Effect of θ' phase on plasticity and fracture under shock wave loading of Al–Cu alloy

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The molecular dynamics method was used for simulating the propagation of a shock wave in single crystals of pure aluminum and aluminum containing θ' precipitates, which have the maximum strengthening effect among other phase precipitates in Al–Cu-based alloys. Two-wave structure with elastic precursor is revealed for both pure Al and Al–Cu alloy. In the case of pure Al, the elastic precursor has a sharp peak, which slightly attenuates as it propagates. The amplitude elastic precursor reaches about 19.5 GPa, which is comparable with the main shock wave. In the alloy, the amplitude of the main part of the shock wave is higher than in the case of pure aluminum by 0.2–0.3 GPa at the same impact velocity, which is due to the presence of precipitates characterized by lower compressibility compared to the main matrix. The amplitude of the elastic precursor in the alloy is significantly lower than in the case of pure aluminum and amounts to 10.5–11.6 GPa. The propagation of the shock wave is accompanied by the formation of dislocations. Further, the dislocation density rapidly increases at the front of the plastic shock wave. The accumulation of immobilized dislocation segments promotes the pinning of movable partial Shockley dislocations and leads to strengthening of the material. An earlier increase in the dislocation density takes place in the system containing θ' phase. The spall strength of Al with θ' phase (7.17 GPa) is revealed to be 5% higher than in the case of pure Al (6.85 GPa). Nucleation of cavities in alloy occurs near precipitates and in places where dislocations accumulate.

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