B4: Phase changes in liquid metals for direct energy conversion.

**Alkali Metal Thermo-Electric Converter (AMTEC)**

N. Diez de los Rios Ramos, L. Biergangs, P. Guiffard, A. Onea, W. Hering, R. Stiegitz

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**Alkali Metal Thermo-Electric Converter (AMTEC)**

- Direct conversion of heat to electricity
- Working fluid/vapor: sodium
- Key process: $\Delta p$ across BASE
- High expected efficiency (~40%)

**Issues:**

- Ceramic-metal joint
- Electrode coating
- Overvoltage losses
- Power degradation

**AMTEC electrodes**

Challenges:

- Good electrical conductivity
- Good physical bond to BASE
- Low or neutral reactivity against Na and BASE
- High T resistant (<1000°C, corrosion resistant)
- Slow grain growth

**Similar CTE with BASE (7.2x10^-6 K^-1)**

<table>
<thead>
<tr>
<th>Electrode</th>
<th>$\rho_e$ (25°C)</th>
<th>Melting point</th>
<th>CTE (25°C)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mo</td>
<td>5.5</td>
<td>2623°C</td>
<td>5.2</td>
<td>Rapid grain growth &gt; 827°C Reaction Na $\rightarrow$ Na$_2$Mo$_4$O$_7$</td>
</tr>
<tr>
<td>TiN</td>
<td>~37</td>
<td>2930°C</td>
<td>9.4</td>
<td>Reduced perf. vs. Mo. Reaction with Mn. Cr. Large power loss</td>
</tr>
<tr>
<td>TiC</td>
<td>~150</td>
<td>3160°C</td>
<td>7.4</td>
<td>Chemically stable. No long time experience</td>
</tr>
<tr>
<td>TiB$_2$</td>
<td>20</td>
<td>3230°C</td>
<td>7.2</td>
<td>Moderate perf. No long time experience</td>
</tr>
<tr>
<td>NbN</td>
<td>137</td>
<td>2573°C</td>
<td>10.1</td>
<td>Chem. stable vs Na, BASE No long time experience</td>
</tr>
<tr>
<td>Rh/W</td>
<td>41.3</td>
<td>W 3422/Rh 1964</td>
<td>W 4.2/Rh 8.4</td>
<td>Low power loss. Diffusion Rh$\rightarrow$Ni. Chemically stable, Expensive</td>
</tr>
<tr>
<td>PtW</td>
<td>~65</td>
<td>Pt 1768°C</td>
<td>Pt 9</td>
<td>Lifetime ~7 yr. Reaction with Mn from steel. Expensive</td>
</tr>
</tbody>
</table>

**Status AMTEC Laboratory**

- Ceramic to metal joint developed
- Ceramic coating developed
- Cooling system for AMTEC cell built
- Trace heating system designed
- Current collector structure analyzed
- Na melting device built
- Na-tank filled with 3 liter sodium
- Na-level sensor tested (250 °C)
- AMTEC integration unit designed and under construction
- Optical analysis of coating started (SEM, TEM)

**Current collector – Preliminary tests**

- Current collector: inner fine structure + outer corset
- Tested combinations:
  3 outer corset vs. 9 inner fine structure variations
- Best combination: SS mesh with Cu wires + Cu
- Electrical resistance reduced to 1/8th of former results*
- Next step: integration of cathode + effect of porosity

**Na-level sensor – Preliminary tests**

- Simultaneous measurement of Temp. & Na-level
- Fast response
- No remnants (250 °C)
- Thick oxide layer perturbs measurements

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* F. Huber, Interner Bericht IRE 4.1059.90, Elektroden test 8, 1990