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Shock waves generated by underwater electrical explosion of a single wire

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The observation and analysis of shock waves generated by the underwater electrical explosion of a single aluminum and copper wires are reported. Experiments were carried out using microsecond timescale high-current generators delivering ˜180 kA pulse with 1.2 μs rise-time and ˜30 kA pulse with 1 μs rise-time. Shadow streak imaging was applied to study shock waves generated by the radially expanding wire while energy was deposited into the wire. The first two weak shock waves, generated prior to the wire explosion, are related to the solid-liquid and liquid-vapor phase transitions. The energy density deposition analysis and one-dimensional magneto-hydrodynamic simulation coupled with the equation of state and conductivity model revealed that these shock waves were not associated with melting or evaporation of the entire wire. The third strong shock wave is related to the beginning of the vapor-low ionized plasma phase transition when the main energy deposition occurs. One-dimensional hydrodynamic simulations coupled with the equation of states for a wire material and water showed that the wire expanded with sub-sonic velocity and the strong shock was generated by the compressed water layer formed in the vicinity of expanding wire. The dynamics of this shock was analyzed employing a simplified model, which assumes the uniform density of a compressed layer between the shock wave and expanding wire. The model results showed a satisfactory fit for both the shock wave trajectory and radial expansion of the wire's boundary obtained in the experiment.

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