Computational Microelectronics Report (Homework #3)

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1. Specification

Figure 1 shows the structure of the epi-layer I am researching. In case of layer 4,5, the problem was solved. Thus, it is essential to specify the thickness and the relative permittivity of each layer, as mobile carriers are ignored. It is stated in Table 1.

a. Layer Structure

Layer #	Layer Materials	Thickness (nm)	Composition	Doping	Note
5	GaN	2	-	Undoped	
4	$Al_xGa_{1-x}N$	27	x=0.22	-	
3	GaN Channel	300	-	Undoped	
2	GaN Buffer	4000	-	Fe	
1	AlN Nucleation	300	-	-	
Substrate	Si				

Figure 1. GaN HEMT Layer structure

Table 1. Thickness and relative permittivity of each layer

	GaN	AlGaN
Thickness (unit: nm)	2	27
Relative permittivity	8.9	8.8

Figure 2. Two dielectric layers

2. Captured code

HW3.m

```
t1 = 2*10^-9; % GaN thickness (unit: m)
t2 = 27*10^-9; % AlGaN thickness (unit: m)
e1 = 8.9*8.854*10^-12; % GaN permittivity (unit: F/m)
e2 = 8.8*8.854*10^-12; % AlGaN permittivity (unit: F/m)

T1 = t1/10^-9;
T2 = t2/10^-9;
N = T1+T2+1; % Point values

% Matrix form for approximation %
A = zeros(N,N);
A(1,1) = 1; A(N,N) = 1;
A(2,1) = e1; A(2,2) = -2*e1; A(2,3) = e1;
A(3,2) = e1; A(3,3) = -e2-e1; A(3,4) = e2;
for i = 4:N-1
    A(i,i-1) = e2;
    A(i,i) = -2*e2;
    A(i,i+1) = e2;
end

b = zeros(N,1); b(N,1) = 1;
x = inv(A)*b;
Vmatrix = x(3,1); % Result

a = [0:N-1];
stem(a,x);
xlabel('Distance (nm)');
ylabel('Electric potential (V)');

C1 = e1/t1;
C2 = e2/t2;
Vformular = C2/(C1+C2); % Analytic solution

Error = (abs(Vmatrix - Vformular))/Vformular*100; % Comparision (error)
```

Figure 3. Captured code

3. Result

C1 = $3.94\times10^{-2}\ \mathrm{F/m^2}$ C2 = $2.88\times10^{-3}\ \mathrm{F/m^2}$

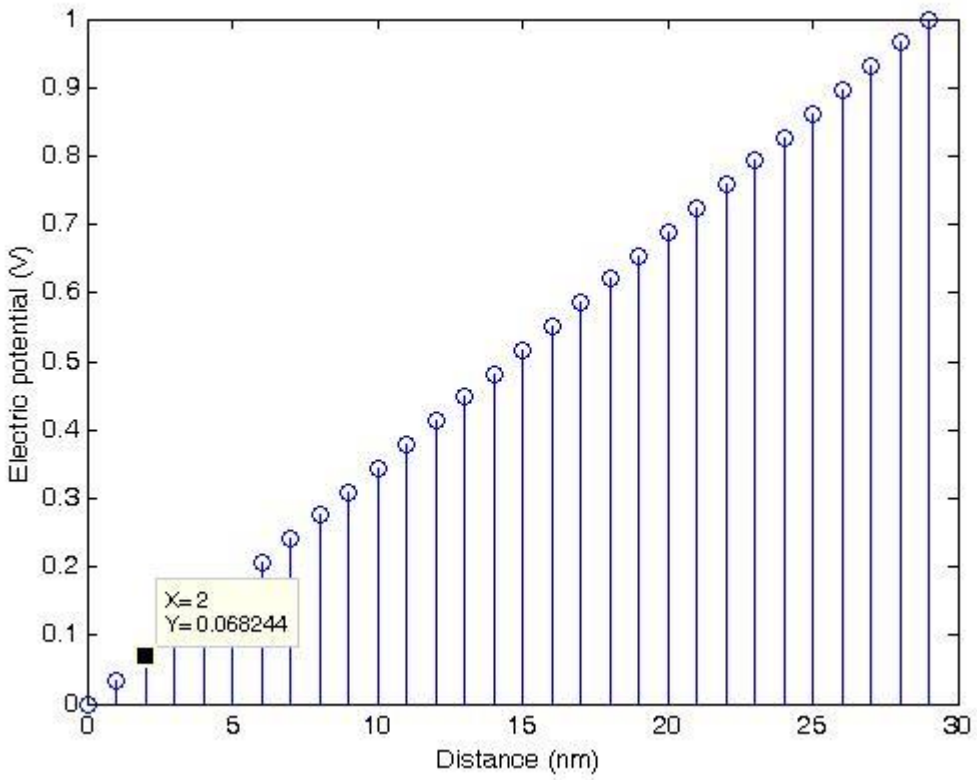

Figure 4. Electric potential - distance graph

Table 2. Comparison of result and solution / error

Result	Analytic solution
>> Vmatrix Vmatrix = 0.0682 0.0682 V	>> Vformular Vformular = 0.0682 0.0682 V
Error >> Error Error = 1.0168e-13 $2.30\times10^{-6}\%$	

The relative error between the result and the analytic expression is $2.30\times10^{-6}\%$.