Contribution ID: **104** Type: **not specified**

High-resolution neutron imaging of hydrogen concentrations in nuclear fuel claddings

Tuesday, 29 October 2019 15:00 (30 minutes)

Hydrogen (hydrides) distribution in the nuclear fuel claddings can often be highly non-uniform because of the high mobility of hydrogen interstitial atoms, raising the risk to the nuclear fuel rod integrity. High-resolution neutron imaging provides an excellent non-destructive tool for the quantification of the hydrogen in nuclear fuel claddings consisting of zirconium based alloys. The spatial resolution of neutron imaging was recently extended down to the sub-5 micrometres domain in 2D and below 10 micrometres in 3D within the 'PSI Neutron Microscope'(NM) project. The high spatial resolution of neutron imaging (equivalent to the scale of the common width of zirconium hydride packets) together with the sub-10 wppm sensitivity to hydrogen is worldwide unique and enabled to reveal clearly the influence of cooling rate on the hydrogen distribution in inactive duplex nuclear fuel cladding rods. Above that, the prototype of a sample container allowing for neutron high-resolution radiography of highly radioactive samples was recently pilot tested using NM and allowed for the acquisition of the first-ever high-resolution neutron radiography of highly radioactive cladding rod that was operated in a (Swiss) nuclear power plant.

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Session Classification: Poster session

Track Classification: Poster