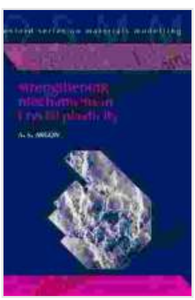
Strengthening Mechanisms In Crystal Plasticity

An Oxford On Materials Modelling Publication

The development of high-performance materials requires a fundamental understanding of the mechanisms that contribute to their strength and ductility. Crystals, the building blocks of most engineering materials, exhibit a wide range of strengthening mechanisms that can be tailored to achieve specific material properties.



Strengthening Mechanisms in Crystal Plasticity (Oxford Series on Materials Modelling Book 4)

5 out of 5

Language	: English
File size	: 7397 KB
Print length	: 404 pages
Lending	: Enabled
Screen Reader	: Supported

This book provides a comprehensive overview of strengthening mechanisms in crystal plasticity, covering both theoretical and experimental aspects. It is an essential resource for researchers and engineers working in the field of materials science and engineering.

Dislocation-Based Strengthening

Dislocations are line defects in crystals that play a major role in their mechanical properties. Dislocations can be introduced into crystals by various means, such as plastic deformation, thermal shock, and irradiation.

The presence of dislocations increases the strength of crystals by hindering the motion of other dislocations. This is because dislocations can interact with each other to form junctions and pile-ups, which can block the movement of dislocations and lead to plastic deformation.

Grain Boundary Strengthening

Grain boundaries are the boundaries between adjacent grains in a polycrystalline material. Grain boundaries can act as barriers to dislocation motion, which can lead to strengthening.

The strength of grain boundaries depends on their orientation and character. Low-angle grain boundaries are typically weaker than high-angle grain boundaries. Grain boundaries with a high density of dislocations are also weaker than grain boundaries with a low density of dislocations.

Solid Solution Strengthening

Solid solution strengthening is a strengthening mechanism that occurs when a solute atom is added to a crystal. Solute atoms can interact with dislocations to form Cottrell atmospheres, which can hinder the motion of dislocations.

The strength of solid solution strengthening depends on the size, shape, and concentration of the solute atoms. Solute atoms that are larger than the host atoms are more effective at strengthening than solute atoms that are smaller than the host atoms.

Dispersion Strengthening

Dispersion strengthening is a strengthening mechanism that occurs when a second phase is dispersed in a matrix phase. The second phase particles can act as barriers to dislocation motion, which can lead to strengthening.

The strength of dispersion strengthening depends on the size, shape, volume fraction, and distribution of the second phase particles. Second phase particles that are small, spherical, and evenly distributed are more effective at strengthening than second phase particles that are large, irregularly shaped, and non-uniformly distributed.

Precipitation Strengthening

Precipitation strengthening is a strengthening mechanism that occurs when a second phase precipitates from a supersaturated solid solution. The precipitate particles can act as barriers to dislocation motion, which can lead to strengthening.

The strength of precipitation strengthening depends on the size, shape, volume fraction, and distribution of the precipitate particles. Precipitate particles that are small, spherical, and evenly distributed are more effective at strengthening than precipitate particles that are large, irregularly shaped, and non-uniformly distributed.

Twinning

Twinning is a crystallographic shear transformation that can occur in certain materials. Twinning can lead to strengthening by creating new dislocations and by hindering the motion of existing dislocations.

The strength of twinning depends on the type of twin, the orientation of the twin, and the amount of twinning. Tensile twins are typically stronger than compression twins. Twins that are oriented at an angle to the loading direction are more effective at strengthening than twins that are oriented parallel to the loading direction.

Martensitic Transformation

Martensitic transformation is a solid-state phase transformation that can occur in certain materials. Martensite is a product phase that is typically harder and stronger than the parent phase.

Martensitic transformation can lead to strengthening by creating new dislocations and by hindering the motion of existing dislocations. The strength of martensitic transformation depends on the type of martensite, the orientation of the martensite, and the amount of martensite.

Strengthening mechanisms are essential for the development of high-performance materials. By understanding the various strengthening mechanisms that are available, materials scientists and engineers can design materials that meet the specific requirements of their applications.

Further Reading

- Strengthening mechanisms in crystal plasticity, Acta Materialia, Volume 87, 2015, Pages 1-45
- Strengthening Mechanisms in Materials, Springer, 2016
- Strengthening Mechanisms in Metallic Alloys, Taylor & Francis, 2018

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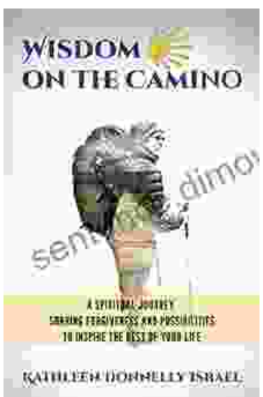

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