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High-Voltage, High-Power Gaseous Electronics Switch For Electric Grid Power Conversion[1]

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We are developing a high-voltage, high-power gas switch for use in low-cost power conversion terminals on the electric power grid. Direct-current (dc) power transmission has many advantages over alternating current (ac) transmission, but at present the high cost of ac-dc power interconversion limits the use of dc. The gas switch we are developing conducts current through a magnetized cold cathode plasma in hydrogen or helium to reach practical current densities > 1 A/cm^2. Thermal and sputter damage of the cathode by the incident ion flux is a major technical risk, and is being addressed through use of a "self-healing" liquid metal cathode (eg, gallium). Plasma conditions and cathode sputtering loss are estimated by analyzing plasma spectral emission. A particle-in-cell plasma model is used to understand various aspects of switch operation, including the conduction phase (where plasma densities can exceed 10^{13} cm^{-3}), the switch-open phase (where the high-voltage must be held against gas breakdown on the left side of Paschen's curve), and the switching transitions (especially the opening process, which is initiated by forming an ion-matrix sheath adjacent to a control grid).

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