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Inverted Geometry Ceramic Insulators in High Voltage Direct Current Electron Guns for Accelerators

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Abstract : High-energy nuclear physics experiments performed at the Jefferson Lab (JLab) Continuous Electron Beam Accelerator Facility require a beam of spin-polarized ps-long electron bunches. The electron beam is generated when a circularly polarized laser beam illuminates a GaAs semiconductor photocathode biased at hundreds of kV dc inside an ultra-high vacuum chamber. The photocathode is mounted on highly polished stainless steel electrodes electrically isolated by means of a conical-shape ceramic insulator that extends into the vacuum chamber, serving as the cathode electrode support structure. The assembly is known as a dc photogun, which has to simultaneously meet the following criteria: high voltage to manage space charge forces within the electron bunch, ultra-high vacuum conditions to preserve the photocathode quantum efficiency, no field emission to prevent gas load when field emitted electrons impact the vacuum chamber, and finally no voltage breakdown for robust operation. Over the past decade, JLab has tested and implemented the use of inverted geometry ceramic insulators connected to commercial high voltage cables to operate a photogun at 200kV dc with a 10 cm long insulator, and a larger version at 300kV dc with 20 cm long insulator. Plans to develop a third photogun operating at 400kV dc to meet the stringent requirements of the proposed International Linear Collider are underway at JLab, utilizing even larger inverted insulators. This contribution describes approaches that have been successful in solving challenging problems related to breakdown and field emission, such as triple-point junction screening electrodes, mechanical polishing to achieve mirror-like surface finish and high voltage conditioning procedures with Kr gas to extinguish field emission.

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