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Post-irradiation examinations of solution annealed and cold worked Inconel 718

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Ni-based alloys have been widely utilized as proton beam window (PBW) materials in existing spallation neutron sources and are potential materials for advanced generation IV reactors like molten salt reactors. However, the radiation-induced loss of ductility is still a concern, and the post-irradiation examination between different heat treatment methods is limited. This study aims to investigate the behavior of solution annealed (SA) and cold worked (CW) Inconel 718 after irradiation at the Swiss spallation neutron source (SINQ). The findings of this study will be useful for materials selection and lifetime prediction of PBWs and improve the understanding of radiation damage for Ni-based alloys in nuclear applications.
Inconel 718 alloys were solution annealed at 1065℃ for 0.5 h to form austenitic structure and part of that were cold worked. Specimens were irradiated in the STIP-II program at 7.6-19.5 dpa in a temperature range of 137-395 ℃. Post-irradiation tensile tests were performed at room temperature and irradiation temperatures. The microhardness of the irradiated sample was measured after tensile test. The fracture morphology and irradiation-induced defect structures were observed by scanning electron microscope and transmission electron microscope.
The tensile test results indicate that both SA and CW Inconel 718 alloys retained a significant amount of ductility after irradiation, except for a high dose (18 dpa) and irradiation temperature (395 ℃) condition, where the SA alloys show intergranular fracture surfaces while CW alloys show quasi-cleavage fracture surfaces. In the SA condition, the microhardness increased after irradiation, whereas the hardening was less pronounced at higher irradiation dose and temperature due to the formation of fewer frank loops. In the CW condition, the hardness decreased after irradiation, despite the existence of frank loops and He bubbles could strengthen the alloy. The reduction of high-density dislocations in initial microstructure of the CW condition was mainly cause of the irradiation-induced softening. Moreover, the microstructures in deformed areas were also observed.

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