Hydrides and fracture of pure zirconium and Zircaloy-4 at temperatures typical for loss-of-coolant accident conditions

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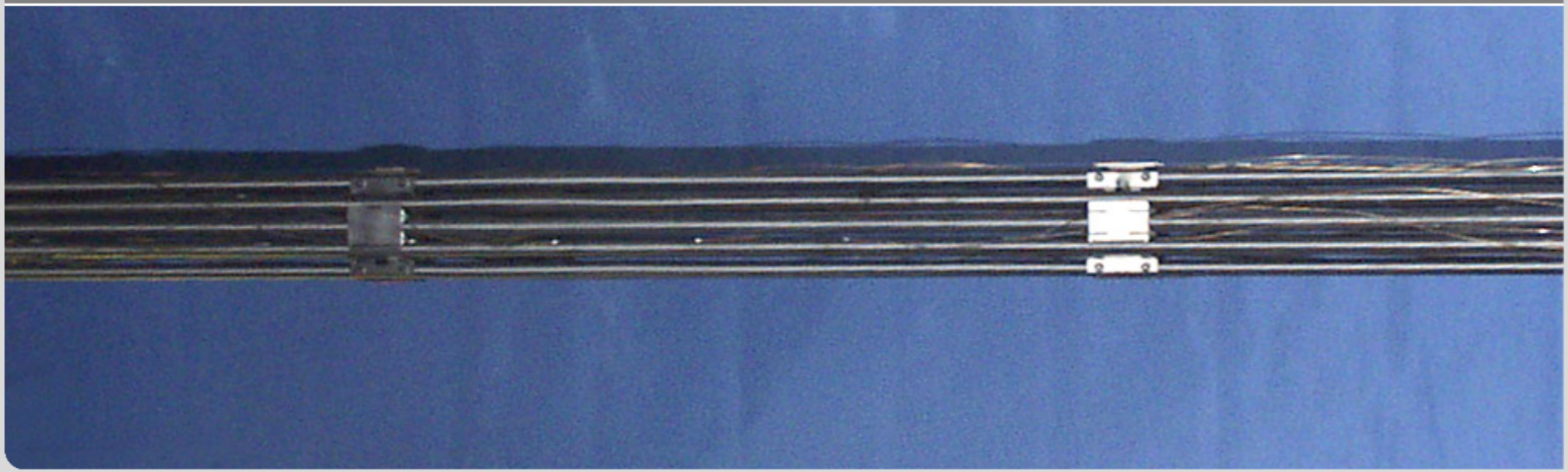

Objectives

- Electron back scattered diffraction (EBSD) analysis of annealed and hydrogenated specimens
- Zirconium hydrides detection
- Fracture surface investigation
- Progress in understanding the mechanism of embrittlement of Zirconium and its alloys
- Application to the results of QUENCH-LOCA test

Conclusion

- The XRD-analysis showed the presence of γ-, δ-phases of zirconium hydrides in all of performed experiments. With the increase of hydrogen content the hydride peak intensity was also increased. Simultaneously the hydrogen should be partially dissolved in the lattice which is indicated by increase of the lattice parameter “c”.
- The electron back scattered diffraction is up to date the best tool to detect hydrides and to build the phase distribution map and analyze grain orientation and microtexture. On the basis of the EBSD-analysis the difference in the hydride formation and growth between pure Zr and Zircaloy-4 is shown.
- Fracture surface analysis helps to understand the mechanisms of fracture of a brittle material after hydrogenation and hydride formation. There are the “islands” of retained plasticity detected. The scheme of such kind of plasticity and fracture was determined.
- The decohesion mechanism helps to understand the embrittlement of zirconium and Zircaloy-4 and other hydride forming alloys with hexagonal close-packed crystal lattice. The fact of the increase of the lattice parameter “c” allows to suggest that the decohesion mechanism accompanied by increscent internal stress due to hydrogen atoms inside the lattice could be responsible for cladding material destruction.
- The increased brittleness of some zirconium claddings after QUENCH-LOCA tests could be caused by hydrides which are distributed in the bulk of material. The thorough analysis of claddings after QUENCH-LOCA experiment is planned.