Karlsruhe Institute of Technology
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HELMHOLTZ ASSOCIATION
LIMTECH Alliance and HEMCP

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

Alkali Metal Thermo-Electric Converter (AMTEC)

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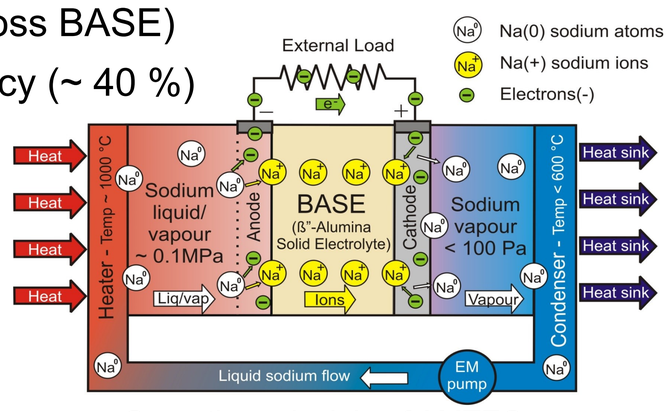
Alkali Metal Thermo-Electric Converter (AMTEC)

- Direct conversion of heat to electricity
- Working fluid/vapor: sodium
- Key process: (Δp across BASE)
- High expected efficiency (~ 40 %)
- Issues:
  - Ceramic-metal joint
  - Electrode coating
  - Overvoltage losses
  - Power degradation

$Na \rightarrow Na^+ + e^-$



Operation principle of AMTEC

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 (7.2×10^{-6} K^{-1})

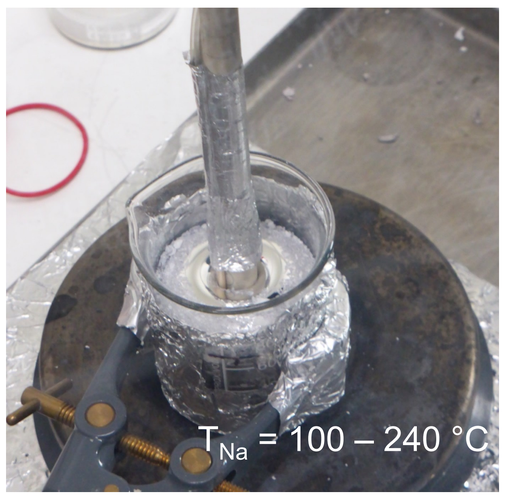
Electrode	ρ_{el} (25°C)	Melting point	CTE (25°C)	Remarks
	10^{-8} Ωm	°C	10^{-6} K^{-1}	
Mo	5.5	2623	5.2	Rapid grain growth > 827°C Reaction Na → Na_2MoO_4
TiN	~37	2930	9.4	Reduced perf. vs. Mo. Reaction with Mn, Cr. Large power loss
TiC	~150	3160	7.4	Chemically stable. No long time experience
TiB_2	20	3230	7.2	Moderate perf. No long time experience
NbN	137	2573	10.1	Chem. stable vs Na, BASE No long time experience
RhW	41.3	W 3422 Rh 1964	W 4.2 Rh 8.4	Low power loss. Diffusion Rh→Ni, Chemically stable, Expensive
PtW	~65	Pt 1768	Pt 9	Lifetime ~7 yr. Reaction with Mn from steel. Expensive

Na-level sensor – Preliminary tests

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

Na-level sensor

Oxide layer thicknesses



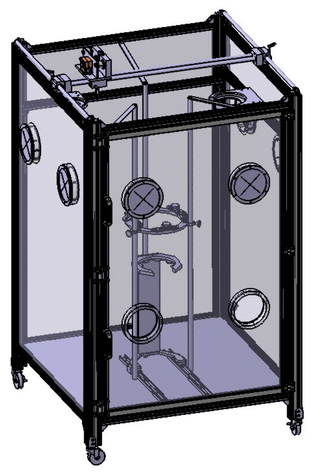
Na-level measurements

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)

AMTEC Test cell

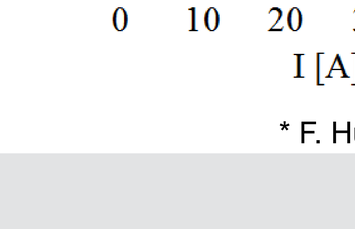
Na-melting device



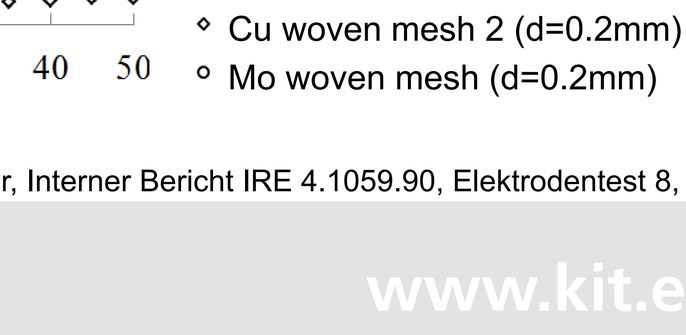
AMTEC integration unit

Current collector – Preliminary tests

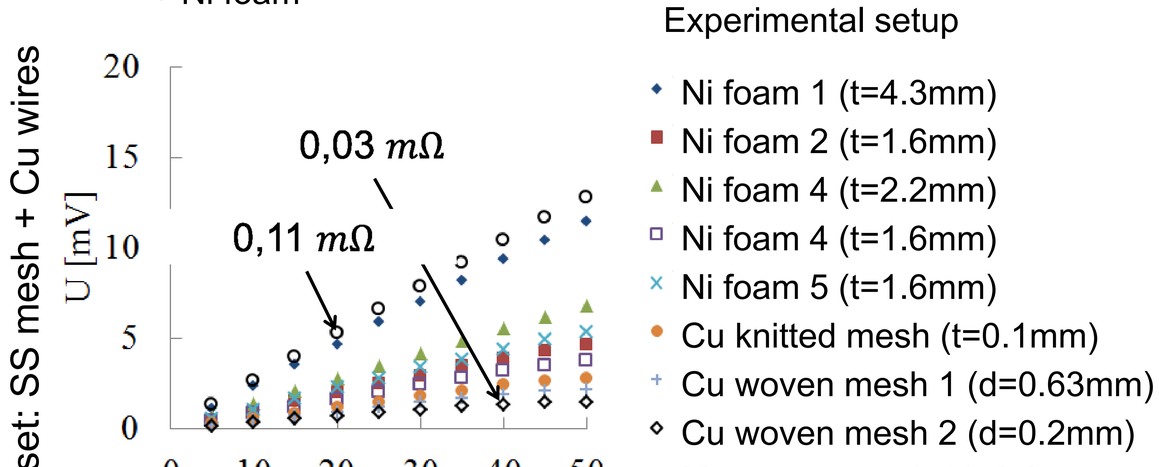
- Current collector: inner fine structure + outer corset
- Tested combinations:
  3 outer corset vs. 9 inner fine structure variations
- Best combination: SS mesh with Cu wires + Cu
- Electrical resistance reduced to 1/8th of former results*
- Next step: integration of cathode + effect of porosity



SS mesh with Cu wires + Ni foam



Experimental setup



* F. Huber, Interner Bericht IRE 4.1059.90, Elektrodentest 8, 1990