

Study of the Microstructure and Oxidation Phenomena in Model Austenitic Steel Alloys under Non-Irradiated and Irradiated Conditions

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Austenitic steels are widely used in the nuclear industry, particularly as structural materials for reactor components in pressurized water reactors (PWRs). These alloys are exposed to extreme operating conditions, including irradiation, oxidation and corrosion phenomena, as well as severe thermomechanical stresses. A fundamental understanding of their behaviour is therefore essential. Face-centred cubic (FCC) Fe-Ni alloys are widely used as model systems for studying austenitic steels. They exhibit distinctive structural and thermodynamic features, including a lattice-parameter evolution that significantly deviates from that predicted by Vegard's law.

During a preliminary study carried out at the SOLEIL synchrotron facility, Fe-Ni alloys containing 30–50 at. % Ni were subjected to various isothermal and non-isothermal annealing treatments. This study experimentally revealed the appearance of secondary peaks in the vicinity of the main diffraction peaks, which were correlated with the occurrence of oxidation phenomena. The present work aims to confirm these preliminary results while extending the study to other compositions, particularly alloys with higher nickel contents, such as Fe-75 at. % Ni. Particular attention will be paid to the initial metallurgical state of the samples, especially their initial oxidation state.

Several experimental approaches have been and will be employed. Further *in situ* annealing experiments using synchrotron radiation at SOLEIL has been performed on Fe-xNi alloys with different compositions and at different temperatures, with the aim of investigating the evolution of their microstructure during annealing. Scanning Electron Microscopy (SEM) will also be used to characterize cross-sections of the samples annealed *in situ*, in particular to assess the thickness of the oxide layer formed.

In a subsequent stage, this work will also investigate the behaviour of these alloys under irradiation, given their relevance to the targeted nuclear applications.