Electrical/Thermal Modeling of a Molten Salt Electro-Refiner

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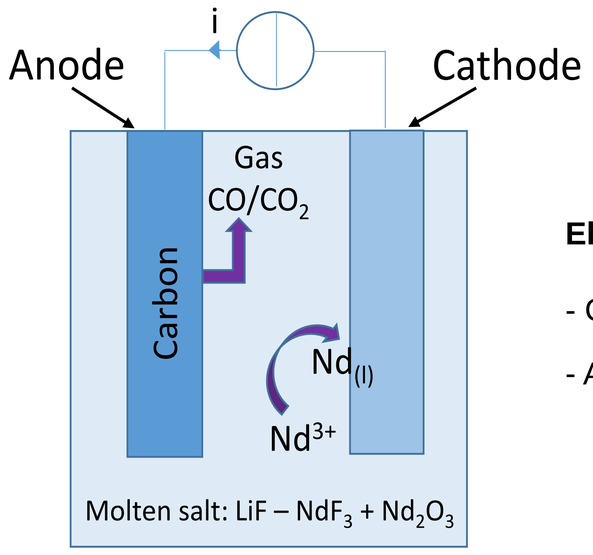
Introduction:

- ✓ High-temperature electrolysis in molten salt: electro-refining process for the recovery of metals such as rare earths.
- ✓ Current applied between cathode and anode → metal deposited as a solid or a liquid at the cathode + gas (CO/CO_2) evolving at the carbon-based anode.

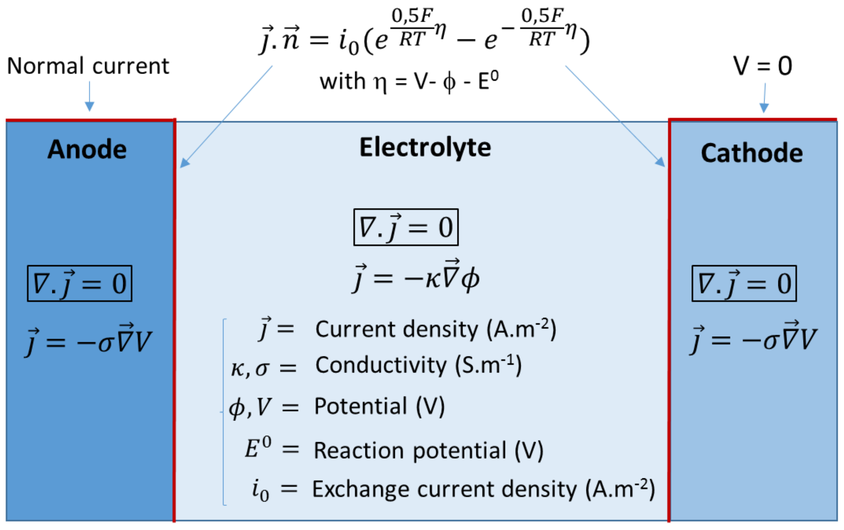


Electrode reactions:

- Cathode: $Nd^{3+} + 3e^- \rightarrow Nd_{(l)}$
- Anode: $C + O^{2-} \rightarrow CO + 2e^-$
  $C + 2O^{2-} \rightarrow CO_2 + 4e^-$

Computational Methods:

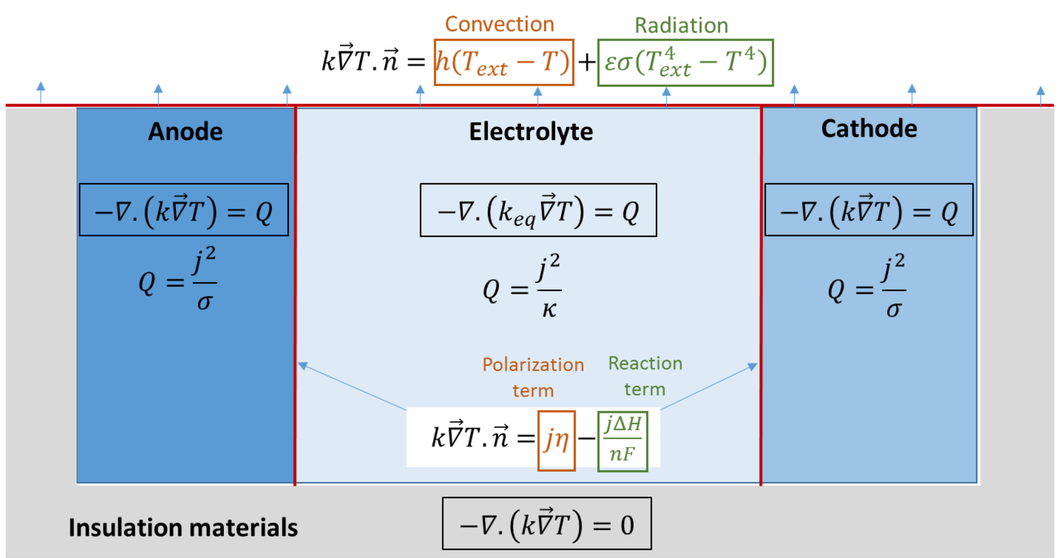
- **Electrical model:** secondary current distribution



- **Thermal model:** conduction-radiation model

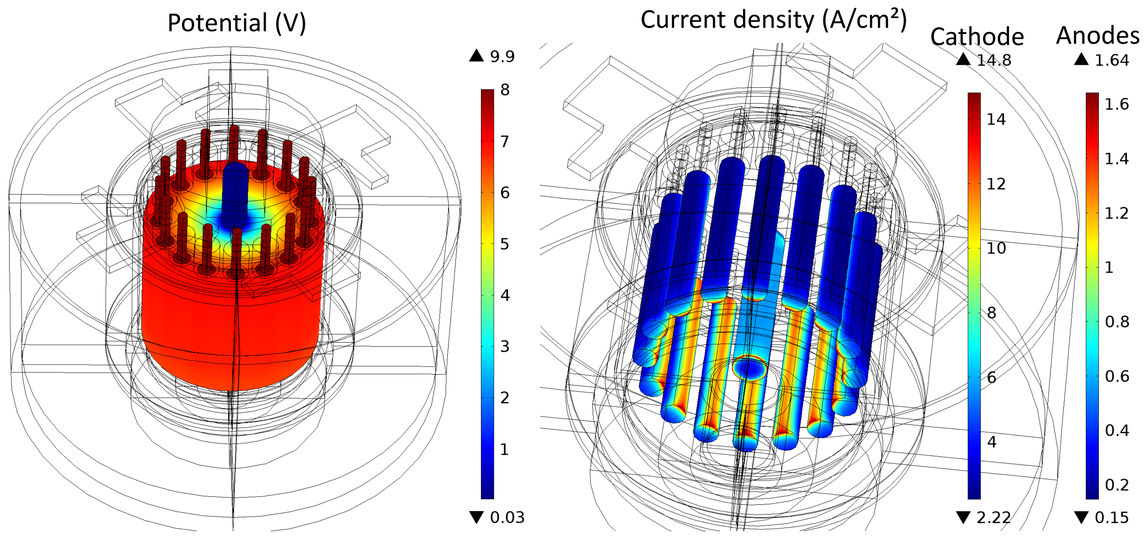
✓ **Heat sources:** Joule effect, reaction overpotentials, enthalpy of reactions

✓ Convective transport in the electrolyte → treated with an equivalent conductivity $k_{eq} > k_{real}$



Results:

- **Electrical model:**



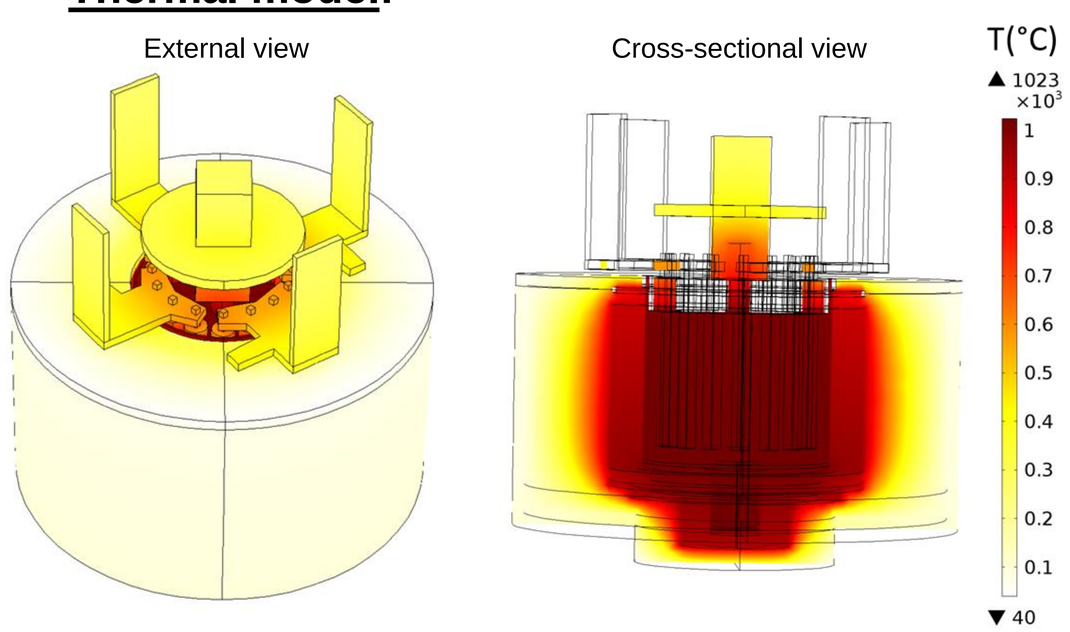
✓ Calculation of potential and current distributions within the cell

✓ Anodes mostly active on the faces regarding the central cathode

✓ Strong edge effect expected at the cathode

✓ Can be used for assessing the partial current associated with undesirable gas evolution (e.g. fluorinated gas)

- **Thermal model:**



✓ Calculation of the temperature distribution throughout the cell

✓ Heat losses: 75% by convection with surrounding air + 25 % by radiation

Conclusions:

✓ Simple electrical and thermal description of a complex multiphysics process.

✓ Models to be used for: optimizing of the cell design, selecting the best current/voltage specifications, controlling the operating temperature of the process.

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