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Electret: A Solution of Partial Discharge in High Voltage Applications

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Abstract : The high efficiency, high field, and high power density provided by wide bandgap (WBG) semiconductors and advanced power electronic converter (PEC) topologies enabled the dynamic control of power in medium to high voltage systems. Although WBG semiconductors outperform the conventional Silicon based devices in terms of voltage rating, switching speed, and efficiency, the increased voltage handling properties, high dv/dt, and compact device packaging increase local electric fields, which are the main causes of partial discharge (PD) in the advanced medium and high voltage applications. PD, which occurs actively in voids, triple points, and airgaps, is an inevitable dielectric challenge that causes insulation and device aging. The aging process accelerates over time and eventually leads to the complete failure of the applications. Hence, it is critical to mitigating PD. Sharp edges, airgaps, triple points, and bubbles are common defects that exist in any medium to high voltage device. The defects are created during the manufacturing processes of the devices and are prone to high-electric-field-induced PD due to the low permittivity and low breakdown strength of the gaseous medium filling the defects. A contemporary approach of mitigating PD by neutralizing electric fields in high power density applications is introduced in this study. To neutralize the locally enhanced electric fields that occur around the triple points, airgaps, sharp edges, and bubbles, electrets are developed and incorporated into high voltage applications. Electrets are electric fields emitting dielectric materials that are embedded with electrical charges on the surface and in bulk. In this study, electrets are fabricated by electrically charging polyvinylidene difluoride (PVDF) films based on the widely used triode corona discharge method. To investigate the PD mitigation performance of the fabricated electret films, a series of PD experiments are conducted on both the charged and uncharged PVDF films under square voltage stimuli that represent PWM waveform. In addition to the use of single layer electrets, multiple layers of electrets are also experimented with to mitigate PD caused by higher system voltages. The electret-based approach shows great promise in mitigating PD by neutralizing the local electric field. The results of the PD measurements suggest that the development of an ultimate solution to the decades-long dielectric challenge would be possible with further developments in the fabrication process of electrets.

Keywords : electrets, high power density, partial discharge, triode corona discharge
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