



LIMTECH Alliance and HEMCP:
Helmholtz Energy Materials
Characterization Platform

Institut für Neutronenphysik und Reaktortechnik

Anlagenentwicklung, Systemdynamik und Sicherheit



B4: Phase changes in liquid metals for direct energy conversion

Alkali Metal Thermal to Electric Converter (AMTEC)

N. Díez de los Ríos, A. Onea, M. Lux, W. Hering, J. L. Palacios, R. Stieglitz

Project status

- Test facility currently in the construction phase (acquisition phase finished; components in fabrication)
- Infrastructure of the AMTEC laboratory available
- Optical laboratory available for ceramic examination
- First attempts for sputtered electrode achieved

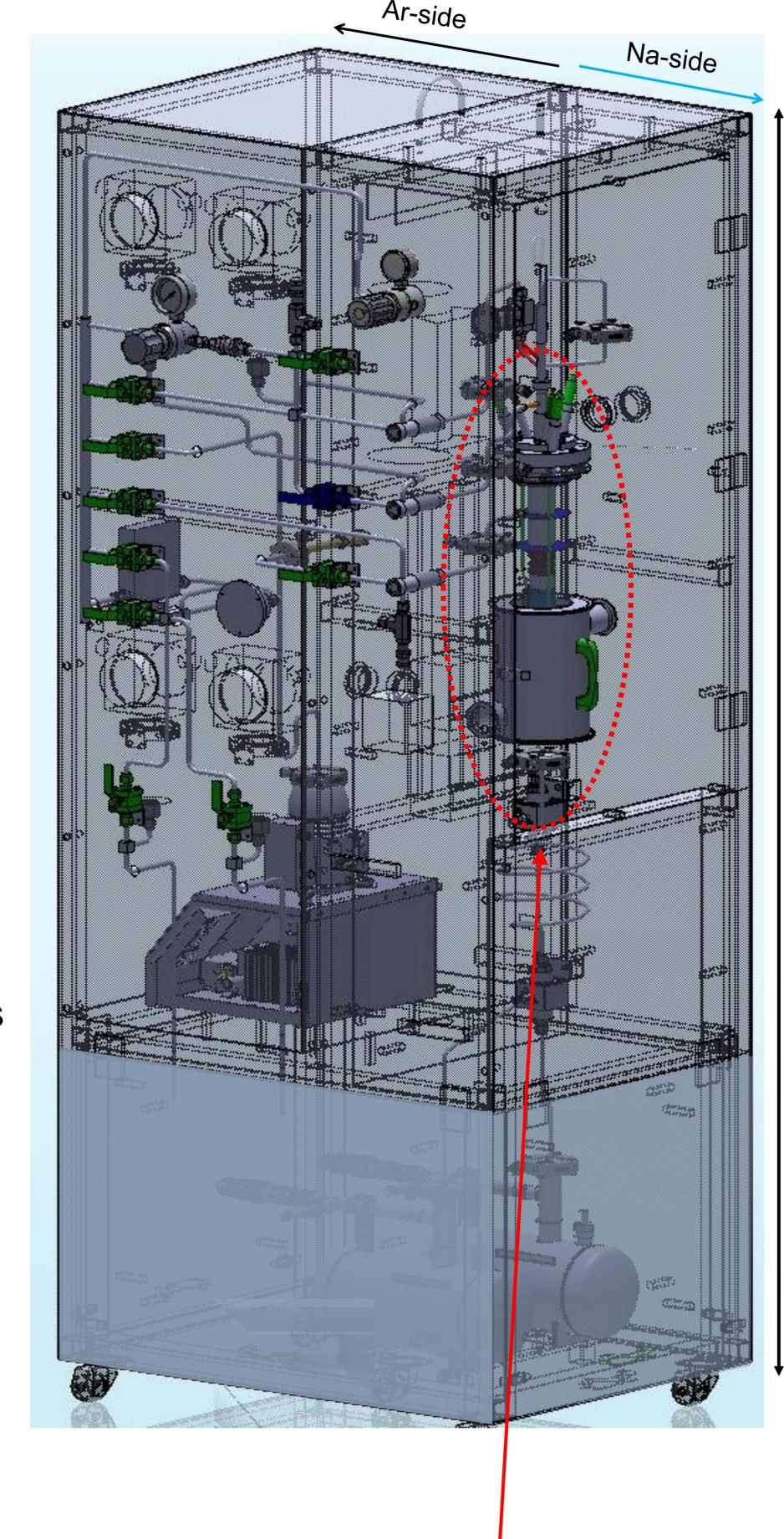
AMTEC TEst FAcility (ATEFA)

- Compact design
- Control Na-flow and pressure trough Ar $(p_{Ar} \& \dot{m}_{Ar})$
- Na-side separated from Ar-side
- Separable cell and storage tanks
- Safety aspects:
 - Na-side isolated in a metallic containment
 - In case of power loss (PC) manual control possible
 - Highest pressure 1.5 bara
 - Metallic tub for Na collection
 - In case of fire Na containment will be floated with Ar
 - Tanks tested to overpressure

AMTEC @ INR
0.4 – 1.2 V
$0.5 - 1.5 \text{A/cm}^2$
0.5 - 1.5 W/cm ²
~ 20 %
600 – 1000 °C
10 Pa – 0.1 MPa

Main goals 2014

- Set into operation: November 2014
- Ceramic-metal joining
- Sputtered electrode
- Analysis of the ceramic surface
- CO₂ cleaning of the ceramic
- First measurements
- Proposals for design optimization
 Improved technology



Ceramic-

metal brazing

Condenser

(air cooled,

250 – 450 °C)

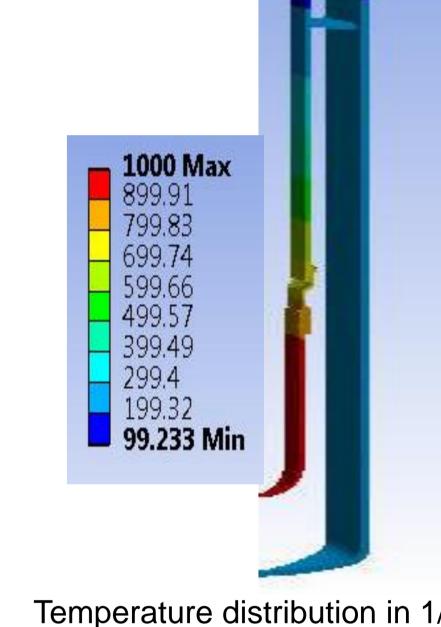
Heater

(1000 °C) ·

Safety analysis

- Temperature and stress distribution in cell obtained (steady state and transient analysis)
- No failure at working conditions
 (1.5 bar, 1000 °C) → safe design
- Highest stresses in BASE-Nb joining
 → possible failure at ≥ 6 bar
- Cooling under forced convection (transient) → no failure
- High ΔT along BASE → no failure

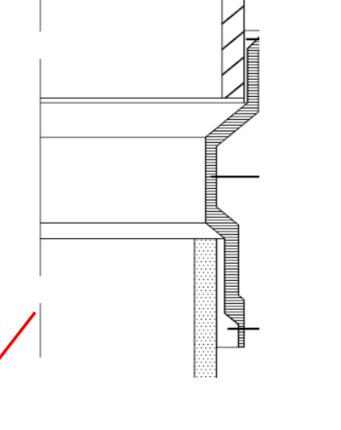




Temperature distribution in 1/8 of the cell [°C]. Steady state.

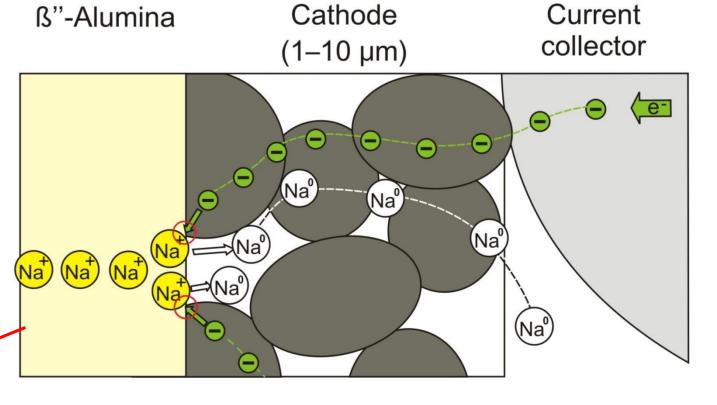
AMTEC test cell

Ceramic to metal joining



- New sealing materials (active brazing alloy)

Electrode (Cathode) and current collector



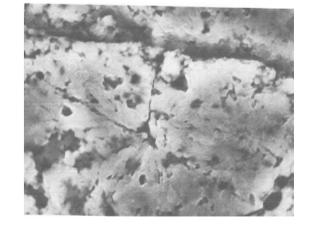
- Magnetron sputtered cathode
- Grid / foam current collector

BASE (ß"-Alumina Solid Electrolyte)





Surface microcracks



Surface microcrack (Tennenhouse, 1975)