The molecular dynamics method study on the micro-spallation in metal under shock wave loading

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ABSTRACT

Just as classical spallation, the micro-spallation also is one of important dynamics damages of metal under shock loading. However, the micro-mechanism of the micro-spallation is still under investigation until today. In recent years, we studied the micro-mechanism of micro-spallation for some metals (such as Pb, Al etc) by using the molecular dynamics method. Our studies discover some features of the micro-spallation of metal under shock loading.

In this present, we will introduce a serial of numerical simulations on crystalline and polycrystall metals under shock loading. The atomic number of simulated model is more than several millions. A wide range of shock intensity is conducted with the lowest one just above the threshold of solid spallation, and the highest one higher than the threshold of compression melting. Our results show that both of spallation and micro-spallation mechanisms are dominated by cavitation, i.e., nucleation, growth, and coalescence of voids. The grain boundaries have significant influences on spalling behaviors in cases of classical spallation and releasing melting. In these cases, cavitation and melting both start on grain boundaries, and they display mutual promotion: melting makes the voids nucleate at smaller tensile stress, and void growth speeds melting process in return. And the micro-spallation will be formatted only under enough high loading intensity that metal material will be in the condition of melting (compression melting or releasing melting). Influences of microstructure, strain rate, and temperature on spall strength are qualitatively discussed. Due to grain boundary effects, the spall strength of nanocrystalline metal varies slowly with the shock intensity in cases of classical spallation. In cases of releasing melting and compression melting, spall strength of both single-crystalline and nanocrystalline metal drops dramatically as shock intensity increases.

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