Influence of the microstructure of additively manufactured Ni20Cr microstructure on aging under irradiation

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The metal additive manufacturing is a fast growing process that present many advantages such as the quick design of intricate parts. Its use is considered in the nuclear field, for example to replace outdated parts. Because of their great properties such as corrosion and irradiation resistance and stability in temperature, Ni based superalloys are good candidate. Ni20Cr alloy can be used as model for these complex alloys. However, the microstructure of additive manufactured parts is particular. For example, the formation of precipitates or a structural anisotropy due to columnar grain growth are often observed [2]. These differences can strongly affect the properties of the matter, so it is necessary to investigate the response of Ni20Cr to irradiation. In addition, three different building strategies are studied, varying the volume energy density and are compared to a cold drawn reference.

Defects induced by irradiation are characterized by Transmission Electronic Microscopy (TEM). Observations in "two-beam" conditions highlight that irradiation mainly induce the formation of Frank dislocation loops (Fig. 1). The evolution of these defects is followed by measuring their density and size (Fig. 2). If the strategy do not seems to affect the response of the Ni20Cr, dendritic cellular structure is damaged. However, the results shows that the reference presents more loops so it is less resistant to irradiation. Another effect of irradiation is the dissolution of dendrites cells, what can influence the mechanical properties. EDS analysis were carried out on precipitates and prove that no segregation happens during the irradiation.

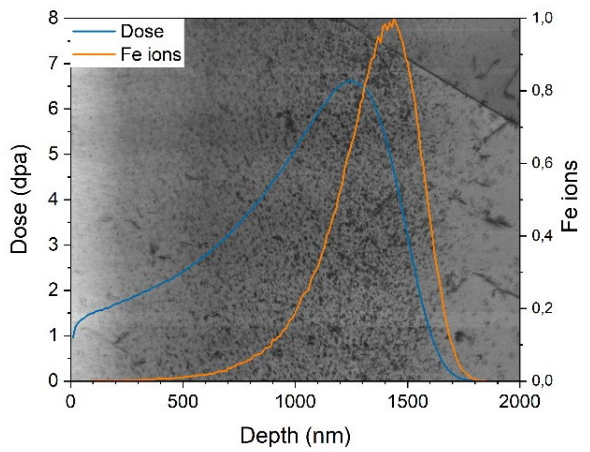

Figure 2 : Correlation between SRIM simulation of irradiation and observation of defects in STEM showing the evolution of the number of dislocation loops in function of depth

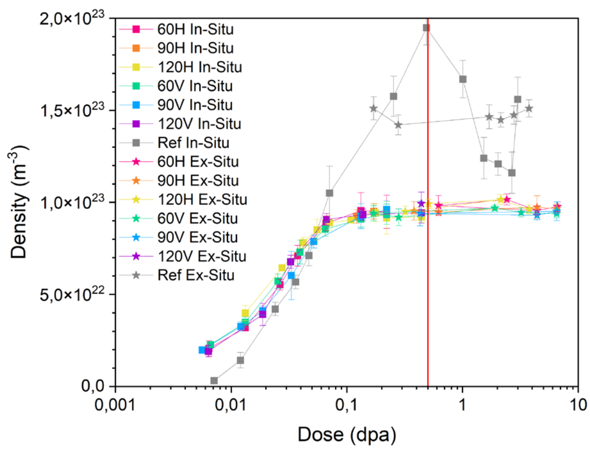

Figure 2 : Evolution of loops density in function of the irradiation dose

References:

[1] A.F. Rowcliffe et al., Perspectives on radiation effects in nickel-base alloys for applications in advanced reactors, J. Nucl. Mater. 392 (2009) 341–352.

[2] E. Hug et al., Additive manufacturing of a Ni-20 wt%Cr binary alloy by laser powder bed fusion: Impact of the microstructure on the mechanical properties, Mater. Sci. Eng., A 834 (2022) 142625