Corrosion barriers processed by Al-electroplating and their resistance against flowing Pb-15.7Li

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**Motivation**

- Reduced activation ferritic-martensitic steels (RAFM) are considered as main structural material in future fusion systems, e.g. envisaged in the He-cooled liquid lead (HCLL) design. Thereby, these steels will be in direct contact with the breeding material Pb-15.7Li, which lead to strong corrosion attack of the structural material.
- Aluminum rich Fe-Al scales on RAFM steels are considered as promising corrosion barriers, which also offer T permeation reduction properties.
- Scale produced by Hot-dipping aluminization (HDA) exhibited some disadvantages in the past, and therefore electrochemical processes (ECA, ECX) were introduced, but have lack concerning corrosion protection data in flowing Pb-15.7Li.

**Electrochemical Al-deposition**

- Due to its high electronegativity (E<sub>B</sub> = 1.7 V vs. NHE) aluminum cannot be electrodeposited from common and well understood water-based electrolytes.
- Non-aqueous electrolytes are required for Al-deposition.
- Two different deposition processes were used for the production of test samples for corrosion testing in PICOLO loop (1st series: ECA, currently started 2nd series: ECX).
- Substrate: cylindrical Eurofer samples (diameter: 8 mm)
  - Toluene based electrolytes
  - Applied current density 10 mA/cm<sup>2</sup>
  - Deposition rate: 10-12 µm/h
  - Process temperature: 100°C
  - Al thickness on Eurofer test samples: ca. 20 µm
  - Al thickness easily adjustable

**Corrosion resistance of ECA coated Eurofer samples**

- Al based coatings made by ECA process protect Eurofer steel samples from corrosion attack in flowing Pb-15.7Li for up to 12000 h.
- Remaining scale thickness after 12000 h was above 35 µm.
- Inhomogeneous corrosion attack of the Fe-Al scale itself: "high" and "low" plateaus.
- Two values for radial material loss Δr<sub>RAD</sub> / Δr<sub>MAX</sub>.
- No clear dependency of material loss and exposure time was found (no control samples).

**Scale formation by heat treatment**

- Al-coated test samples need subsequent heat treating to convert the pure aluminum layers into the desired Fe-Al scales, responsible for the barrier properties.
- FeAl and α-Fe(Al) are the preferred phases, due to their ductility and hardness comparable to Eurofer steel.
- 1st series coated by ECA: Two-step heat treating procedure
- 2nd series coated by ECX: Optimized three-step procedure

**Outlook – First results from ECX coatings**

- Electrochemical Al-deposition of Fe-Al equilibrium phase diagram
- Heat treatment schemes
- Corrosion testing
- Conclusions
- References