Table of Contents

Part 1

To begin the assignment , the first task was a Monte - Carlo simulation of electrons moving in an empty region in the influence of a electric field.

The magnitude of electric field present in the region was 50,000 V/m given by:

$$E = \frac{V}{\Delta X}$$

Where V -0.1 and Delta X =200nm.

Each electron felt a force of 8.1E-14 N due to this electric field.

$$F = q \times E$$

and the electrons experienced an acceleration of 3.82E17 m/s^2.

$$a = \frac{F}{m}$$

The average current density of the system wasfound using:

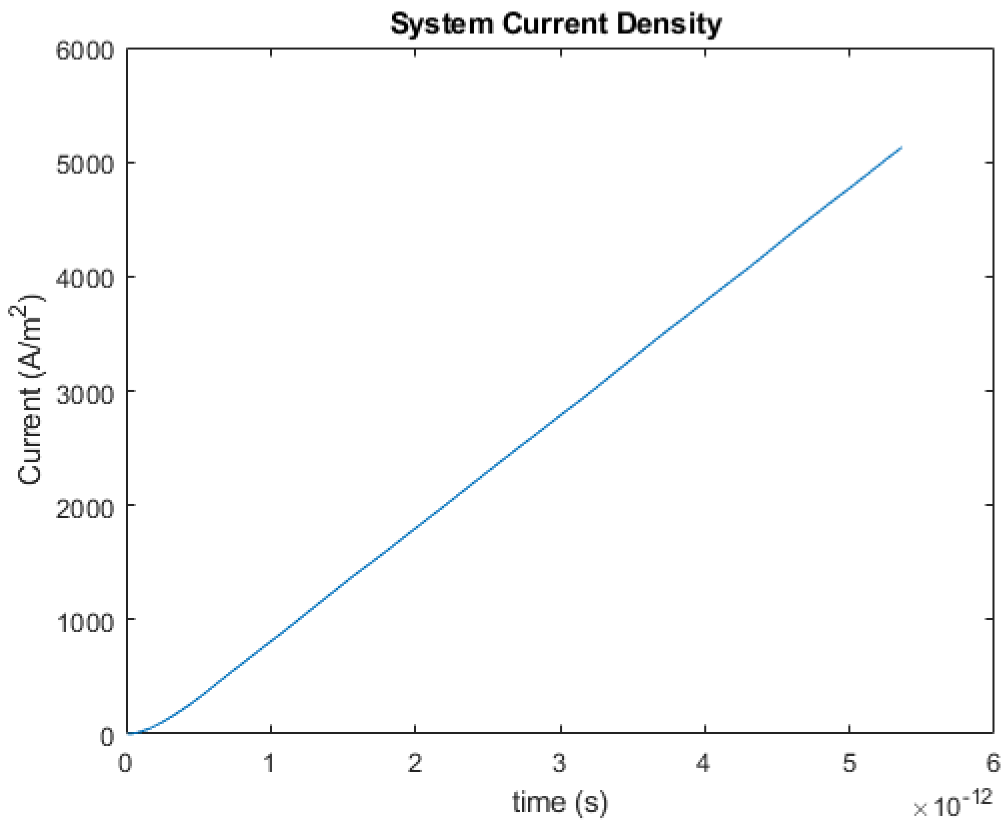
$$J = q \times n \times \bar{v}$$

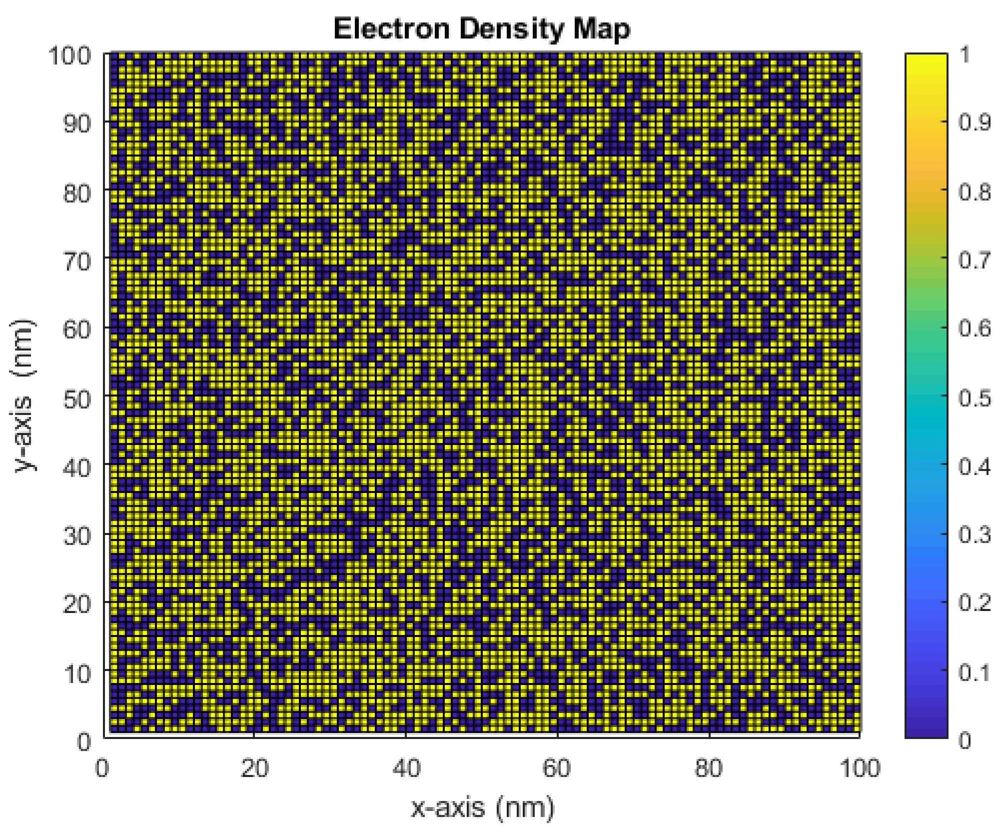
n: electron density 1*10^15 cm^2 , q: elementary charge 1.602E-19C, vbar: average drift velocity in the system.

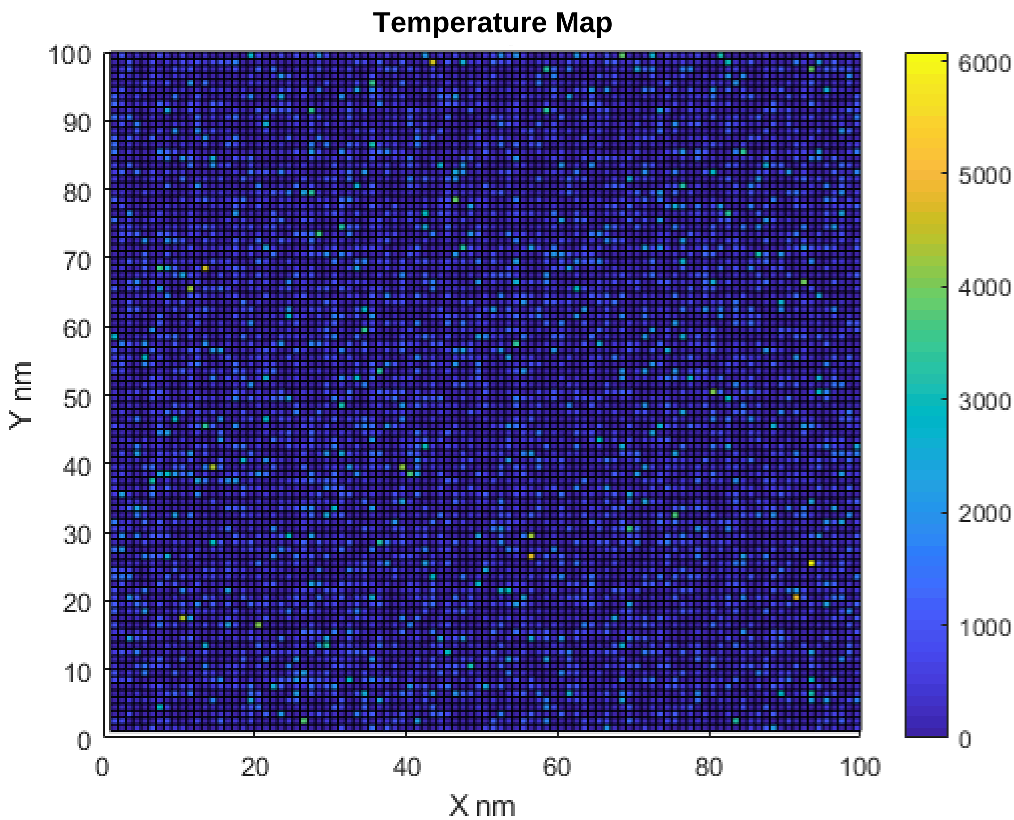
The electron trajectories, the current density plot, electron density map and temperature map can be found in this section.

```
close all
clear all
%set(groot,'defaultFigureVisible','off')% Figures off
set(groot,'defaultFigureVisible','on') % Figures on
Part1()
```

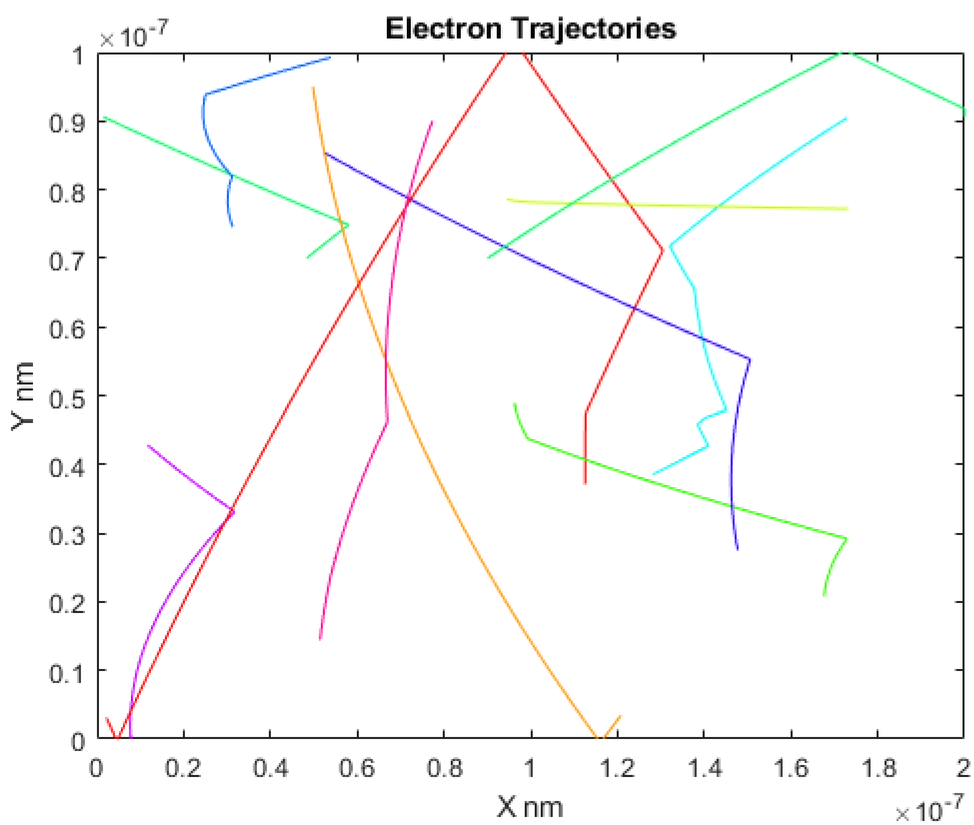
```
The electric field strength is 5.000000e+05
The force on any electron is 8.010000e-14
Acceleration of the electron due to the Force 338174449041627968
```


System Current Density
Current (A/m^2)
time (s)
$\times 10^{-12}$
0
1000
2000
3000
4000
5000
6000
0
1
2
3
4
5
6


Electron Density Map
y-axis (nm)
x-axis (nm)
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1



Temperature Map
Y nm
X nm
0
20
40
60
80
100
10
30
50
70
90
1000
2000
3000
4000
5000
6000



Electron Trajectories
$\times 10^{-7}$
Y nm
X nm
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.2
1.4
1.6
1.8
2

Part 1 Summary

The electric field strength is 50,000 V/m of a 200nm region length. The force on any electron is 8.1E-14 N and the acceleration of any electron is 3.382E17 m/s^2. Due to this acceleration it is observed that the electrons paths are curving.

The systems electric field is constantly accelerating the electrons and thus increasing the current density. The electrons are distributed uniformly throughout the region as seen in the electron density and temperature plots.

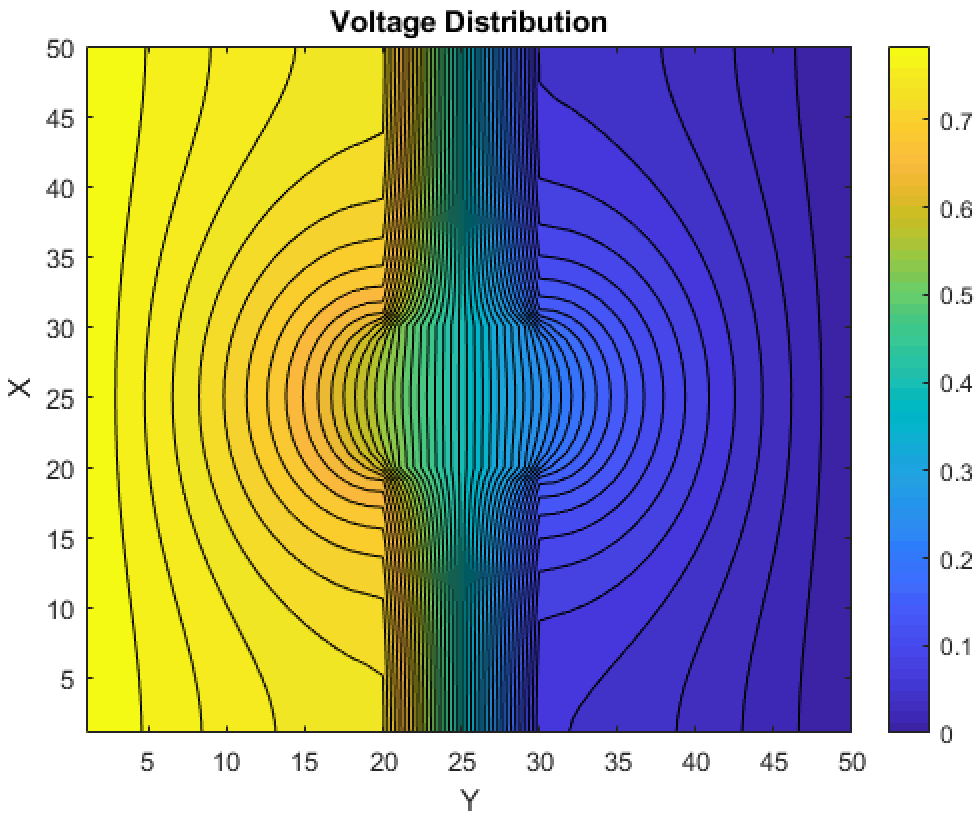
Part 2

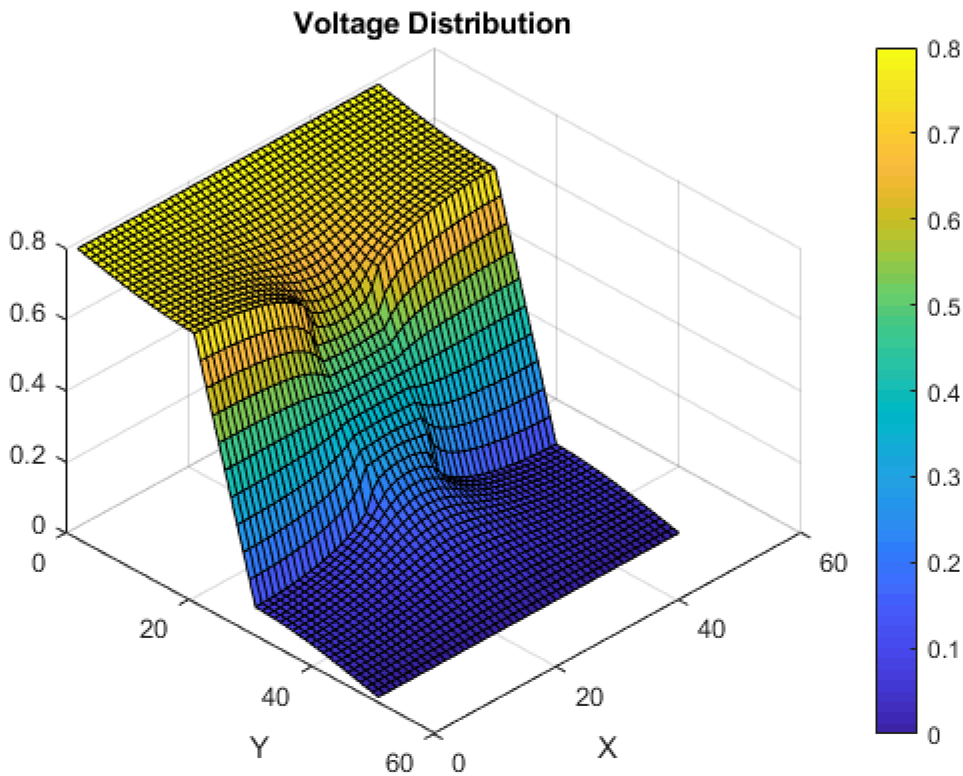
In this part we computed the voltage potential of the entire region using the Finite Difference method. The boundary conditions were set as follows.

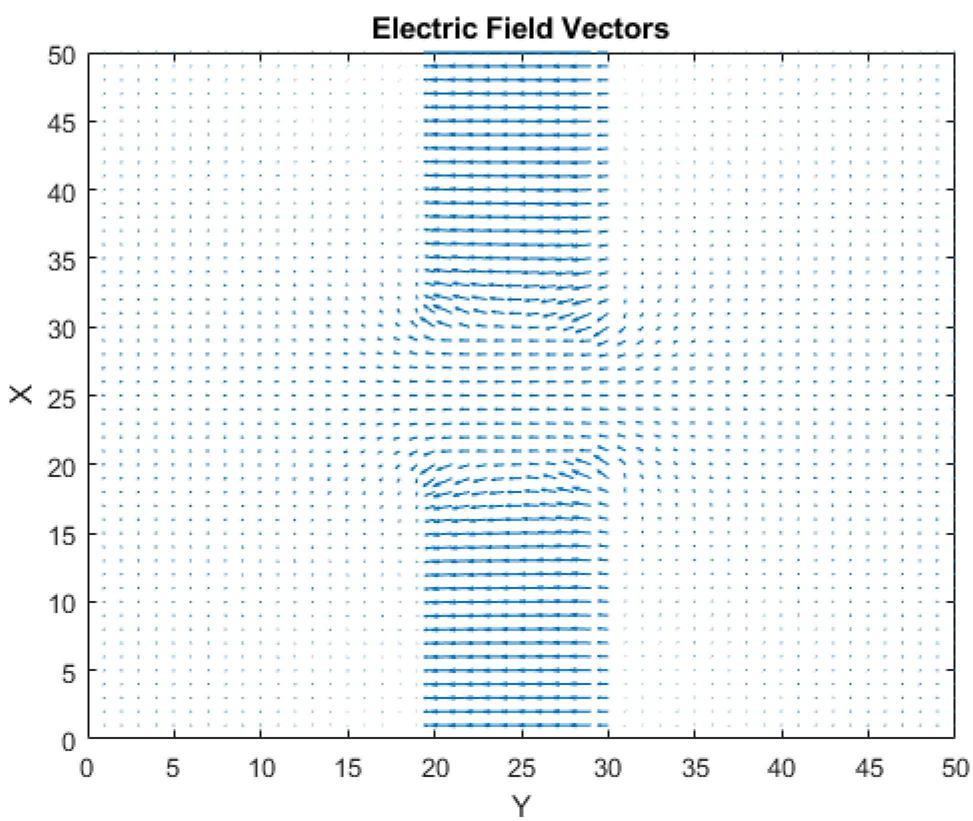
V =0.8volt at x=0nm and V=0 at x=50nm. The top and bottom boundaries were set such that their first derivative was 0.

The conductivity of the region was initialized as 1 except for the area which the boxes contained having a conducvity of 0.01.

```
Part2();
```




Voltage Distribution
0.8
0.6
0.4
0.2
0
0
20
40
Y
60
0
20
40
60
X
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Electric Field Vectors
50
45
40
35
30
X
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45
50
Y

Part 2 Summary

The voltage changes rapidly near the lower conductivity boxes to satisfy the boundary conditions. In addition, we see that the electric field is quite strong between the two boxes and near the corners.

Part 3

The goal of part 3 was to incorporate the electric field results of part 2 as an input to the monte carlo simulation of electron movements from part 1.

The electric field influences the electron movement because the forces acting on the electrons are described as:

Force:

$F = E \times q$

Acceleration:

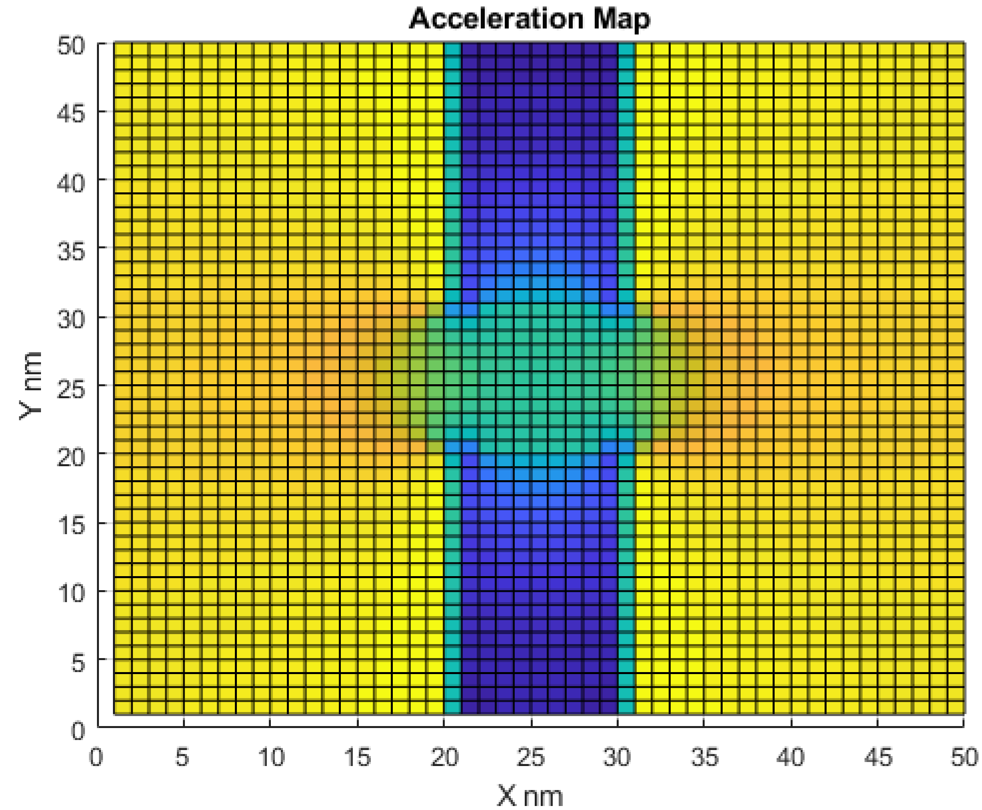
$a = \frac{F}{m}$

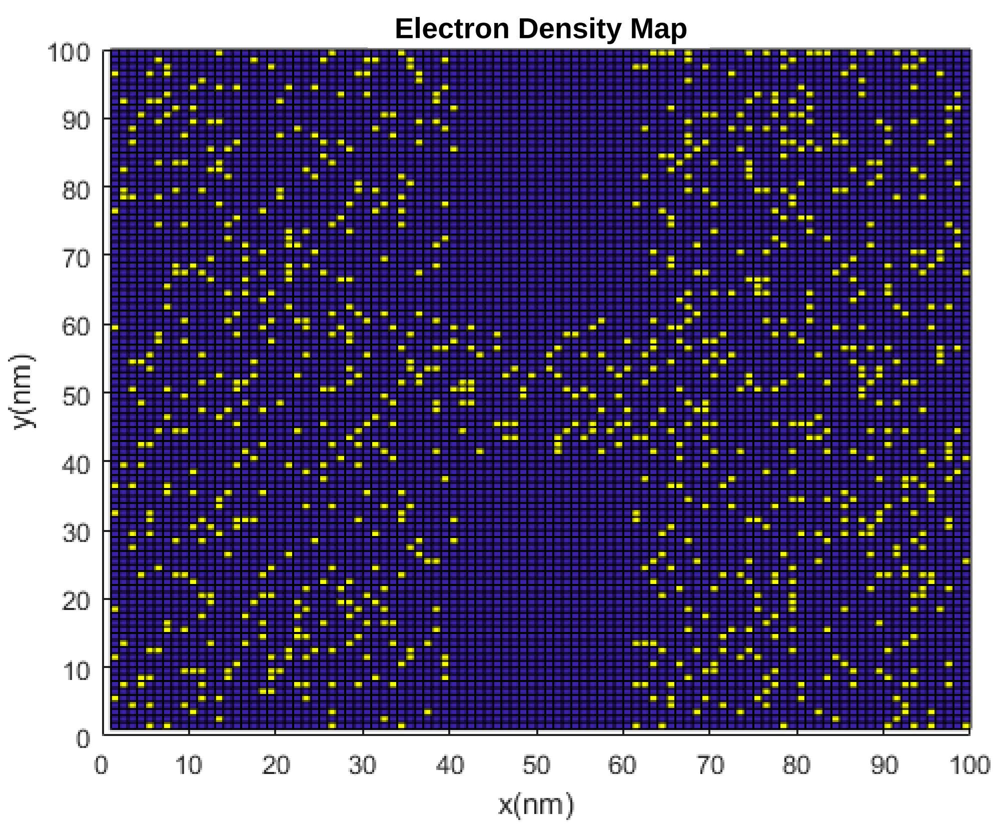
Additive Speed:

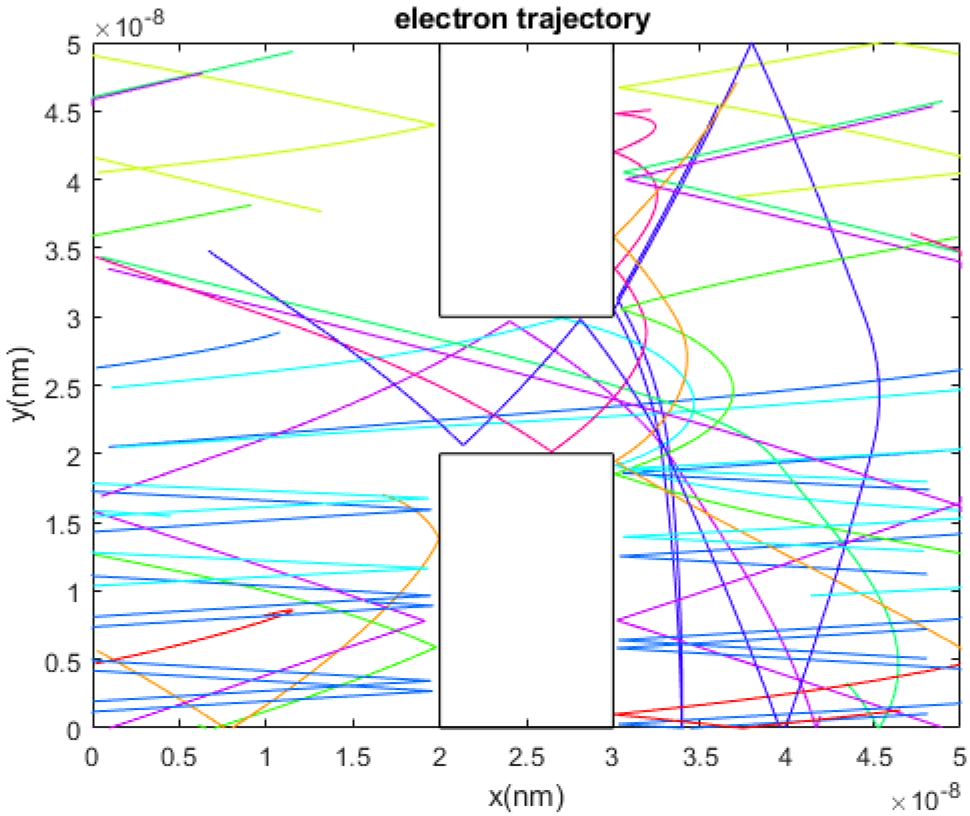
$V_{addtivie} = a \times dt$

A plot of electron density, electron trajectories and the acceleration due to the electric field result are displayed.

```
Part3()
```


Acceleration Map
Y nm
X nm
0
5
10
15
20
25
30
35
40
45
50


Electron Density Map
y(nm)
x(nm)
0
10
20
30
40
50
60
70
80
90
100



Part 3 Summary

Observing the electron density plot we can see that there are no electrons in the boxes as we expect due to to their opaque boundaries. In addition we can see an even distribution of electrons throughout the plot. This makes sense because the increased acceleration due to the E-field symmetrical about a y -axis in the middle of the plot.

To increase the simulations accuracy we could add more electrons to the simulation and increase the mesh density during the finite difference calculation of the voltage solution.

Published with MATLAB® R2018b