Effet de la microstructure obtenue par fabrication additive sur le vieillissement sous irradiation d'alliages NI-20CR

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Abstract

Additive Manufacturing (AM) of metals is an advanced technology that enables rapid implementation and design optimization of complex parts. It is now used in many industrial sectors, including nuclear. One of the most common processes in AM is Laser Powder Bed Fusion, which results in a particular microstructure that could influence the material's response to irradiation. The objective of this thesis was to study the effect of heavy ion irradiation on the microstructure of AM Ni-20Cr using Transmission Electron Microscopy (TEM), as well as its impact on its mechanical properties, to determine whether AM could be used for nuclear applications. For this purpose, three additive manufacturing strategies and the effect of annealing were studied and compared to a reference material. Various heavy ion irradiation experiments were conducted, on bulk samples as well as on thin foils observed via in situ TEM. In situ experiments allow measuring the defect growth kinetics at low doses and tracking the evolution of certain characteristics. It is thus demonstrated that in all samples, irradiation induces the formation of Frank loops and perfect loops. The manufacturing strategy does not influence the microstructure evolution of AM samples. However, the dendritic cells, characteristic of AM, are dissolved under irradiation. Additionally, a lower density of dislocation loops is measured in the AM samples compared to the annealed and reference samples that show a similar evolution. This is explained by a higher density of defect sinks in the as built AM material. The observed microstructural evolution is linked to the mechanical properties, which are measured by micropillar compression. It is shown that the annealed and reference materials experience an increase in their critical resolved shear stress due to the creation of dislocation loops, whereas the AM material show a decrease due to the dissolution of dislocation cells, superior to the hardening component. These changes are confirmed by the application of the dispersed barrier-hardening model.