微秒脉冲下两电极开关的低真空击穿特性研究 *

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摘 要:针对巴申曲线在低真空范围击穿特性尚无详细研究,且只适用于均匀电场的情况,本文研究了 10^{-3}~10 Pa 低真空范围微秒脉冲下两电极开关击穿特性,在真空击穿试件内进行不同球电极间隙距离的真空击穿实验,探索并总结了其击穿规律。首先,对不同电极间距下放电腔场强分布进行了仿真,结果显示场分布为稍不均匀场,场强最大值集中在电极球面顶点之间。然后采用光学显微镜观察实验后电极表面状态,分析了击穿场强以及离散度随真空度和电极间隙的变化规律。结果表明:阴极烧蚀比阳极更为明显,小间隙下真空击穿主要为阴极引发;击穿场强随气压不断降低而迅速增大,上升斜率先增后减,击穿场强趋于稳定,该现象与真空击穿规律相符合;真空击穿场强离散度也随真空度变大,证明真空击穿的随机性和分散性较大。

关 键 词:微秒脉冲;真空击穿;低真空
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Study on Low Vacuum Breakdown Characteristics of Microseconds Pulse in Two-electrode Switch

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Abstract: The breakdown characteristics of the Paschen curve in the low vacuum range are not revealed in detail, and it is only applicable to the case of uniform electric field. This paper explores the breakdown characteristics of 10^{-3}-10 Pa in microsecond pulse of two-electrode switch. The vacuum breakdown test was carried out with spherical electrode at different electrode spacing to explore and summarize its breakdown rules. Firstly, the field intensity distribution of the discharge cavity with different electrode spacing is simulated. The simulation results show that the field distribution is slightly uneven, and the maximum field intensity is concentrated between the spherical vertices of the electrodes. Then, the state of the electrode surface after the experiment is observed by optical microscope, and the variation of the breakdown field strength and dispersion with the vacuum degree and electrode gap is analyzed. The results show that the ablation of cathode is more obvious than that of anode, and the vacuum breakdown is mainly caused by cathode in small gap. The breakdown field strength increases rapidly with the decrease of pressure, the rising slope increases first and then decreases, and the breakdown field strength tends to be stable, which accords with the rule of vacuum breakdown. The dispersion of vacuum breakdown also increases with vacuum degree, which verifies the randomness and dispersion of vacuum breakdown.

Key words: microsecond pulse; vacuum breakdown; low vacuum

脉冲功率技术是在 20 世纪 60 年代,伴随着核物理、强激光、等离子体物理和电子加速器等研究发展起来的一门新兴科学技术,是把长时间、低功率储存的能量经过脉冲调制、整形后释放给负载的电物理技术[1-4]。脉冲功率技术的关键是绝缘和开关技术。脉冲功率系统中多数采用电

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