doi:10.1017/S1431927621011612
Microsc. Microanal. 27 (Suppl 1), 2021


# Towards development of a nickel-based oxide dispersion strengthened alloy for use in Molten Salt reactors.

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Molten salt reactors are a generation IV nuclear fission reactor design that have inherent efficiency- and safety-related advantages over existing light water reactor designs. The materials used to construct the molten salt containment vessel in these reactors must have a combination of good radiation resistance and corrosion resistance, and must have good high-temperature performance, since the reactors will operate at ~600-700oC.

Nickel-based alloys have the potential to meet the high temperature and corrosion requirements. In the Molten-Salt Reactor Experiment (MSRE) at Oak Ridge National Laboratory [1], Hastelloy N was used for the containment vessel. However, the MSRE highlighted several key materials challenges facing Hastelloy N, including irradiation induced swelling, hardening and embrittlement.

This work concerns the development of an oxide dispersion strengthened (ODS) nickel-based alloy to address these materials challenges. The oxide dispersion is intended to capture and trap the He, improving its swelling resistance and stopping it from causing failure, as well as improving high temperature strength.

In this study, we combine atom probe tomography (APT) and nanoindentation to provide insight into the irradiation behavior of Hastelloy N. We then explore the effect of yttria particles on the ion irradiation response of ODS Hastelloy N. Finally, the effect of changing the base alloy composition to develop a new alloy is investigated.

Hastelloy N material, provided by Australian Nuclear Science and Technology Organisation, was irradiated with 2MeV Ni+ ions at a temperature of 600oC to a peak damage level of 10 dpa at ~0.6 microns depth at the Ion Beam Centre, University of Surrey. The as-received material, the heat-treated, and the irradiated+heat treated material was indented in order to isolate the effect of thermal treatment and ion irradiation on mechanical properties. Using the 3D spatial and chemical information provided by APT, changes in microstructure and chemical distribution caused by heat treatment and ion irradiation can be measured and correlated to changes in hardness. Parallel analysis of Hastelloy N ODS alloy, made using Field Assisted Sintering Technology (FAST) at the University of Oxford, enables comparison of the ion irradiation and thermal response of the ODS and non-ODS material. The effect of the nanoscale yttria additions on microstructural evolution during the heat treatment and ion irradiation is discussed.

Powder particles of a new Nickel-based alloy, with improved composition compared to Hastelloy N, are being manufactured in the University of California, Berkeley. APT analysis of these Nickel-based powder particles will be presented and used to inform selection of the final powder composition for use in the new Nickel ODS alloy.

References

[1] Haubenreich PN, Engel JR. Experience with the Molten-Salt Reactor Experiment. NuclApplTechnol1970;8:118.