Effect of Nb Precipitates on Cu-Nb Multilayer Composites

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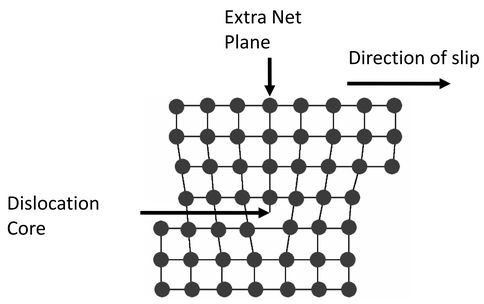
Introduction

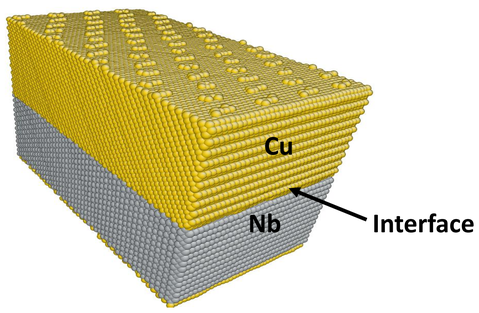
Dislocations cause thin film materials to deform and fail under loading. Finding ways of preventing dislocations from spreading would increase the strength of a material. This project focuses on Cu-Nb multilayer composites and the effect of Nb precipitate in the Cu layer on the material's strength.

Dislocations



- Defects in the crystal structure of a material
- Lattice structure effects direction and plane of dislocation propagation.

Cu-Nb Multilayer Composites

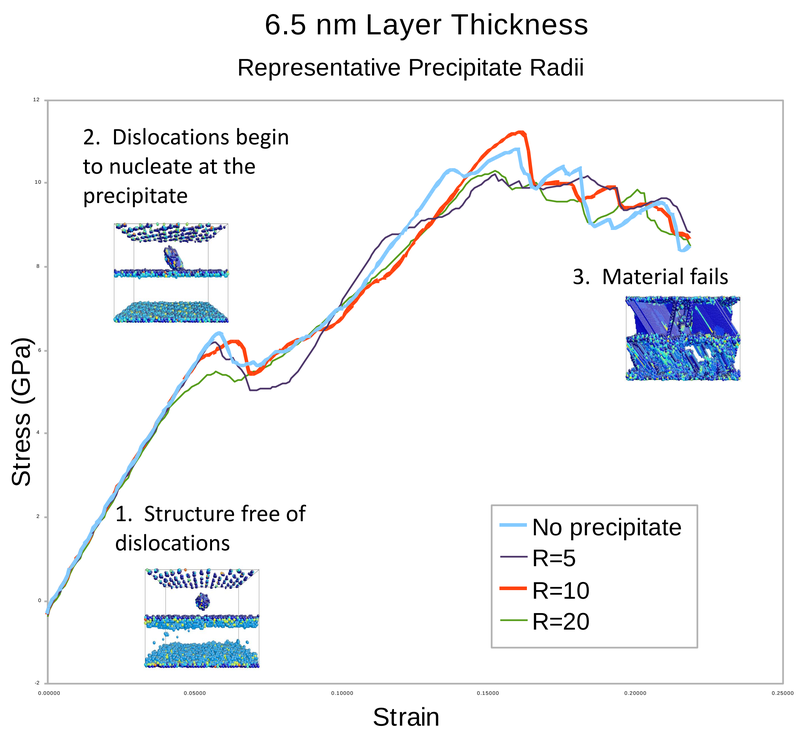


- Cu and Nb have different lattice structures
- Interface prevents propagation of dislocations
- More obstacles to dislocations = stronger material?

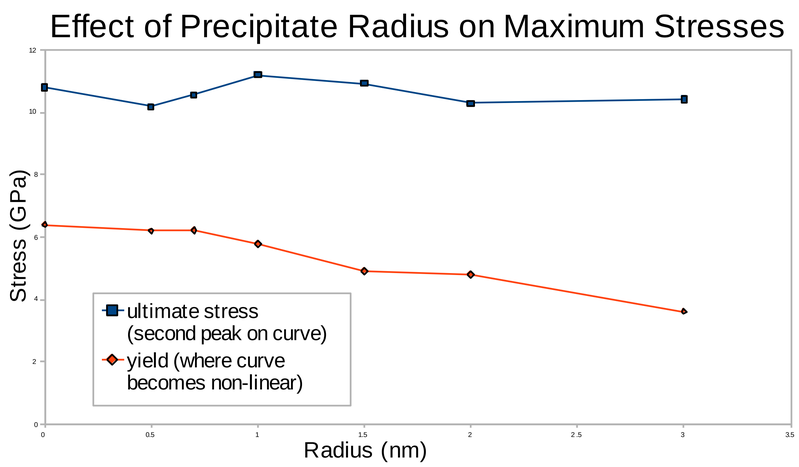
Method

- Molecular dynamics (MD) simulations
- Embed a Nb precipitate inside the Cu layer
- Layer thickness: 6.5 nm, 8.5 nm
- Apply uniaxial tensile load

Effect of Varying Precipitate Radius



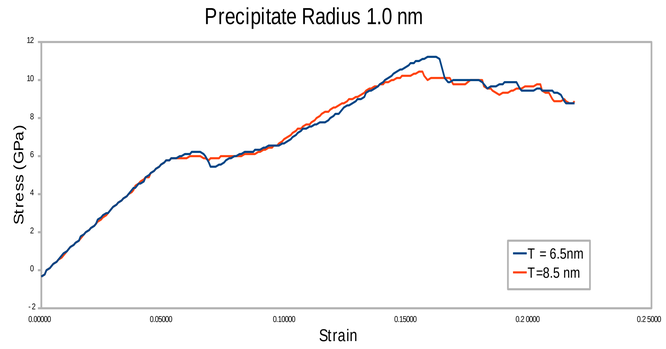
- The stress-strain curves indicate that the size of the precipitate determines whether the material strengthens or weakens



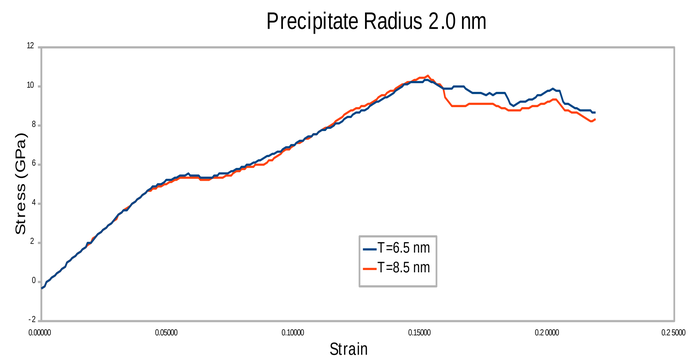
- The ultimate stress reaches a maximum with a precipitate radius between 1.0nm and 1.5nm.
- The yield stress tends to decrease with increasing precipitate radius. This could be because the precipitate interface favors dislocation nucleation

Effect of Varying Layer Thickness

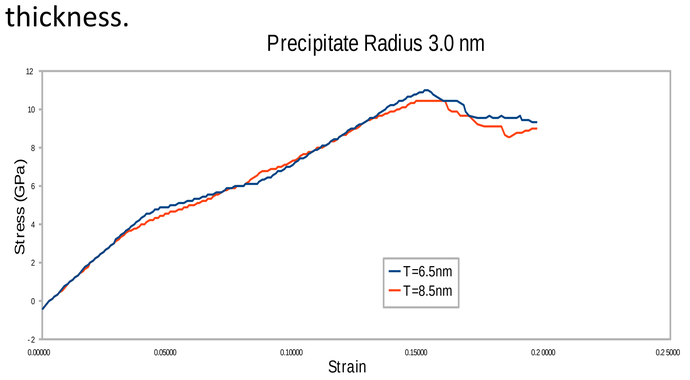
- Research has shown that for layer thicknesses greater than 5nm, strength tends to increase with decreasing thickness
- For precipitate radius 1.0nm, strength increases with decreasing layer thickness. This is the expected result.



- However, for precipitate radius 2.0 nm, the strength is about the same for both 6.5nm and 8.5nm. This is attributed to the thinning of the Cu layer by the presence of the precipitate that brings the total layer thickness close to critical optimum thickness.



- For precipitate radius 3.0 nm, the strength is again about the same for both 6.5 nm and 8.5 nm layer thickness.



- By changing the size of the precipitate, a thicker material can be made as strong as a thinner material. Adding precipitates to Cu-Nb multilayer composites will help to improve the performance of these materials.

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