COMSOL Simulation of the Free Electrons in a Surface Flashover

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The background theory

1. Parameters in a flashover.

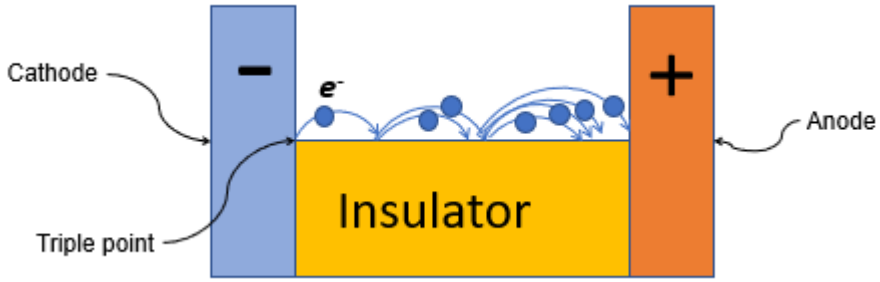
Many parameters can influence the flashover voltage of insulators in vacuum, such as:

- Material
- Geometry
- Surface finish
- Attachments to electrodes
- For AC HV
  - the applied voltage waveform
  - duration
  - single pulse or repetitive
- The process history
- Operating environment
- Previous applications of voltage

This simulation is only about the geometry of the insulators.

(H. Craig Miller, 2015)

2. The SEEA(Secondary electron emission avalanche) theory



a. Electrons are emitted from the triple point of the cathode/negative electrode.
b. Electrons collide the surface of the insulator and more secondary electrons are then emitted.
c. Step b. happens repeatedly and the total amount of electrons multiplies.
d. This avalanche finally causes a discharge between two electrodes.

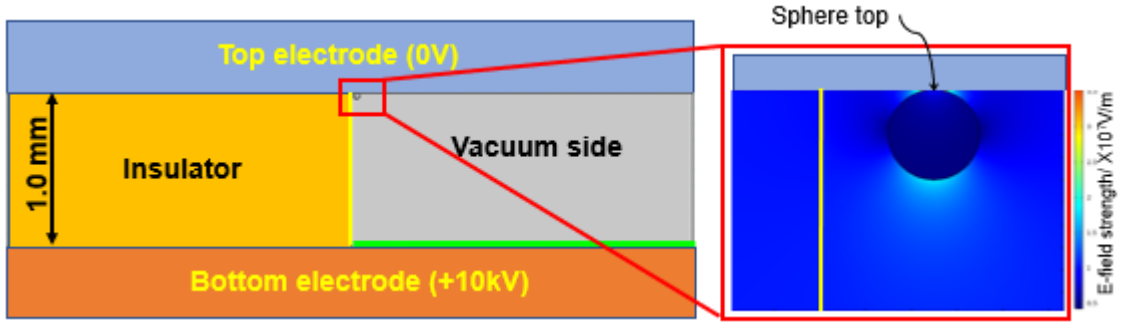
The flashover simulation in COMSOL

3. The basics of the simulation(1)

- Software
  - COMSOL Multiphysics 5.4
- Modules of COMSOL used
  - AC\DC
  - Charged particle tracing
- Judging criteria
  - The Multiplication factor of electrons from the cathode to the anode(negative wafer to the positive wafer).

3. The basics of the simulation(2)

- Geometry
  - –The simulation is done in 2D regime
  - −Top and bottom boundaries are GND wafer and positive HV wafer.(Distance 1mm)
  - −A sphere near the triple point is set to represent a particle
  - −Several typical insulator shapes are considered
- Voltage setting
  - −Top electrode 0V
  - −Bottom electrode 10kV



4. Different shapes of the insulator surface

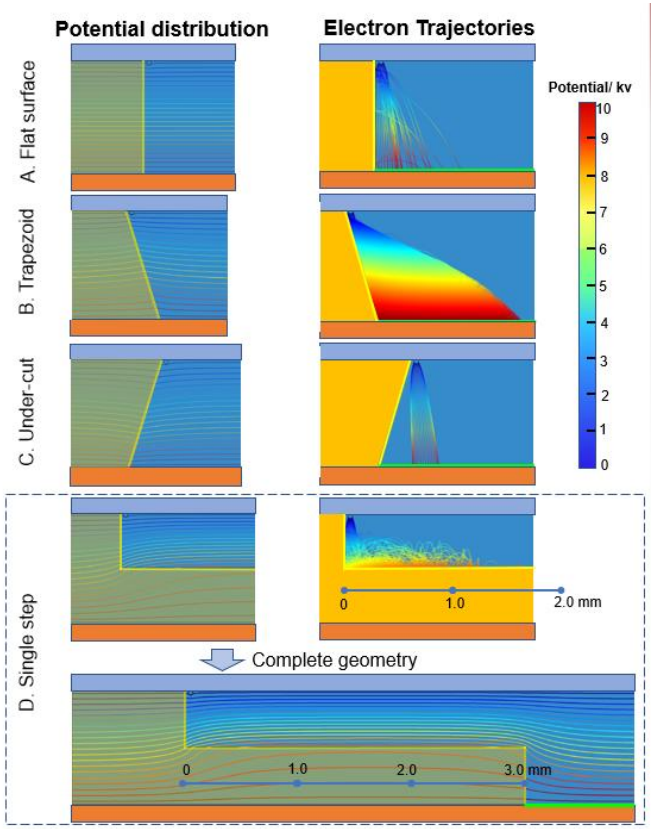
A Flat Surface

B Trapezoid

C Under-cut

D Single step

5. Trajectories and field simulation results



Insulator Geometries	Electric field strength at the triple point / V/m	Electric field strength at the sphere top / V/m	Number of electron on the anode	Multiplication factor
A. Flat Surface	0.93E+07	3.24E+07	38	**1.9**
B. Trapezoid	1.92E+07	4.45E+07	>10000	**>5000**
C. Under-cut	0.39E+07	2.43E+07	20	**1**
D. Single step	1.10E+07	3.68E+07	0	**0**

6. Conclusions

- Different geometries of insulator surface have significant influence on the SEEA of a surface flash over.
- A dielectric particle can enhance the electric field by at least 2 times in the simulation.
- The single step insulator with proper width is easy to manufacture and can block the SE emission avalanche.
- The insulator with trapezoid surface in case B, has very high chance to trigger an secondary electron emission avalanche.