ID de Contribution: **35** Type: **Oral Presentation**

Investigation of the formation mechanisms of the High Burnup Structure in the spent nuclear fuel – Experimental simulation by in situ Transmission Electron Microscopy experiment with ion beams

lundi 9 mai 2016 17:30 (15 minutes)

This Ph.D. study is concerned with the UO2 nuclear spent fuel. A high burnup structure (HBS, also so-called rim structure) is observed with a typical thickness of 100 to 200 µm at the peripheral region of the nuclear fuel pellets. Several observations and characterizations are notable in that zone [1-5]:

1- An increase of Pu content and burnup.

2- The development of fission gas pores (leading to a porous region) with a typical diameter 1-2 µm and the maximum porosity between 10% and 22%.

3- A large reduction in crystallite size, where the original grain, having a typical size of around 10 µm, subdivides into sub-micron grains with a size of about 0.2 to 0.3 µm.

4- A decrease in the content of Xenon fission product within the UO2 grains (athermal release of Xe from the UO2 grains).

The main objective of this study is to understand the mechanisms of formation of this high burnup structure, using experimental simulation with ion beams.
The Transmission Electron Microscopy (TEM) technique is one of the characterization methods that can be applied to observe the HBS structure and to identify the mechanisms which are responsible to the appearance of such structure. Ion beams are a very convenient tool to experimentally simulate both the damage induced by neutron irradiation in a nuclear reactor, and the presence of foreign species, like fission products produced by nuclear reactions.

Therefore, in situ TEM experiment was performed at JANNuS-Orsay facility [6] to reproduce and observe directly the specific microstructure evolution of the irradiated nuclear fuel. This is experimentally simulated by using a very simplified model system –namely uranium dioxide single crystals –and 260 keV Xe ion beam at 500°C for generating radiation damage and doping the material with xenon fission product. The results show the importance of the various relevant parameters involved in the formation of high burnup structure, and help in clarifying the synergies between them.
The results will compared to RBS/C (Rutherford Backscattering Spectrometry in channeling geometry) experiments in the near future.

References:

[1] Vincenoz V.Rondinella and Thierry Wiss, The high burnup structure in nuclear fuel. Materials Today, 13 (2010)12.

[2] Hj.Matzke, On the rim effect in high burnup UO2 LWR fuels, Journal of Nuclear Materials 189 (1992) 141-148.

[3] K. Lassmann, C.T. Walker, J. van de Laar, F. Lindstrom, Modelling the high burnup UO2 structure in LWR fuel. Journal of Nuclear Materials 226 (1995) 1-8.

[4] K. Une, K. Nogita, S. Kashibe and M. Imamura , Microstructural change and its influence on fission gas release in high burnup UO2 fuel, Journal of Nuclear Materials 188 (1992) 65-72.

[5] K. Nogita , K. Une , M. Hirai , K. Ito , K. Ito , y. Shirai , Effect of grain size on recrystallization in high burnup fuel pellets, Journal of Nuclear Materials 248 (1997) 196-203.

[6] The JANNuS-Orsay facility consists of a Transmission Electron Microscope coupled to two ion accelerators, IRMA and ARAMIS. See http://www.csnsm.in2p3.fr/Equipements for more details.

Auteur principal: Mlle HADDAD, Yara (CSNSM, Univ Paris-Sud)

Co-auteurs: Dr GENTILS, Aurélie (CSNSM, Univ Paris-Sud); Prof. GARRIDO, Frédérico (CSNSM, Univ Paris--Sud); Mlle DELAUCHE, lucie (CSNSM, Univ Paris-Sud)

Orateur: Mlle HADDAD, Yara (CSNSM, Univ Paris-Sud)

Classification de Session: Nuclear reactors and medical physics

Classification de thématique: Nuclear Physics