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A Combined Experimental and Simulation Study of Deformation Mechanisms of Order Precipitates in Superalloys

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High-temperature alloys in general and superalloys in particular are strengthened by ordered intermetallic phases that are relatively stable at elevated temperatures. However, their low symmetry and complicated crystal structures impose difficult challenges on detailed understanding of their deformation mechanisms at high temperatures.

In this study, motivated by detailed TEM observations, we use a combination of *ab initio* calculations of the generalized stacking fault energy surfaces and microscopic phase field model of dislocations [1] to illustrate how dislocations interact with γ' ($L1_0$, cubic) and γ" ($D0_{22}$, tetragonal) precipitates in Ni-base superalloys. The simulations reveal a rich variety of interesting dislocation reactions, leading to various stacking faults and dislocation configurations (including stacking-fault ribbons) actually observed in the experiments.

These findings may shed light on operating deformation mechanisms of these precipitates during creep and the corresponding strengthening of the superalloys. Incorporation of these detailed deformation mechanisms into continuum level FEM modeling through intermediate level image- and dislocation-density based crystal plasticity modeling for the development of location-specific, microstructure- and mechanism-sensitive deformation models will also be discussed.

[1] Y. Wang and J. Li, "Acta Materialia Overview 150: Phase Field Modeling of Defects and Deformation," Acta Mater. 58 (**2010**) 1212-1235.

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