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Local Phase Transformation Strengthening in Ni-based Superalloys and Induction of Displacive-Diffusional Phase Formation via Alternative Deformation Pathways

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Strain rates during intermediate temperature creep in nickel-based superalloys (~700-800 °C) are primarily dominated by planar defects and microtwinning, where shearing processes are controlled by diffusion mediated segregation and reordering [1]. Local Phase Transformation (LPT) at defects strengthen alloys possessing critical ratios of η/χ formers. Novel LPT strengthening has recently been shown along microtwin boundaries through correlative controlled Electron Channeling Contrast Imaging (cECCI) and Scanning Transmission Electron Microscopy (STEM) studies [2,3]. This LPT prevents additional shearing partial dislocations from thickening microtwins, thus preventing rapid strain accumulation. In response, strain alternatively accumulates via deformation induced formation of ordered-HCP "nano-laths"; these are associated and grow from LPT at microtwin interfaces and appear formed by otherwise twin-inducing partials. Advanced characterization of deformation processes was conducted utilizing cECCI, probe corrected STEM, and atomic resolution Energy Dispersive X-Ray Spectroscopy (EDS) to confirm lattice site occupancies. Correlative Atom Probe Tomography (APT) was used for phase confirmation and accurate compositional analysis. Orientation effects of operative shearing mechanisms, LPTs, and lath formation were studied in polycrystalline specimens and compared to single crystal results/theory. Understanding of this process will inform multiscale modeling efforts.

Keywords: Local Phase Transformation, Creep, Microtwin, STEM, EDS, APT

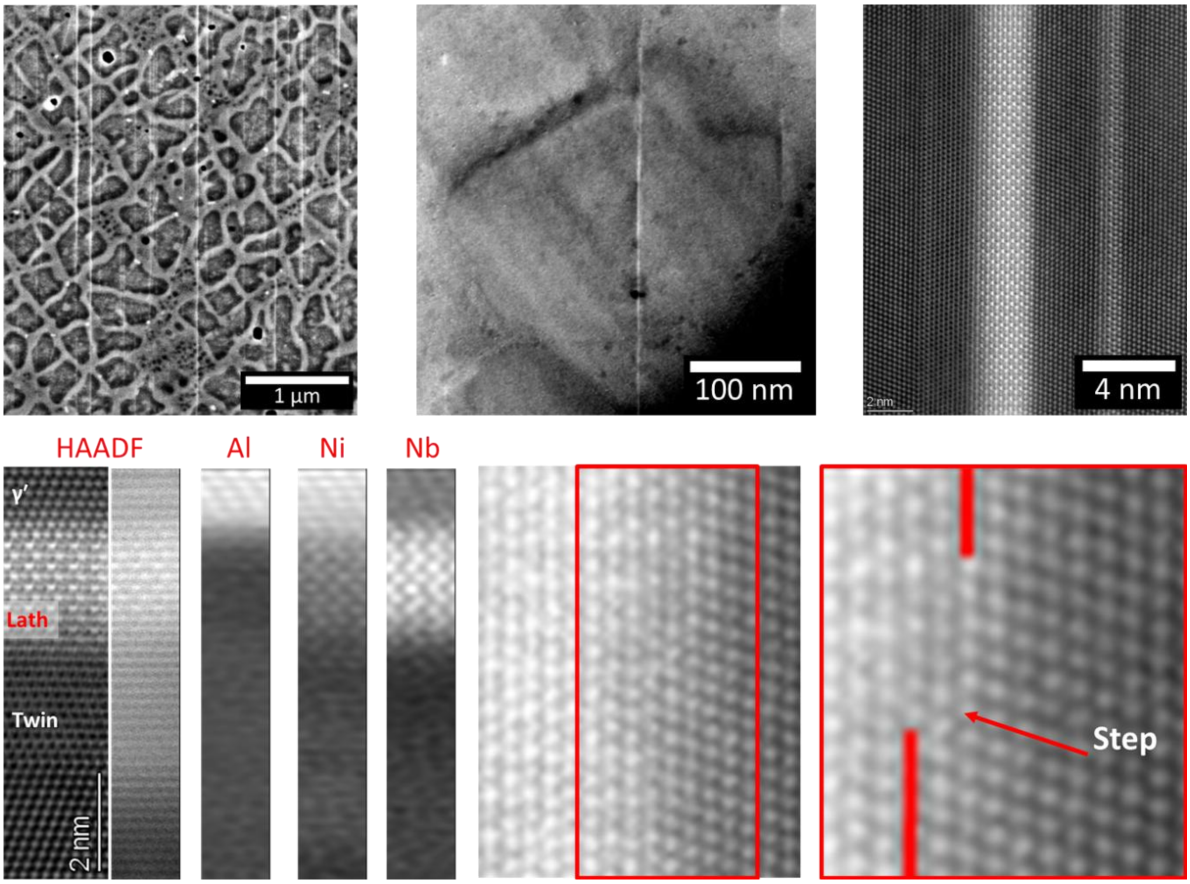

Figure 1 : Analysis of deformation induced ordered-HCP nano-laths. Top left shows cECCI image of microtwins (thin bright features) and nano-laths (thicker, brighter features). Other images were taken using on-zone HAADF and XEDS using a probe corrected STEM.

References:

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[2] **A.J. Egan, Y. Rao, G.B. Viswanathan, T.M. Smith, M. Ghazisaeidi, S. Tin, M.J. Mills, Effect of Nb Alloying Addition on Local Phase Transformation at Microtwin Boundaries in Nickel-Based Superalloys, in: Miner. Met. Mater. Ser., Springer Science and Business Media Deutschland GmbH, 2020: pp. 640–650. doi:10.1007/978-3-030-51834-9_62.**

[3] **A.J. Egan, F. Xue, Y. Rao, G. Sparks, E. Marquis, M. Ghazisaeidi, S. Tin, M.J. Mills, Local Phase Transformation Strengthening Along Microtwin Interfaces in Nickel Based Superalloys, In Manuscript.**