VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Daniel Dietrich Stein**

The public defense will take place on **Monday 9th November 2026 at 4pm** in room **D.2.01** (Building D, VUB Main Campus)

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ELECTROCHEMICAL OXYGEN PUMPING AS AN IN-SITU PROBE FOR CORROSION IN LIQUID LEAD: VALIDATION OF THE METHOD AND INVESTIGATION OF DISSOLVED FE AND NI EFFECTS ON 316L STAINLESS STEEL

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Abstract of the PhD research

The compatibility of structural steels with liquid lead is a key materials challenge for the development of lead cooled fast reactors. Austenitic stainless steels such as 316L are considered candidate structural materials because of their established performance in nuclear systems. However, in liquid Pb at temperatures relevant for reactor operation, typically around 450–500 °C, these steels may be affected by liquid metal corrosion (LMC). Depending on the chemical condition of the liquid metal, corrosion can occur either by dissolution of alloying elements into the Pb or by oxidation at the steel surface. Significant amount of research has been conducted to address the corrosion mechanisms of austenitic steels exposed to Pb and Pb-based coolants, especially with regards to the role of oxygen. Despite important insights gained, gaps remain including the lack of in situ methods to measure corrosion during exposure, and the limited understanding of how dissolved metallic elements in liquid Pb influence the corrosion process.

This thesis investigates the use of an electrochemical oxygen pump (EOP) as both an oxygen control device and an in situ probe for corrosion in liquid Pb. This approach was first applied to pure metallic specimens of Fe, Cr, Mo, and Ta, demonstrating that the EOP can provide in situ information on corrosion reactions in simple liquid Pb systems. For 316L stainless steel exposed to static liquid Pb at 500 °C, the influence of dissolved Fe and Ni on the corrosion was then investigated. Fe dissolution contributes to potentially limiting the initiation sites of corrosion rather than influencing the propagation of corrosion. Addition of Ni shifted the corrosion behavior toward oxidation under the investigated oxygen concentrations. Although Ni selective leaching is a key feature of dissolution corrosion in liquid Pb, the overall dissolution corrosion process of 316L in liquid Pb also involves significant dissolution of Fe and Cr. Overall, this thesis demonstrates the early-stage capability of the EOP as an in situ probe of corrosion regime and liquid metal chemistry during exposure in Pb. The results also show that dissolved metallic elements strongly influence corrosion behavior, with Ni addition providing a potential route to suppress selective leaching and promote oxidation-dominated corrosion. These findings contribute to the development of chemistry-based corrosion mitigation strategies for liquid Pb systems.