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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In the present work, hardening by misfitting precipitate has been energetically investigated by means of the parametric dislocation dynamics simulation, where the dislocation motion and its interaction with misfitting precipitates are analyzed in accord with the micromechanical formulation of the stress and energy associated the dislocation motion. Throughout the computation, Green's function method was employed for the calculation of the stress caused by dislocations and misfitting precipitates. The shape, orientation, geometry dependent hardening behaviors in the dislocation interaction with a single precipitate and multiple precipitates predicted by the present study revealed the origins of the hardening mechanisms by dislocations and precipitates. The computed stress-strain curves are implemented by the analysis in terms of the dislocation self-energy, dislocation interaction energy and potential energy. The important findings obtained in each of the chapters are briefly summarized as follows,

Chapter 1: General Introduction

This chapter addressed the brief introduction about the development of the dislocation dynamics simulation methods and its application to simulate the interaction between dislocations and precipitates in past decades. The method to achieve the accurate calculation of the dislocation motion under the external and the internal stress field of the misfitting precipitate was also mentioned in view of micromechanics theory. The motivation and organization of this thesis is summarized.

Chapter 2: Parametric dislocation dynamics simulation

This chapter implemented the fundamental methodology of the dislocation dynamics techniques, such as the numerical representation of curved dislocation lines, the stress field of precipitate and dislocation segments, the stress and energy associated with the dislocation motion, etc. The energy formulas associated with the dislocation motion proposed by the present study enabled to clarify the effect of the dislocation interaction with misfitting precipitates on the hardening behavior from the energetic point of view.

Chapter 3: Misfit hardening by spherical precipitate

The dislocation interaction with a spherical misfitting precipitate was investigated. The effect of relative position of the slip plane and precipitate, existence of cross slip, precipitate size and initial length of dislocation line on the misfit hardening has been investigated quantitatively. During the dislocation bypassing process, topological change of dislocation segments was strongly influenced by the stress field of the misfitting precipitate, which depends on the relative position of the slip plane. The interaction energy analysis revealed that the strengthening effect is more obvious by the dislocation interaction with smaller misfitting precipitate, which suggests that simultaneous hardening by misfitting precipitates and dislocations.

Chapter 4: Misfit Hardening by {111} Plate Precipitate

The orientation dependent hardening by a {111} misfitting plate precipitate has been investigated. Because of the shape and the orientation dependency of the internal stress, the evolution of dislocation microstructure was largely changed with the geometry of the dislocation and the precipitation variant. Simulation results for the dislocation interaction with the different types of precipitation variants were almost consistent with the theoretical prediction of the average interaction energy between the eigenstrain of the misfitting precipitate and the stress associated with the dislocation glide. The orientation dependent hardening by the {111} plate was emphasized when the plate was intersected by burgers vector with the angle of 60 deg. (Type B variant) as compared with that by 0 deg. (Type A and C variants). Throughout the simulation results, the cross-slip plays an important role in formation of the dislocation jogs, which

contributes to the simultaneous hardening by misfitting precipitate and dislocation.

Chapter 5: Misfit Hardening by <001> Rod Precipitate

The dislocation interaction with <001> rod precipitate has been simulated. The dislocation motion and its hardening behavior was changed with the relative position of dislocation slip plane and the <001> rod precipitates as well as the orientation of the rod, which was associated with the distribution of the internal stress field around the <001> rod precipitate. In practice, hardening and softening behaviors were observed by the [100] and [010] rod precipitate, respectively, while medium level of the flow stress was achieved by the [001] rod precipitate. By comparison of the strengthening by <001> rod and {111} plate precipitates, the rod precipitate is found to be more effective for the misfit hardening.

Chapter 6: Misfit Hardening by Multiple Precipitates

The effect of multiple precipitates on the misfit hardening behavior has been investigated. The hardening behavior associated with the dislocation motion was greatly influenced by the interspacing of multiple precipitates, especially, the magnitude of the interaction energy was increased by the multiple precipitates with narrow interspacing. In the meanwhile, the effect of the radius of the dislocation source on the stress-strain curves is not obvious when the initial length of the dislocation line was larger than the interspacing of multiple precipitates. These results suggest that the further strengthening effect on the misfit hardening can be expected by the dislocation strengthening when the length between pinned dislocations is comparable to the interspacing of multiple precipitates.

Chapter 7: General Conclusions

The conclusions of each chapter was summarized, and the future prospect has been given.