>
<th>Si</th>
<th>SiO₂</th>
<th>SiC</th>
<th>Fe</th>
<th>Cu</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>~41%</td>
<td>~7.5%</td>
<td>~45%</td>
<td>~6.5%</td>
<td>&lt;0.5%</td>
<td>&lt;0.05%</td>
<td></td>
</tr>
</tbody>
</table>

**Si production in EAF - main reactions:**
- y·SiO₂ + SiC = (2-y)·Si + (2y-1)·SiO + CO
- SiO + SiC = 2 Si + CO → risk of Si losses

**EPMA Analysis of silicon**
- Complete reaction of SiC with SiO₂ to Si
- Segregation of the impurities at the grain boundaries

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