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Hydrogen Effects in Superalloys - Insights from Neutron and X-Ray diffraction

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Alloy 718, a widely used Ni-based superalloy, is susceptible to hydrogen embrittlement. The γ' and γ'' precipitates and the δ phase significantly contribute to this embrittlement. To determine if other superalloys with different grain boundary pinning phases exhibit similar behavior, we investigated two γ' strengthened CoNiCr-based superalloys containing B2-structured β or D85-structured μ phase particles. NanoSIMS mapping revealed the highest hydrogen concentration localized in the grain boundary pinning μ and β precipitates, confirmed by synchrotron diffraction showing significant lattice expansion post hydrogen charging. Neutron diffraction indicates that the γ' phase absorbs more hydrogen than the γ phase, leading to greater expansion and increased lattice misfit between γ and γ' phases. Atom probe tomography results confirm preferred hydrogen partitioning towards the γ' phase. Tensile tests reveal that hydrogen markedly affects the mechanical properties of samples charged with high-pressure hydrogen. The hydrogen accumulation in intermetallic particles and strengthening precipitates promotes crack initiation and facilitates propagation along weakened γ/γ' interfaces. These findings enhance our understanding of hydrogen embrittlement in superalloys and aid in developing more hydrogen-resistant alloys.

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