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Micromechanism of Ionization Effects on Metal/Gas Mixing Instabilty at Extreme Shock Compressing Conditions

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Abstract : Understanding of material mixing induced by Richtmyer-Meshkov instability (RMI) at extreme shock compressing conditions (high energy density environment: P >> 100GPa, T >> 10000k) is of great significance in engineering and science, such as inertial confinement fusion(ICF), supersonic combustion, etc. Turbulent mixing induced by RMI is a kind of complex fluid dynamics, which is closely related with hydrodynamic conditions, thermodynamic states, material physical properties such as compressibility, strength, surface tension and viscosity, etc. as well as initial perturbation on interface. For phenomena in ordinary thermodynamic conditions (low energy density environment), many investigations have been conducted and many progresses have been reported, while for mixing in extreme thermodynamic conditions, the evolution may be very different due to ionization as well as large difference of material physical properties, which is full of scientific problems and academic interests. In this investigation, the first principle based molecular dynamic method is applied to study metal Lithium and gas Hydrogen (Li-H2) interface mixing in micro/meso scale regime at different shock compressing loading speed ranging from 3 km/s to 30 km/s. It's found that, 1) Different from low-speed shock compressing cases, in high-speed shock compresing (>9km/s) cases, a strong acceleration of metal/gas interface after strong shock compression is observed numerically, leading to a strong phase inverse and spike growing with a relative larger linear rate. And more specially, the spike growing rate is observed to be increased with shock loading speed, presenting large discrepancy with available empirical RMI models; 2) Ionization is happened in shock font zone at high-speed loading cases(>9km/s). An additional local electric field induced by the inhomogeneous diffusion of electrons and nuclei after shock font is observed to occur near the metal/gas interface, leading to a large acceleration of nuclei in this zone; 3) In conclusion, the work of additional electric field contributes to a mechanism of RMI in micro/meso scale regime at extreme shock compressing conditions, i.e., a Rayleigh-Taylor instability(RTI) is induced by additional electric field during RMI mixing process and thus a larger linear growing rate of interface spike.

Keywords : ionization, micro/meso scale, material mixing, shock
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