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Finite element modeling of electrostatic discharge using a collisional plasma spark conductivity model[1] JOHN ROSE, MARK COFFEY, PHILIP FLAMMER, MICHAEL LACOUNT, LIAM POCHER, CLAUDIA SCHRAMA, Colorado School of Mines, DAN BOROVINA, JONATHAN MACE, Los Alamos National Laboratory, CHARLES DURFEE, Colorado School of Mines
— Electrostatic discharge (ESD) is an important safety concern for many industrial operations, in particular those that involve risk for fire or explosion. A key aim for our work is to develop a physical model that can place limits on the current and energy of an ESD pulse that can be used for safety measures. We consider ESD pulses from charged, insulating materials to low-resistance victim loads. After implementing the full set of Maxwell equations in potential form using a finite element solver (COMSOL Multiphysics), we developed a framework for calculating the collisional processes in the spark channel plasma. We find that the energy that can be transferred to a low-resistance victim load is strongly limited by the surface resistance of the charged object and by the spark resistance, which is in turn fundamentally tied to the ionization of the gas. We have also analyzed simpler nonlinear spark resistance models that result from the thermodynamic energy balance for a cylindrically-uniform spark channel. We compared these simpler spark models alongside our more general plasma model and established which ESD regimes are valid for the simpler models.

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