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Operating modes of a low pressure, high current, magnetized rare-gas plasma[1]

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We have investigated high current operation of a magnetically-enhanced rare-gas plasma for use as a high-voltage, high-power gas switch in grid-scale electric power conversion. It is desirable to operate at a low voltage to minimize incident ion energy and reduce the cathode erosion rate by sputtering. We have determined the key characteristics of low-voltage mode operation by correlating the electrical pulse and optical emission spectroscopy data with observations from high-speed movies. We have identified four key modes of operation, namely magnetron mode (200-300 V), a constricted, rotating mode (70-120 V), an edge-enhanced constricted mode (40-60 V), and metal/arc mode (20-40 V), along with the cathode geometry and the operating conditions required to select the desirable modes. It is essential to minimize operation time in either magnetron mode or metal mode due to the high erosion rate of cathode material in each case. The edge-enhanced constricted mode has a favorably low voltage but is characterized by the plasma attaching to sharp/rough surface features. The constricted, rotating mode is the preferred operating regime due to low voltage losses and the absence of cathode material observed in optical emission spectra.

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