

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	Composition	Doping	Note
		(nm)			
5	GaN	2	-	Undoped	
4	$\text{Al}_x\text{Ga}_{1-x}\text{N}$	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

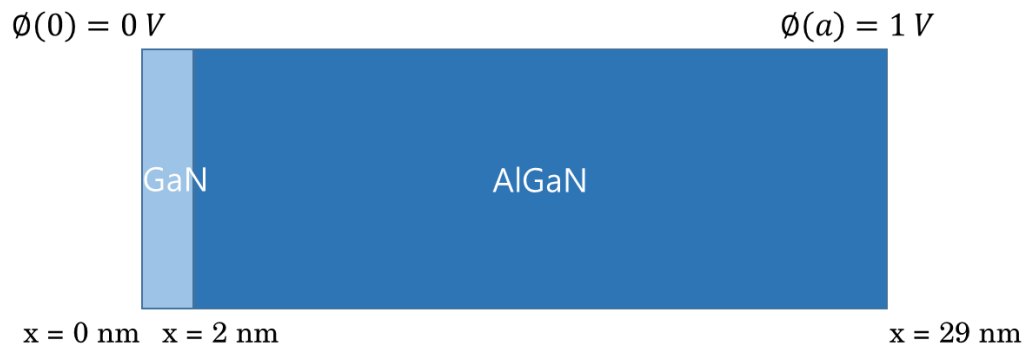


Figure 2. Two dielectric layers

2. Captured code

```
HW3.m x +
1 - t1 = 2*10^-9; % GaN thickness (unit: m)
2 - t2 = 27*10^-9; % AlGaIn thickness (unit: m)
3 - e1 = 8.9*8.854*10^-12; % GaN permittivity (unit: F/m)
4 - e2 = 8.8*8.854*10^-12; % AlGaIn permittivity (unit: F/m)
5
6 - T1 = t1/10^-9;
7 - T2 = t2/10^-9;
8 - N = T1+T2+1; % Point values
9
10 % Matrix form for approximation %
11 - A = zeros(N,N);
12 - A(1,1) = 1; A(N,N) = 1;
13 - A(2,1) = e1; A(2,2) = -2*e1; A(2,3) = e1;
14 - A(3,2) = e1; A(3,3) = -e2-e1; A(3,4) = e2;
15 - for i = 4:N-1
16 -     A(i,i-1) = e2;
17 -     A(i,i) = -2*e2;
18 -     A(i,i+1) = e2;
19 - end
20
21 - b = zeros(N,1); b(N,1) = 1;
22 - x = inv(A)*b;
23 - Vmatrix = x(3,1); % Result
24
25 - a = [0:N-1];
26 - stem(a,x);
27 - xlabel('Distance (nm)');
28 - ylabel('Electric potential (V)');
29
30 - C1 = e1/t1;
31 - C2 = e2/t2;
32 - Vformular = C2/(C1+C2); % Analytic solution
33
34 - Error = (abs(Vmatrix - Vformular))/Vformular*100; % Comparision (error)
```

Figure 3. Captured code

3. Result

$$C1 = 3.94 \times 10^{-2} \text{ F/cm}^2$$

$$C2 = 2.88 \times 10^{-3} \text{ F/cm}^2$$

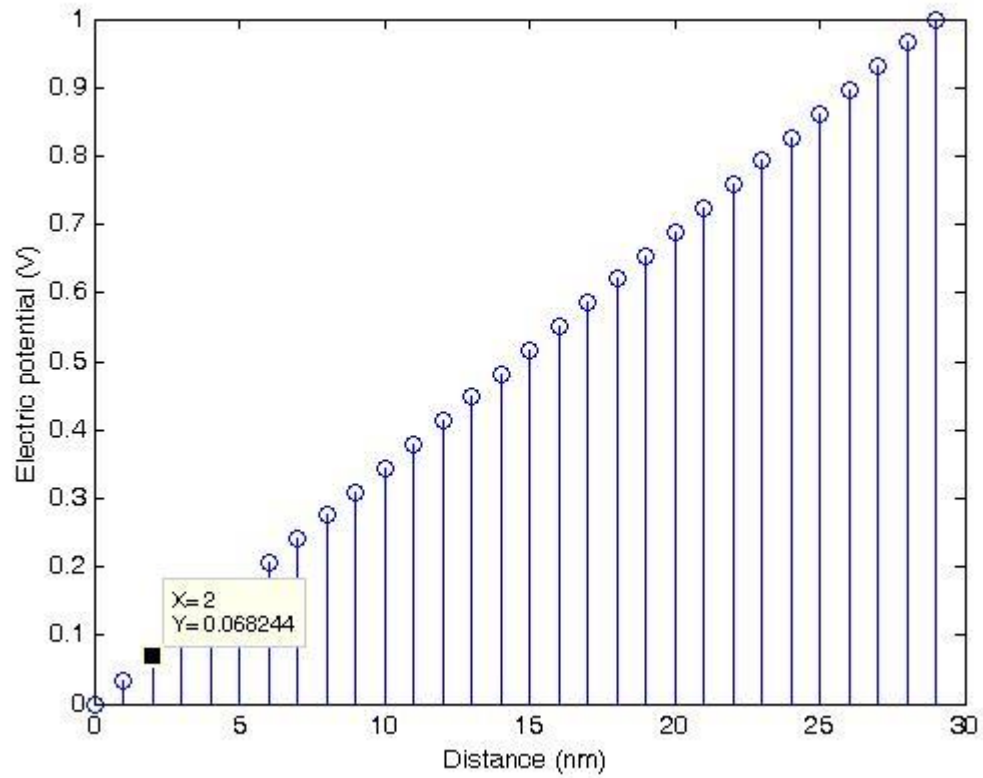


Figure 4. Electric potential - distance graph

Table 2. Comparison of result and solution / error

<u>Result</u> >> Vmatrix Vmatrix = 0.0682 0.0682 V	<u>Analytic solution</u> >> Vformular Vformular = 0.0682 0.0682 V
<u>Error</u> >> Error Error = 1.0168e-13 2.30 × 10 ⁻⁶ %	

The relative error between the result and the analytic expression is 2.30 × 10⁻⁶%.