Microdiffraction Characterization of Multiscale Deformation Mechanisms in the Weld Joint of a Nickel-based Superalloy

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Motivation:
Nanosize L12 ordered particles are responsible for high temperature strengthening of the TMS 75 Ni based single crystal materials used for energy systems components

- Microstructural stability of blade materials used in turbine systems has become a critical issue for the reliability and economy of entire power generation systems
- When manufacturing fusion welds, the potential exists for defects to be introduced:
  - Dissolution and re-growth of nanosize L12 ordered particles influences phase and microstructure stability
  - Centerline grain boundaries may appear
  - Interdendritic microporosity, liquation and solidification cracking may form
  - Plastic deformation may cause cracking in the HAZ

Simulated distributions of temperature, T(x), temperature gradient, dT/dx, and its derivative, d²T/d²x, have maximal values near the fusion line.

Simulated and experimental Laue pattern determine lattice curvature tensor related to predominant GNDs in each location.

Summary
- Dissolution of the nanosize L12 strengthening precipitates in the HAZ reduces yield strength
- This soft region experiences plastic deformation due to the generation of thermal stresses
- Dislocation density increases with thermal gradient and has a maximum value near the fusion line
- Splitting of Laue spots demonstrates that dislocations group together, forming sub-boundaries and causing fragmentation and local rotation in the HAZ
- Macropscopic rotation axis is perpendicular to the direction of thermal gradient [010]

References

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