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TEM CHARACTERIZATION OF A SWELLING-RESISTANT AUSTENITIC STEEL IRRADIATED AT HIGH TEMPERATURE (>600°C) IN THE PHENIX FAST REACTOR

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In the framework of the sodium fast-reactor (SFR) project ASTRID, an optimized austenitic steel 15%Cr-15%Ni stabilized with titanium was chosen for the fuel-pin cladding. Besides irradiation swelling, one of the main issue of irradiated austenitic steels in fast reactor is the embrittlement at high temperature (>600°C).

To investigate the long-term behaviour of cladding material irradiated at temperatures greater than 600°C, fuel pins cladded with optimized 15-15Ti, were irradiated in experimental assemblies of the Phénix SFR to reach a cumulative irradiation time of 941 days (EFPD Equivalent Full Power Day).

Thin foil specimen suitable for Transmission Electron Microscope (TEM) were taken from the upper part of the fuel pin where the irradiation temperature ranges from 600 to 630°C. The final dose of the irradiated thin foil is about 40 dpa NRT.

TEM observation was carried out to characterize irradiation defects, dislocation network and precipitation to identify possible embrittlement mechanisms. Faulted Frank loops were observed and characterized. A population of nanometric bubbles was also detected in grains and grain boundaries. In addition, fine nanometric secondary precipitation of titanium carbides and its interaction with dislocation network was investigated.

A significant intergranular precipitation was observed in the specimen. Combination of EDX (Energy Dispersive X-ray Spectroscopy), EFTEM (Energy Filtered Transmission Electron Microscopy) and micro-diffraction techniques were used to identify the various types of precipitates at grain boundaries. The role of this intergranular precipitation in the embrittlement mechanisms is discussed in the paper.

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