Result and Discussion:

Case 1:

- The air gap and the surrounding environment are air, and the electrode is copper. The upper electrode is maintained at very high voltage of 6e3 V and the lower electrode is grounded. it has no projections.
- Since there are no sharp needles projecting out of the electrodes the electric field are estimated to be relatively uniform with slight intensification near the edges of the curved electrode. Thus, the equipotential lines would be symmetrically spaced as seen in Fig 3.
- The electric field stress will be maximum along the edges of the HV electrode where the curvatures are sharp when compared to the center of the electrode it can be clearly seen in Fig 3 where the maximum electric field of 338886V/m is seen at the edge.
- The average electric field was estimated to be 1.443e5 V/m while the maximum electric field is around 338886 V/m. This indicates that, since there is no projection, the electric field remains relatively undisturbed however there will be some intensification in the corners of the electrodes due to its shape , resulting in a less significant difference between these two values when compared to the other cases with projection.
- The corona inception voltage is the highest in this case, as there are no sharp edges or additional features to enhance the electric field concentration thus larger voltage will be require to induce corona. Since the air gap and the surrounding environment is selected as air the dielectric strength is 3.3e6 V/m. so we should increase the voltage applied to the HV electrode to a point where the maximum electric field exceeds the dielectric strength of the air. In this case this voltage is very high when compare to other 3.

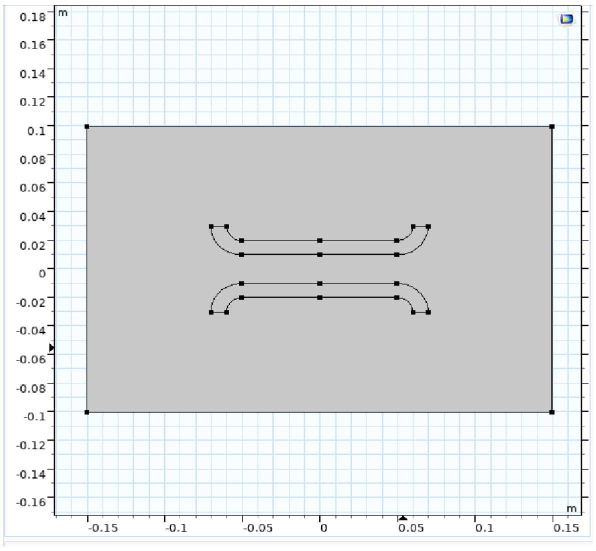


Fig 1: The arrangement of two electrode

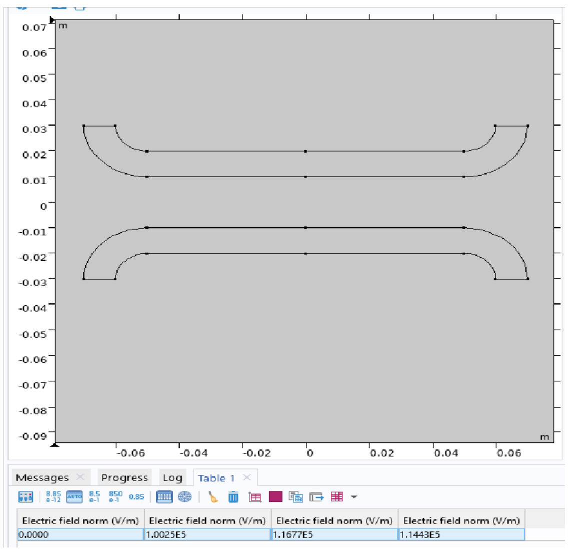


Fig 2: Average electric field

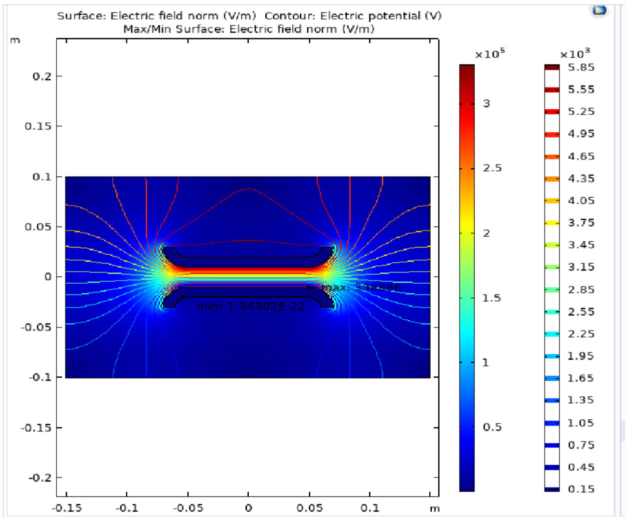


Fig 3: equipotential field lines

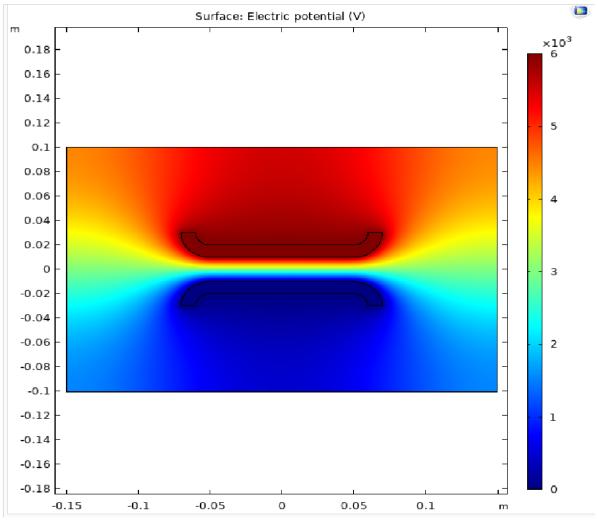


Fig 4: electric potential

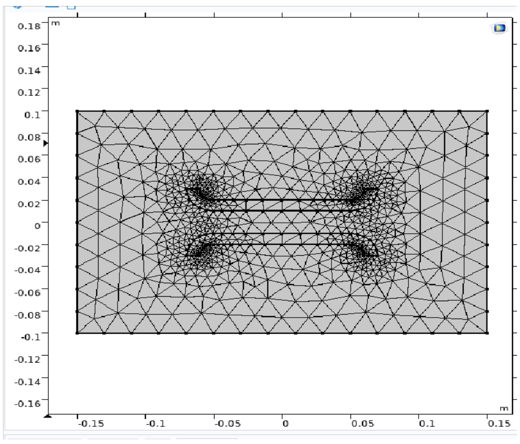


Fig 5: the mesh of high voltage electrode and the grounded electrode with high concertation along the edges

Case 2:

- The air gap and the surrounding environment are air, and the electrode is thought to be copper. With a relative permittivity of 2.3 and an electric conductivity of 1e-15[S/m], the needle is regarded as an insulating material attached to the upper HV electrode. The upper electrode is maintained at very high voltage of 6e3 and the lower electrode is grounded.
- Since there should be a strong electric field at the sharp edge, the equipotential lines is closely spaced at the needle's tip(Fig 5 and Fig 7) . And the farther we go, the wider the lines will be which is clearly seen in the Fig4)
- At the needle's tip, the electric field stress is greatest 1.3397e7 V/m, and as we get farther away, we can observe a sharp decline. As we continue to move the cut line from electrode to needle and back to electrode, the strength of the electric field is shown in Fig 6 where the stress is maximum along the needle and very less in the electrodes.
- Due to the localized field enhancement, the needle tips experience the highest electric field, whereas the rest of the electrode surface experiences a much lower field. Since the sharp enhancement is limited to the needle tips, the average electric field, which is calculated over the entire electrode surface or region of interest, will be less impacted than the maximum field. As a result, it is evident that the maximum electric field of 1.3397e7 V/m is much greater than the average electric field of 1.0025e5 V/m. Because the needle is attached to the electrode, it attracts the field lines more strongly, intensifying the enhancement of the field and causing a greater difference between the maximum and average electric fields.

- Since the air gap and the surrounding environment is selected as air the dielectric strength is 3.3e6 V/m. so we should increase the voltage applied to the HV electrode to a point where the maximum electric field exceeds the dielectric strength of the air. Because of the higher localized field at the needle tip it enhances the field and this would facilitate earlier breakdown, thus a relatively low voltage will be needed for corona inception.

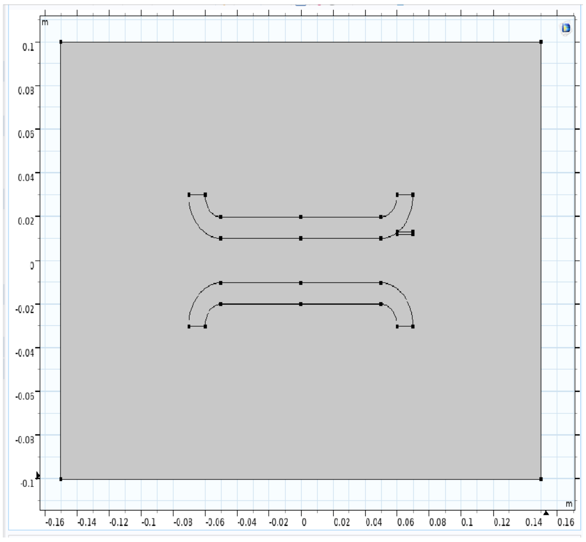


Fig 1: structure of electrode with needle.

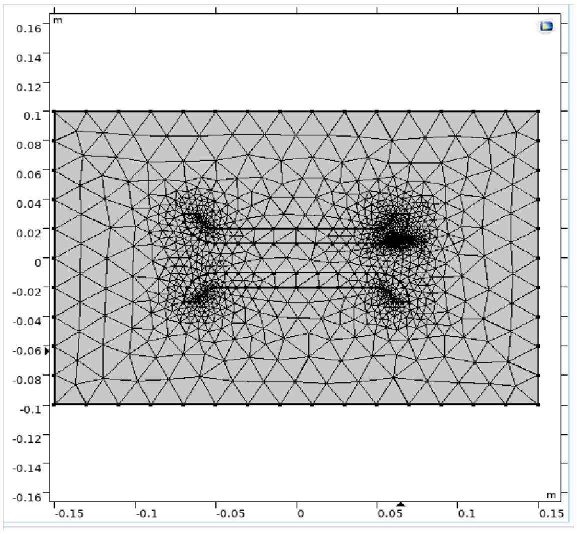


Fig 2: normal meshing of the structure Attached to the upper electrode

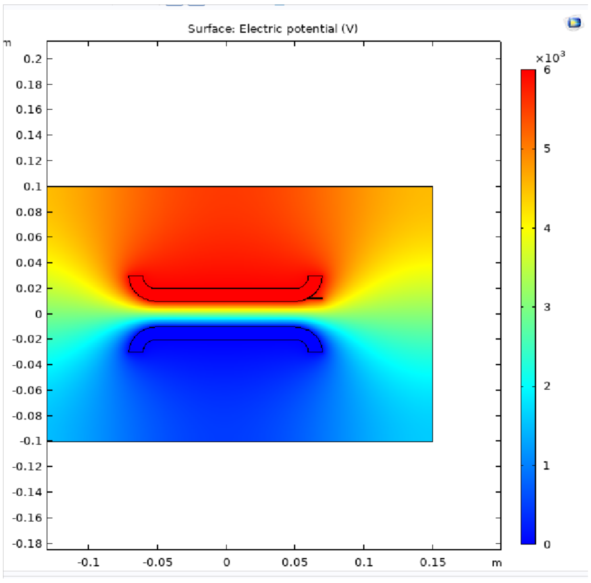


Fig 3: Surface electric potential

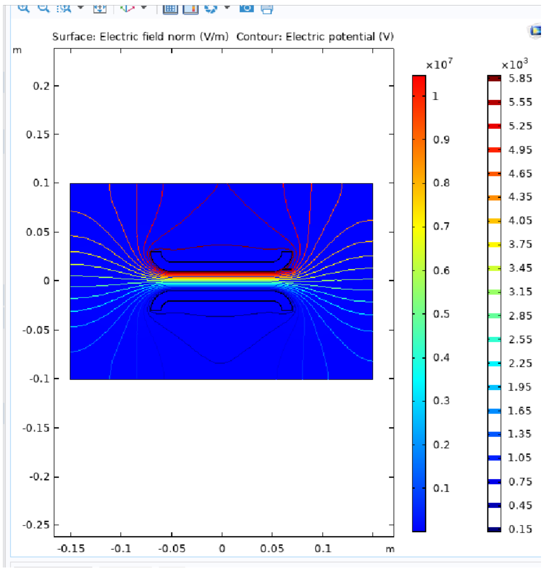


Fig 4: surface electric field contoured with electric potential

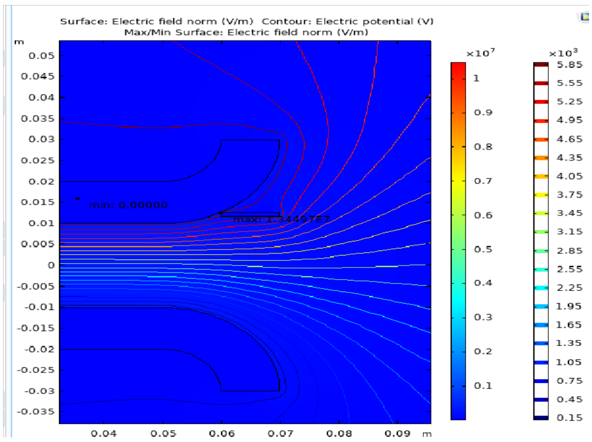


Fig 5: Maximum electric field is at the tip

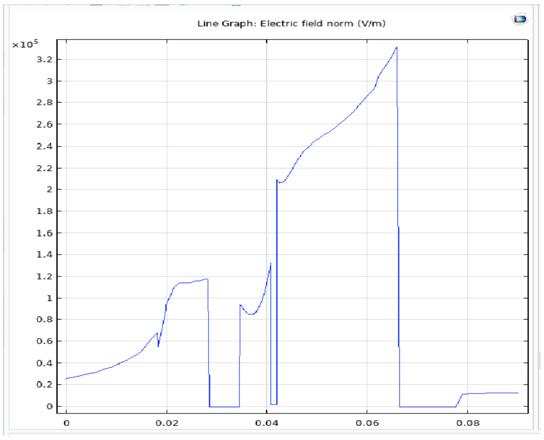


Fig 6: Electric field stress

of the needle

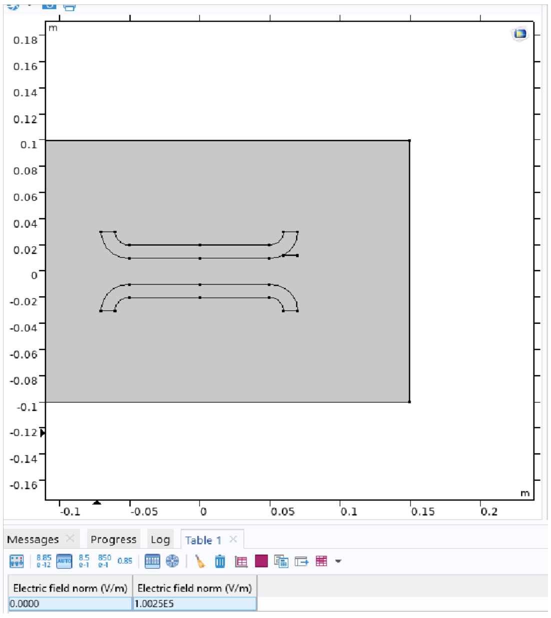


Fig 7: Average electric field

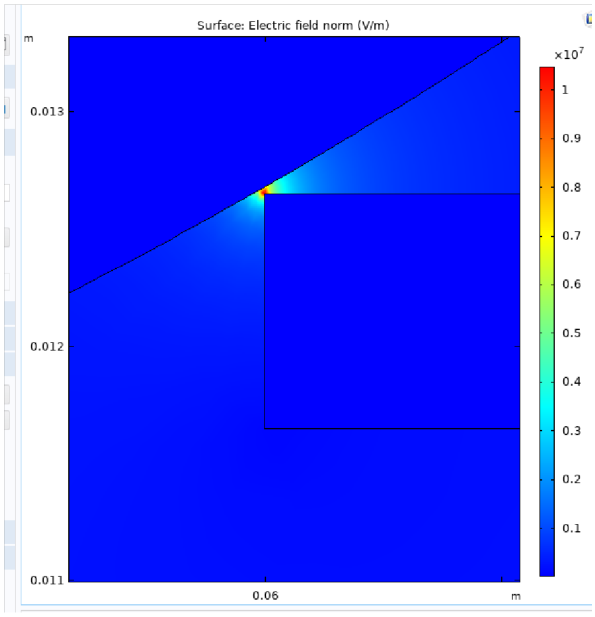


Fig 8: Localized electric field stress

Case 3:

- The electrode is assumed to be copper, and the air gap and surrounding environment are both air. The needle, which is connected to the lower electrode, is considered an insulating material with electric conductivity of 1e-15[S/m] and relative permittivity of 2.3. The bottom electrode is grounded while the upper electrode is maintained at an extremely high voltage of 6e3.
- The equipotential lines are closely distributed near the needle's tip because the sharp edge and thus has a strong electric field. And the lines will get bigger as we move farther which can be seen clearly in Fig 3.
- At the needle's tip, the electric field stress is greatest 1.3397e7 V/m (Fig 2 and Fig 3), and as we get farther away, we can observe a sharp decline. As we continue to move the cut line from electrode to needle and back to electrode, this pattern of the electric field can be seen (Fig 6) where the stress is maximum in the needle.
- The maximum electric field occurs at the needle tips because of the localized field enhancement, while the rest of the electrode surface experiences a much lower field. The average electric field is computed over the entire electrode surface or region of interest and will be less affected than the maximum field because the sharp enhancement is localized to the needle tips. Therefore it can be seen that the average electric field is 1.1677e5 V/m which is very less than the maximum electric field 1.3397e7 V/m. There is larger difference in the maximum and average electric field since the needle is attached to the ground electrode it attracts the field lines more and intensifying the enhancement of the field.
- The corona inception voltage will be way lesser than the case one due to the presence of high field concentration at the needle tip.

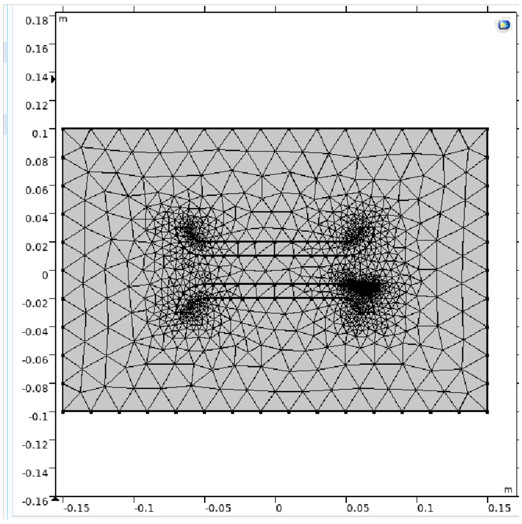


Fig 1: mesh diagram of projection in the ground Electrode

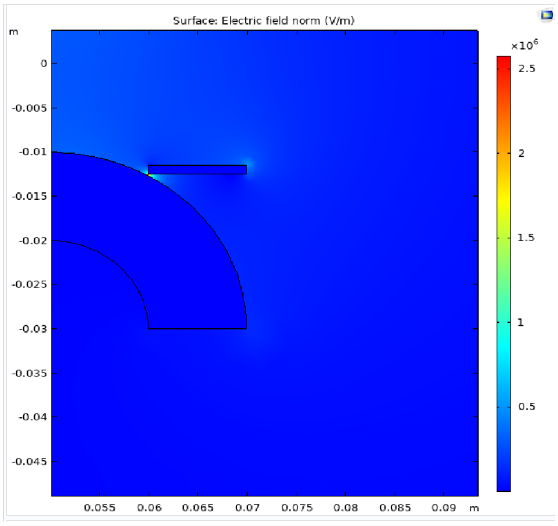


Fig 2: stronger electric field in the sharp tip of the needle

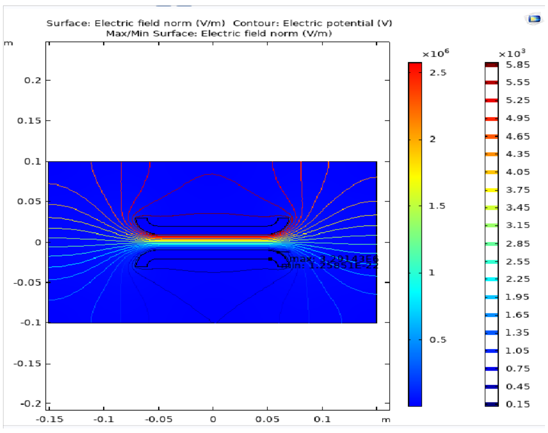


Fig 3: electric field with electric potential

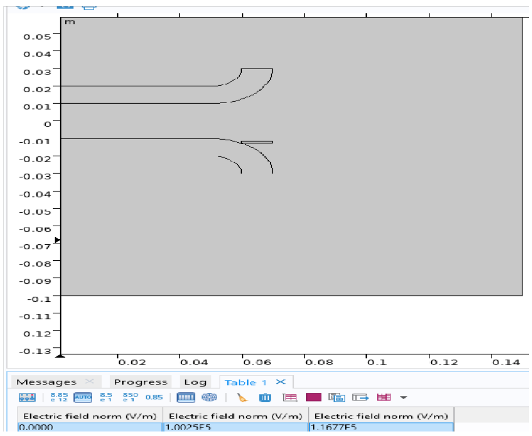


Fig 4: average electric field

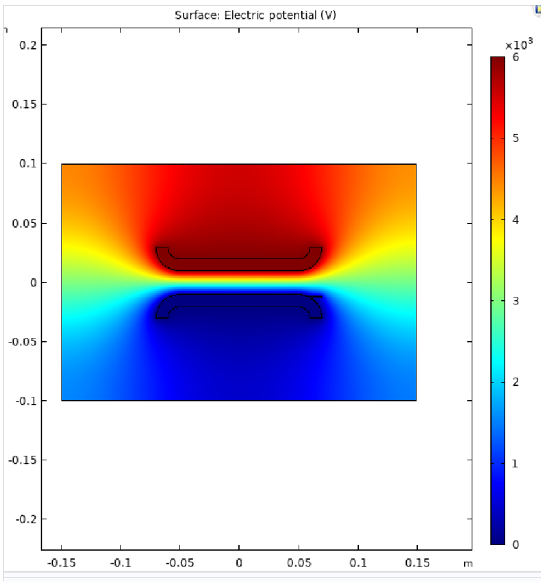


Fig 5: electric potential

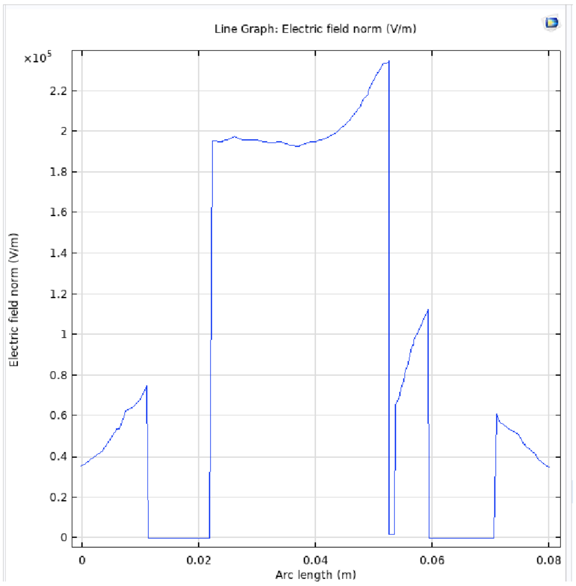
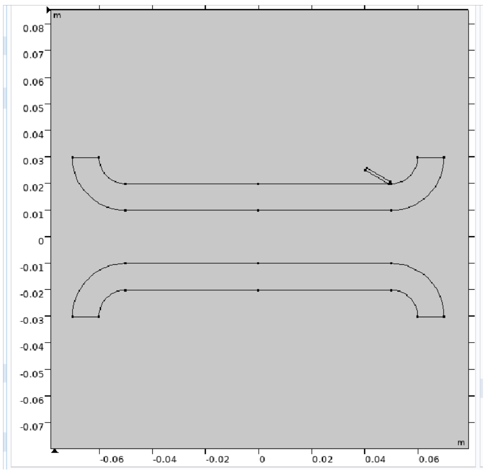


Fig 6: electric field stress

Case 4:

- The electrode is assumed to be copper, and the air gap and surrounding environment are both air. The needle, is projecting out of the upper electrode at an angle, is considered an insulating material with electric conductivity of 1e-15[S/m] and relative permittivity of 2.3. The bottom electrode is grounded while the upper electrode is maintained at an extremely high voltage of 6e3.
- The equipotential lines ought to be closely distributed near the needle's tip because the sharp edge thus will have a strong electric field. And the lines will get bigger as we move farther.
- At the needle's tip, the electric field stress is greatest 410681 V/m (Fig 4), and as we get farther away, we can observe a sharp decline in the electric field stress. As we continue to move the cut line from electrode to needle and back to electrode, this pattern of the electric field can be seen where the electric field strength is maximum in the needle (Fig 5).
- The maximum electric field occurs at the needle tips because of the localized field enhancement, while the rest of the electrode surface experiences a much lower field. The average electric field is computed over the entire electrode surface or region of interest and will be less affected than the maximum field because the sharp enhancement is localized to the needle tips. Therefore it can be seen that the average electric field is 1.1405e5 V/m which is very less than the maximum electric field 410681V/m.
- This case has the lowest corona inception voltage, as the sharp projection dramatically increases the field concentration making it easier for corona to initiate.



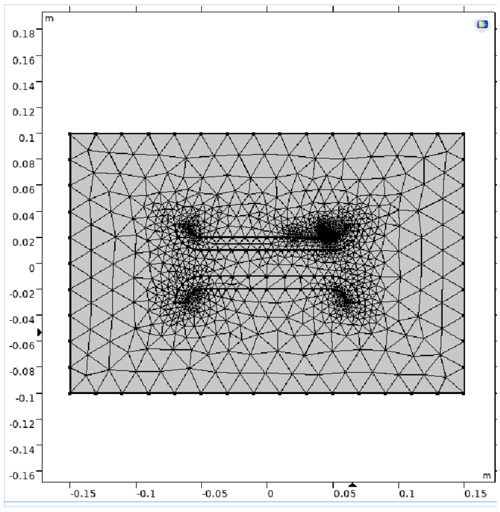
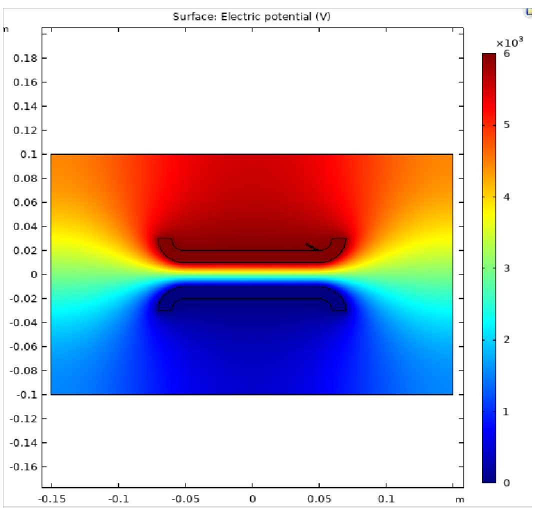


Fig 1: Structure of electrode with needle.

Fig 2: Mesh diagram of structure at

an angle



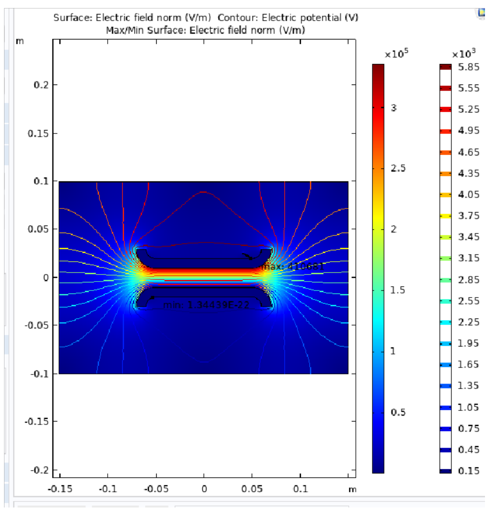


Fig 3: Electric potential

Fig 4: Electric field lines with electric potential

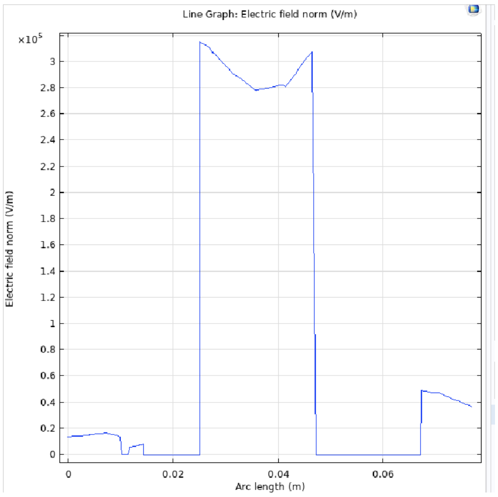


Fig 5: Electric field stress

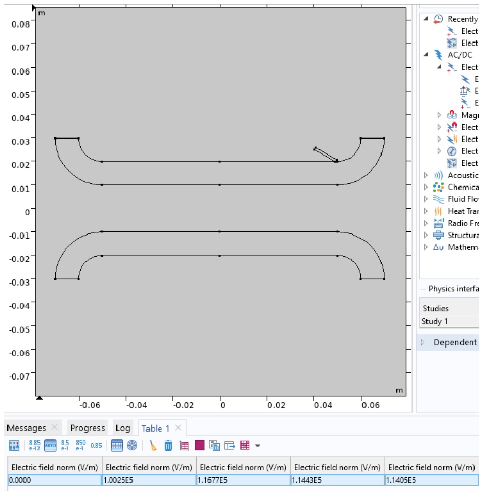


Fig 6: Average electric field