3D PARTICLE-IN-CELL SIMULATION OF SURFACE FLASHOVER IN VACUUM INTERRUPTERS

Svetlana Gossmann[1], Thomas Hammer[1], Andreas Lawall[2] and Frank Graskowski[2]
[1]Siemens AG, Technology, Erlangen, Germany
[2] Siemens AG, Smart Infrastructure, Berlin, Germany

ABSTRACT

The dielectric strength of vacuum interrupters is limited by vacuum surface discharge and breakdown along insulators. Thus, the initiation and temporal development of vacuum discharges along the surface of cylindrical alumina insulator was investigated by means of a 3D particle-in-cell simulation [1] comprising iterative electrostatic field simulation taking into account the electron charge distribution, electric field induced electron emission from copper vapor shields described by the Fowler-Nordheim equation, and electron impact induced secondary electron emission from the insulator surface utilizing the Furman secondary electron yield model [2]. Further formation of volume- and surface charges influencing the electrostatic field were considered. The desorption rate of neutral and ionized atoms and molecules was addressed by evaluating the energy flux density due to electron impact on the insulator surface from electric current density and electron energy. The angle and energy distribution of the primarily emitted electrons were analysed in detail, since they play an important role for the further development of the electron avalanche as well as for charging of the insulator surface. The electric field produced by negative charges either from the insulator surface or from the space charge from electrons remaining close to emitter decreased the electric field at the cathode and, consequently, limited the emission current. The investigated pre-breakdown phenomena belong to the first phase of the unipolar dielectric surface flashover in vacuum, where the saturated secondary electron emission avalanche is built within several nanoseconds [3]. The model was applied to a cylindrical test specimen having design features such as tubular alumina insulator and copper vapor shields being representative for a medium voltage vacuum interrupter. Different electron emission spots on the cathode sided vapor shield were analysed in view of their influence on the development of surface discharges. The influence of surface on the field emission was investigated by varying the field enhancement factor β between 60 and 100. Simulation results of surface discharge initiation and energy flux densities indicating gas desorption induced breakdown were in reasonable agreement with published experimental results [4].

References

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