Effect of Shock Compression Methods on the Defect Substructures in Monocrystalline Copper

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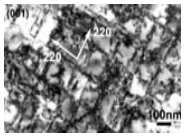
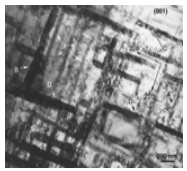
Monocrystalline copper samples with orientations of [001] were shocked at pressures ranging from 30 GPa to 60 GPa using two techniques: explosively driven flyer plates and direct drive lasers. The residual microstructures were dependent on orientation, pressure, and initial temperature. The experimental technique also had a pronounced effect on the defect substructure because of the differences in pulse duration which results in different amounts of heating from shock compression. Because the pulse duration is short in laser shock experiments, the specimens are rapidly quenched and only limited dislocation motion occurs.

30 GPa Plate Impacted



40 GPa Laser Shocked



Stacking faults in 30 GPa plate impacted and 40 GPa laser shocked <001> monocrystalline copper

Shock Wave Configuration

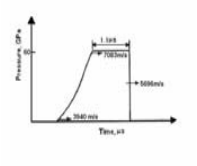
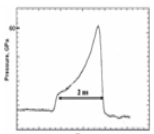


Plate Impact



Laser Shock

Residual Temperature

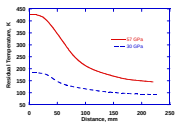
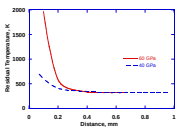
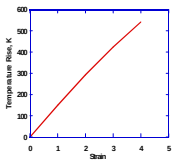


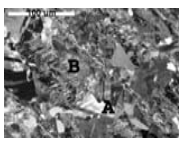
Plate Impact

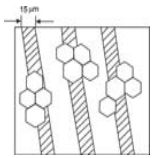


Laser Shock

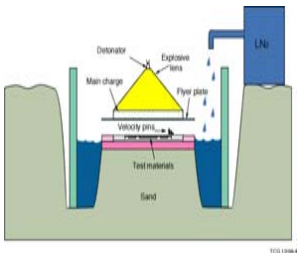
Deformation Induced Temperature Rise



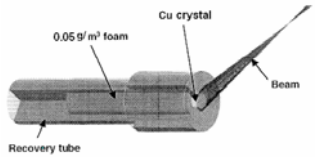




Shock/Recovery Experiments



(a)

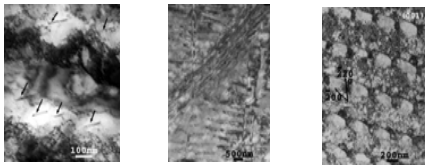


(b)

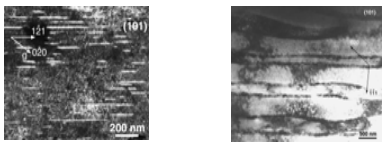
(a) Shock recovery experiment by acceleration of a flyer plate by an explosive charge. (b) Sample and recovery chamber for laser shock experiments.

- The cooling time for plate impact is 1000 s and laser shock is 0.2 s;
- Post shock recovery processes much more pronounced in plate-impact shock;
- Localized deformation induced temperature rise helps to explain recrystallization around shear concentration regions.
- Unique advantage of laser shock: shock defect structure retained to higher pressures

57 GPa Plate Impacted

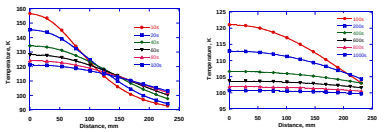


60 GPa Laser Shocked

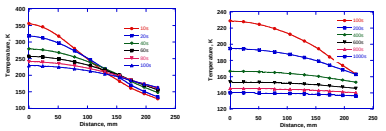


Micro-twines, micro-bands, shear bands and dislocations in 57 GPa plate impacted, and micro-twines and lathes in 60 GPa laser shocked [001] monocrystalline copper.

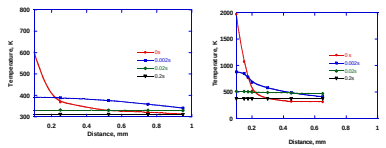
Temperature Changes after Shock



30 GPa Plate Impacted



57 GPa Plate Impacted



40 GPa (left) and 60 GPa (right) Laser shocked