MODELLING IRRADIATION MICROSTRUCTURE OF ZIRCONIUM ALLOYS: APPLICATIONS TO LOCA AND BACK-END OF THE FUEL CYCLE

The overall objective of the project is to quantify the defects created by irradiation in Zr cladding, to determine their nature, how they evolve with time and how they can be annealed out by increasing temperature. The result is used to evaluate the macroscopic consequences on the cladding: growth and variations in ductility.

Zirconium alloys are used to clad the nuclear fuel where the fission reaction occurs. They are corroding, creeping and subjected to intense neutron irradiation. This high flux creates numerous point defect in the metal (vacancies, interstitials, clusters) which evolves with time and temperature. In zirconium alloys they cluster in dislocation loops which in turn impact greatly the mechanical properties as well as the dimensions of the cladding.

EDF has long been working to enhance its knowledge of irradiation defects in Zr claddings since it is of prime importance to assess the state of the cladding in the various conditions encountered by a fuel rod during the lifetime cycle (normal operation but also transportation or storage) or which must be taken into account in the safety case (design basis accident such as Loss Of Coolant Accident).

The PhD project proposed is based on modelling. The student will have to cope with density functional calculation, Monte Carlo modelling which will be used to simulate the microstructure evolution (e.g. how a defect distribution evolves with time). The work does not start from scratch as it will build upon 20 years of experience in such a modelling.

This work will be part of MIDAS, a UK project funded by EPSRC and led by Manchester University. As such, the student will spend part of his PhD time at Manchester where he will help to model the impact of these irradiation defects on diffraction pattern and TEM images. His/her knowledge in the details of atomic positions around the defects gained during the first part of the work will be required. This work is also in close collaboration with UMET laboratory of Université of Lille, within the EM2VM joint laboratory between EDF R&D, Lille and Rouen universities.

Most of his/her time will be spent at EDF Labs Les Renardières. He/she will graduate from Université de Lille. The PhD is funded by EDF and a CIFRE grant from the ANRT.

The student should have no fear of coding nor using computers. Fluency in English is required. Training in material science is appreciated. Good communication skills, initiative, working proficiency and enthusiasm are warmly welcomed.

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