MICRO-MECHANICAL APPROACH OF THE INTERGRANULAR STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEELS IN PWR ENVIRONMENT

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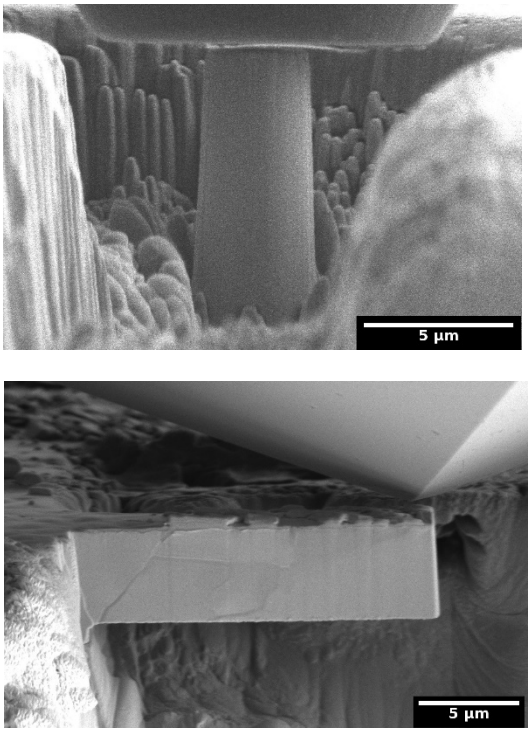
Key Words: Intergranular fracture, Micromechanical testing, IASCC, Austenitic Stainless Steel, Oxidation

Austenitic stainless steels are used in the nuclear industry to make the internals parts of Pressurized Water Reactors (PWR) such as baffle and former plates. Numerous Baffle-to-Former Bolts (BFB) intergranular failures have been reported as a result of Irradiation Assisted Stress Corrosion Cracking (IASCC) phenomenon. In order to predict the cracking of the grain boundary through a micro-mechanical approach, it is necessary to determine the intragranular mechanical behavior of the steel and the grain boundary strength.

Micro-compression tests of non-irradiated and 1dpa proton irradiated 304L micro-pillars have been performed to collect experimental data on the mechanical behavior at the single crystal scale. 3µm to 10µm diameter pillars are milled using Focus Ion Beam after EBSD mapping to determine the crystal orientations. The pillars are tested at 10nm/s using a FT-NMT04 nanoindenter with a diamond flat punch at room temperature. Finite Elements numerical simulations of the micro-compression tests are set up using a plastic crystal behavior law. A reverse optimization algorithm is used to match the experimental data and the simulations results, allowing accessing the behavior law parameters.



To obtain the cracking resistance of the grain boundary, experimental bending tests on micro-cantilevers containing an oxidized grain boundary have been carried out on a $FeCr_{12}Ni_{26}Si_3$ steel and on non-irradiated and 1dpa proton irradiated pre-oxidized 304L steel. Micro beams (15µm x 5µm x 5µm) containing a grain boundary have been milled using Focus Ion Beam. EBSD maps are used to access the crystal orientations of the bi-crystalline beams prior to the milling. Micro bending testing is carried out using a FT-NMT04 nanoindenter at room temperature. The load is applied on the free end of the beam with a Berkovich tip indenter at 20nm/s. Numerical simulations of these experiments have been performed to evaluate failure stresses of the grain boundary.

Figure 1 – Micro-mechanical testing experiments