Atomic-Scale Studies on The Effect of Boundary Coherency on Stability in Twinned Cu

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Introduction

Materials such as Cu containing nanoscale coherent twin boundaries (CTBs) were reported to have an attractive combination of properties such as high strength and stability[1, 2]. If such Cu can be scaled up, it will be a potential candidate for high field magnet conductors. In high field magnets, conductors are usually deformed due to high Lorentz forces. Therefore, deformation-induced microstructure-evolution and stability is studied.

Experimental

High purity Cu foils with high density (99%) of CTBs were synthesized. The microstructures were characterized in transmission electron microscope (TEM, JOEL-2011) and sub-angstrom TEM/STEM (scanning TEM, JEM, ARM200F) on cross sections. Hardness was done on Tukon 2100 microhardness tester.

Results and Discussion

Fig. 1(a) reveals that the atoms in CTBs fit perfectly into both grains and are in undistorted positions. Cold deformation gave rise to the distortion of atomic arrays in twin boundaries (TBs), and TBs do not lie exactly parallel to the twinning planes any more. In Fig. 1 (b), a glissile Shockley partial (1/6<211>) was identified with Burgers vector parallel to the coherent TB (CTB) plane and its core was in the vicinity of CTB plane, constructing an incoherent TB. Continuous nucleation and motion of the associated partial dislocations at TBs lead to TB migration and formation of TB ledges/steps (the inset in Figure 2 (b)). This will reduce the instability and softening as illustrated by hardness test results shown in Fig. 1(c).

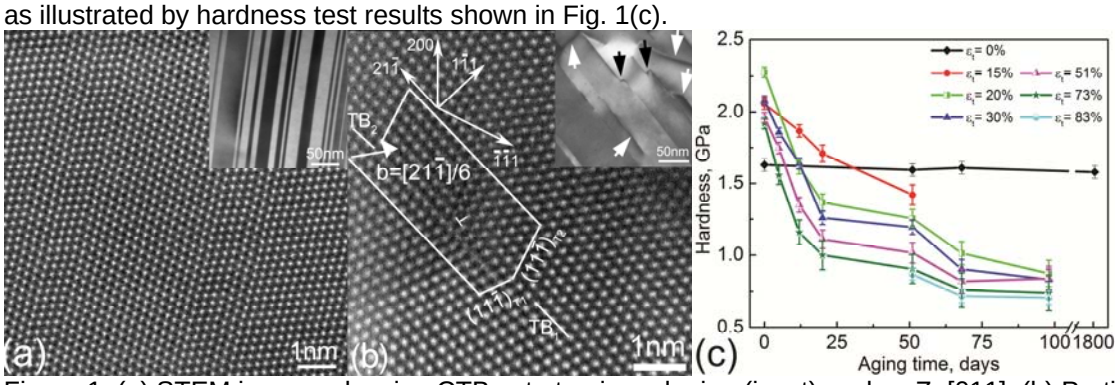

Figure 1. (a) STEM images showing CTBs at atomic and micro(inset) scales, Z=[011]. (b) Partial dislocations with inset exhibiting ITBs (black arrows) and dislocations (white arrows). (c) Hardness reduction with deformation.

Conclusions

The hardness of nanotwinned (NT) Cu is related to interaction between dislocations and {111}-twin boundaries (TBs). Lack of mobile dislocations at CTBs provides as-deposited NT Cu high hardness. The introduction of numerous incoherent TBs by deformation reduces the hardness and stability.

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References

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