## DAFTAR PUSTAKA


1. Tamrin, Thamar. 2008. *Pengaruh Lebar Sumur Kuantum Terhadap Energi Transisi Pita Valansi-Konduksi pada Struktur Kuantum* $In_xGa_{1-x}As/InP$. Skripsi Fisika Unhas. Makassar: Unhas

2. Hiroshi, Muhammad. 2008. *Pengaruh Komposisi Indium pada Sumur Potensial* $In_xGa_{1-x}As/InP$ *Terhadap Perubahan Energi Transisi Pita Valensi dan Pita Konduksi.* Skripsi Fisika Unhas. Makassar: Unhas

3. Hasanah L. Khairurrijal. 2007. *Perhitungan Arus Terobosan pada Transistor Dwikutub Sambungan Hetero Si/Si1-XGeX/Si Anisotropik dengan Menggunakan Matriks Transfer*. Bandung: ITB. No 536/D/2007.

4. Irwansyah.2001. *Permodelan Tiga Potensial Penghalang Simetris pada Semikonduktor Superlattice (Modeling Symetric Triple Barier Potential Of Semicoductor Superlattice).* Bogor: IPB. http://repository.ipb.ac.id/bitstream/handle/123456789/15166/G01irw.pdf. Diakses pada tanggal 7 Maret 2013.

5. Nugraha, Edwin Setiawan. 2001. *Permodelan Dua Potensial Penghalang Tidak Simetris pada Semikonduktor Superlattice.* Bogor: IPB. *pada Semikonduktor Superlattice*. Bogor: IPB. http://repository.ipb.ac.id/handle/123456789/13591. Dikses tanggal 7 Maret 2013.

6. Gareso, P.L, et all.2006. *Proton Irradiation-Induced Intermixing in* $In_xGa_{1-xAs}$*/InP Quantum Well—the Efect of In Composition*, Semicond. Sci. Technol, **21,** (2006) 1441–1446.

7. Hamidah, Ida, dan Wilson W. 2001. *Struktur Double Barrier Untuk Aplikasi pada Divais Silikon Amorf.* Bandung: ITB. Vol. 12 No 1, hal 6.

8. Siregar, Rustam E. 2010. *Teori dan Aplikasi Fisika Kuantum*. Bandung: Widya Padjadjaran.

9. Rio, S.Reka, dan Iida, Masamori. 1999. *Fisika dan Teknologi Semikonduktor.* Jakarta: Pt PradnyaParamita.

10. http://math279.wordpress.com/2012/10/6/matlab-integral-dengan-metode-trapesium/. . Diakses pada tanggal 28 Maret 2013.

11. E. Herbert Li. *Material parameters of InGaAs and InAlGaAs systems for use in quantum well structures at low and room temperatures.*

http://www.sciencedirect.com/science/article/pii/S1386947799002623.
Diakses pada tanggal 25 Maret 2013.

**Lampiran 1**

**Penurunan Persamaan Koefisien Transmisi**

Setelah mendapatkan persamaan (2.25) sampai (2.29), selanjutnya akan diturunkan dengan metoda matriks transfer yang didasarkan pada kemalaran fungsi gelombang partikel dan turunannya pada setiap perbatasan. Pada setiap perbatasan dapat dituliskan:

$$\Psi_n(L) = \Psi_{n+1}(L)$$

(Q1.1)

dan

$$\frac{d\Psi_n(L)}{dL} = \frac{d\Psi_{n+1}(L)}{dL}$$

(Q1.2)

Untuk kasus struktur dua potensial penghalang nilai n= 1,2,3,4 atau $L_1$, $L_2$, $L_3$, dan $L_4$ yang merupakan daerah perbatasan. Selanjutnya dari persamaan 2.25 sampai persamaan 2.29 akan diperoleh dua matrik $M_n$ dengan ukuran 2 x 2 dan C memiiki ukuran 2 x 1 yang didasarkan pada kemalaran gelombang dan turunannya pada setiap daerah perbatasan. Misalnya:

a. Dititik L = 0

$$U_1(0) = U_2(0) \longrightarrow A_1 + B_1 = A_2 + B_2$$

(Q1.3)

$$\frac{dU_1(0)}{dL} = \frac{dU_2(0)}{dL} \longrightarrow i(\alpha - k)A_1 - i(\alpha + k)B_1 = (\beta - ik)A_2 - (\beta_1 + ik)B_2$$

(Q1.4)

Persamaan Q1.3 dan persamaan Q1.4 dapat dituliskan dalam bentuk matriks sebagai berikut:

$$\begin{bmatrix} 1 & 1 \\ i(\alpha-k) & -i(\alpha+k) \end{bmatrix} \begin{bmatrix} A_1 \\ B_1 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ (\beta-ik) & -(\beta+ik) \end{bmatrix} \begin{bmatrix} A_2 \\ B_2 \end{bmatrix}$$

$$\begin{bmatrix} A_1 \\ B_1 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ i(\alpha-k) & -i(\alpha+k) \end{bmatrix}^{-1} \begin{bmatrix} 1 & 1 \\ (\beta-ik) & -(\beta+ik) \end{bmatrix} \begin{bmatrix} A_2 \\ B_2 \end{bmatrix}$$

$$\begin{bmatrix} A_1 \\ B_1 \end{bmatrix} = -\frac{1}{2i\alpha} \begin{bmatrix} -i(\alpha+k) & -1 \\ i(\alpha-k) & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ (\beta-ik) & -(\beta+ik) \end{bmatrix} \begin{bmatrix} A_2 \\ B_2 \end{bmatrix}$$

(Q1.5)

b. Dititik $L = L_b$

$U_2(L_b) = U_3(L_b)$

$\rightarrow A_2\, e^{(\beta-ik)L_b} + B_2\, e^{-(\beta+ik)L_b} = A_3\, e^{i(\alpha-k)L_b} + B_3\, e^{i(\alpha+k)L_b}$

(Q1.6)

$$\frac{dU_2(L_b)}{dL} = \frac{dU_3(L_b)}{dL}$$

$\rightarrow (\beta-ik) A_2 e^{(\beta-ik)L_b} - (\beta+ik) B_2\, e^{-(\beta+ik)L_b} = i(\alpha-k) A_3\, e^{i(\alpha-k)L_b} -$

$i(\alpha+k) B_3\, e^{i(\alpha+k)L_b}$

(Q1.7)

persamaan Q1.6 dan Q1.7 dituliskan dalam bentuk matriks sebagai berikut:

$$\begin{bmatrix} e^{(\beta-ik)L_b} & e^{-(\beta+ik)L_b} \\ (\beta-ik)e^{(\beta-ik)L_b} & -(\beta+ik)e^{-(\beta+ik)L_b} \end{bmatrix} \begin{bmatrix} A_2 \\ B_2 \end{bmatrix}$$

$$= \begin{bmatrix} e^{i(\alpha-k)L_b} & e^{-i(\alpha+k)L_b} \\ i(\alpha-k)e^{i(\alpha-k)L_b} & -i(\alpha+k)e^{-i(\alpha+k)L_b} \end{bmatrix} \begin{bmatrix} A_3 \\ B_3 \end{bmatrix}$$

$$\begin{bmatrix} A_2 \\ B_2 \end{bmatrix} = -\frac{1}{2\beta} e^{2ikL_b} \begin{bmatrix} -(\beta+ik)e^{-(\beta+ik)L_b} & -e^{-(\beta+ik)L_b} \\ -(\beta-ik)e^{-(\beta-ik)L_b} & e^{(\beta-ik)L_b} \end{bmatrix}$$

$$\begin{bmatrix} e^{i(\alpha-k)L_b} & e^{-i(\alpha+k)L_b} \\ i(\alpha-k)e^{i(\alpha-k)L_b} & -i(\alpha+k)e^{-i(\alpha+k)L_b} \end{bmatrix} \begin{bmatrix} A_3 \\ B_3 \end{bmatrix}$$

(Q1.8)

c. Dititik L = $L_b + L_s$

$U_3(L_b+L_s) = U_4(L_b+L_s)$

$\rightarrow A_3 e^{i(\alpha-k)(L_b+L_s)} + B_3\, e^{-i(\alpha+k)(L_b+L_s)} =$

$A_4\, e^{(\beta-ik)(L_b+L_s)} + B_4\, e^{-(\beta+ik)(L_b+L_s)}$

(Q1.9)

$\frac{dU_3(L_b+L_s)}{dx} = \frac{dU_4(L_b+L_s)}{dx}$

$\rightarrow i(\alpha-k)A_3 e^{i(\alpha-k)(L_b+L_s)} - i(\alpha+k)B_3\, e^{-i(\alpha+k)(L_b+L_s)}$

$=(\beta-ik)A_4\, e^{(\beta-ik)(L_b+L_s)} - (\beta+ik)B_4\, e^{-(\beta+ik)(L_b+L_s)}$

(Q1.10)

persamaan Q1.9 dan Q1.10 dituliskan dalam bentuk matriks sebagai berikut:

$$\begin{bmatrix} e^{i(\alpha-k)(L_b+L_s)} & e^{-i(\alpha+k)(L_b+L_s)} \\ i(\alpha-k)e^{i(\alpha-k)(L_b+L_s)} & -i(\alpha+k)e^{-i(\alpha+k)(L_b+L_s)} \end{bmatrix} \begin{bmatrix} A_3 \\ B_3 \end{bmatrix}$$

$$= \begin{bmatrix} e^{(\beta-ik)(L_b+L_s)} & e^{-(\beta+ik)(L_b+L_s)} \\ (\beta-ik)e^{(\beta-ik)(L_b+L_s)} & -(\beta+ik)e^{-(\beta+ik)(L_b+L_s)} \end{bmatrix} \begin{bmatrix} A_4 \\ B_4 \end{bmatrix}$$

$$\begin{bmatrix} A_3 \\ B_3 \end{bmatrix} = -\frac{1}{2i\alpha} e^{2ik(L_b+L_s)} \begin{bmatrix} -i(\alpha+k)e^{-i(\alpha+k)(L_b+L_s)} & -e^{-i(\alpha+k)(L_b+L_s)} \\ -i(\alpha-k)e^{i(\alpha-k)(L_b+L_s)} & e^{i(\alpha-k)(L_b+L_s)} \end{bmatrix}$$

$$\begin{bmatrix} e^{(\beta-ik)(L_b+L_s)} & e^{-(\beta+ik)(L_b+L_s)} \\ (\beta-ik)e^{(\beta-ik)(L_b+L_s)} & -(\beta+ik)e^{-(\beta+ik)(L_b+L_s)} \end{bmatrix} \begin{bmatrix} A_4 \\ B_4 \end{bmatrix}$$

(Q1.11)

d. Dititik $L = L_b + L_s + L_c$

$U_4(L_b + L_s + L_c) = U_5(L_b + L_s + L_c)$

$\rightarrow A_4 e^{(\beta - ik)(Lb + Ls + Lc)} + B_4 e^{-(\beta + ik)(Lb + Ls + Lc)} =$

$A_5 e^{i(\alpha - k)(Lb + Ls + Lc)} + B_5\, e^{-i(\alpha + k)(Lb + Ls + Lc)}$

(Q1.12)

$\frac{d_4(\mathrm{Lb + Ls + Lc})}{dL} = \frac{dU_5(\mathrm{Lb + Ls + Lc})}{dL}$

$\rightarrow (\beta - ik) A_4 e^{(\beta - ik)(Lb + Ls + Lc)} - (\beta + ik)\, B_4 e^{-(\beta + ik)(Lb + Ls + Lc)}$

$= i(\alpha - k) A_5 e^{i(\alpha - k)(Lb + Ls + Lc)} - i(\alpha + k) B_5\, e^{-i(\alpha + k)(Lb + Ls + Lc)}$

(Q1.13)

persamaan Q1.12 dan Q1.13 dituliskan dalam bentuk matriks sebagai berikut:

$$\begin{bmatrix} e^{(\beta - ik)(Lb + Ls + Lc)} & e^{-(\beta + ik)(Lb + Ls + Lc)} \\ (\beta - ik) e^{(\beta - ik)(Lb + Ls + Lc)} & -(\beta + ik)\, \mathrm{B4} e^{-(\beta + ik)(Lb + Ls + Lc)} \end{bmatrix} \begin{bmatrix} A_4 \\ B_4 \end{bmatrix}$$

$$= \begin{bmatrix} e^{i(\alpha - k)(Lb + Ls + Lc)} & e^{-i(\alpha + k)(Lb + Ls + Lc)} \\ i(\alpha - k) e^{i(\alpha - k)(Lb + Ls + Lc)} & -i(\alpha + k) e^{-i(\alpha + k)(Lb + Ls + Lc)} \end{bmatrix} \begin{bmatrix} A_5 \\ B_5 \end{bmatrix}$$

$$\begin{bmatrix} A_4 \\ B_4 \end{bmatrix} = -\frac{1}{2\beta} e^{2ik(Lb + Ls + Lc)}$$

$$\begin{bmatrix} -(\beta + ik)\, \mathrm{B4} e^{-(\beta + ik)(Lb + Ls + Lc)} & -e^{-(\beta + ik)(Lb + Ls + Lc)} \\ -(\beta - ik) e^{(\beta - ik)(Lb + Ls + Lc)} & e^{(\beta - ik)(Lb + Ls + Lc)} \end{bmatrix}$$

$$\begin{bmatrix} e^{i(\alpha - k)(Lb + Ls + Lc)} & e^{-i(\alpha + k)(Lb + Ls + Lc)} \\ i(\alpha - k) e^{i(\alpha - k)(Lb + Ls + Lc)} & -i(\alpha + k) e^{-i(\alpha + k)(Lb + Ls + Lc)} \end{bmatrix} \begin{bmatrix} A_5 \\ B_5 \end{bmatrix}$$

(Q1.14)

Dengan menggabungkan seluruh persamaan matriks diatas akan diperoleh hubungan:

$\begin{bmatrix} A_1 \\ B_1 \end{bmatrix}$ = $M_T$ $\begin{bmatrix} A_5 \\ B_5 \end{bmatrix}$

(Q1.15)

Untuk $B_5$=0 karena tidak ada gelombang di daerah 5 yang dipantulkan. Selanjutnya, $M_T$ dinyatakan:

$$M_T = -\frac{1}{16\alpha^2\beta^2} e^{2ik(3L_b+2L_s+L_b)} \begin{bmatrix} -i(\alpha+k) & -1 \\ i(\alpha-k) & 1 \end{bmatrix} \text{X} \begin{bmatrix} 1 & 1 \\ (\beta-ik) & -(\beta+ik) \end{bmatrix} \text{X}$$

$$\begin{bmatrix} -(\beta+ik)e^{-(\beta+ik)L_b} & -e^{-(\beta+ik)L_b} \\ -(\beta-ik)e^{-(\beta-ik)L_b} & e^{(\beta-ik)L_b} \end{bmatrix} \text{X} \begin{bmatrix} e^{i(\alpha-k)L_b} & e^{-i(\alpha+k)L_b} \\ i(\alpha-k)e^{i(\alpha-k)L_b} & -i(\alpha+k)e^{-i(\alpha+k)L_b} \end{bmatrix}$$

$$\text{X}\begin{bmatrix} -i(\alpha+k)e^{-i(\alpha+k)(L_b+L_s)} & -e^{-i(\alpha+k)(L_b+L_s)} \\ -i(\alpha-k)e^{i(\alpha-k)(L_b+L_s)} & e^{i(\alpha-k)(L_b+L_s)} \end{bmatrix}$$

$$\text{X}\begin{bmatrix} e^{(\beta-ik)(L_b+L_s)} & e^{-(\beta+ik)(L_b+L_s)} \\ (\beta-ik)e^{(\beta-ik)(L_b+L_s)} & -(\beta+ik)e^{-(\beta+ik)(L_b+L_s)} \end{bmatrix}$$

$$\text{X}\begin{bmatrix} -(\beta+ik)\,\text{B4}e^{-(\beta+ik)(Lb+Ls+Lc)} & -e^{-(\beta+ik)(Lb+Ls+Lc)} \\ -(\beta-ik)e^{(\beta-ik)(Lb+Ls+Lc)} & e^{(\beta-ik)(Lb+Ls+Lc)} \end{bmatrix}$$

$$\text{X}\begin{bmatrix} e^{i(\alpha-k)(Lb+Ls+Lc)} & e^{-i(\alpha+k)(Lb+Ls+Lc)} \\ i(\alpha-k)e^{i(\alpha-k)(Lb+Ls+Lc)} & -i(\alpha+k)e^{-i(\alpha+k)(Lb+Ls+Lc)} \end{bmatrix}$$

(Q1.16)

Dengan menyelesaikan perkalian-perkalian matriks pada persamaan Q1.16, diperoleh:

$$\frac{A_1}{A_5} = \cosh(\beta L_b)\cosh(\beta L_c) - \frac{1}{4}\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)^2 \sinh(\beta L_b)\sinh(\beta L_c) + \frac{1}{4}\left(\frac{\alpha}{\beta}+\frac{\beta}{\alpha}\right)^2 \sinh(\beta L_b)\sinh(\beta L_c)\cos(2\alpha L_s) + i\left[-\frac{1}{2}\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)\sinh(\beta L_b)\cosh(\beta L_c) - \frac{1}{2}\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)\sinh(\beta L_c)\cosh(\beta L_c) + \frac{1}{4}\left(\frac{\alpha}{\beta}+\frac{\beta}{\alpha}\right)^2\sinh(\beta L_b)\sinh(\beta L_c)\sin(2\alpha L_s)\right]$$

$e^{i\alpha(L_b+L_c)}$

(Q1.17)

selanjutnya didefinisikan:

$$\mathrm{Re}\left(\frac{A_1}{A_5}\right) = cosh\ (\beta L_b)cosh(\beta L_c) - \frac{1}{4}\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)^2 sinh\ (\beta L_b)\ sinh\ (\beta L_c) + \frac{1}{4}\left(\frac{\alpha}{\beta}+\frac{\beta}{\alpha}\right)^2 sinh\ (\beta L_b) sinh(\beta L_c) cos(2\alpha L_s)$$

(Q1.18)

$$\mathrm{Im}\left(\frac{A_1}{A_5}\right) = -\frac{1}{2}\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)\sinh(\beta Lb)cosh(\beta Lc) - \frac{1}{2}\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)sinh(\beta Lc) cosh(\beta Lc) + \frac{1}{4}\left(\frac{\alpha}{\beta}+\frac{\beta}{\alpha}\right)^2\ sinh(\beta Lb)sinh\ (\beta Lc) si\ n(2\alpha L_s)$$

(Q1.19)

Berdasarkan persamaan 2.20, maka didapatkan harga:

$$\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right) = \frac{2E-V_0}{\sqrt{E(V_0-E)}}$$

$$\left(\frac{\alpha}{\beta}-\frac{\beta}{\alpha}\right)^2 = \frac{(2E-V_0)^2}{E(V_0-E)}$$

$$\left(\frac{\alpha}{\beta}+\frac{\beta}{\alpha}\right)^2 = \frac{{V_0}^2}{E(V_0-E)}$$

(Q1.20)

Dengan memasukkan nilai-nilai pada persamaan Q1.20, ke dalam persamaan Q1.18 dan persamaan Q1.19, diperoleh:

$$\mathrm{Re}\left(\frac{A_1}{A_5}\right) = cosh\ (\beta L_b)cosh(\beta L_c) - \frac{1}{4}\frac{(2E-V_0)^2}{E(V_0-E)} sinh\ (\beta L_b)\ sinh\ (\beta L_c) + \frac{1}{4}\frac{{V_0}^2}{E(V_0-E)} sinh(\beta L_b)sinh(\beta L_c)cos(2\alpha L_s)$$

(Q1.21)

$$\mathrm{Im}\left(\frac{A_1}{A_5}\right) = -\frac{1}{2}\frac{2E-V_0}{\sqrt{E(V_0-E)}}\sinh(\beta Lb)cosh(\beta Lc)$$

$$-\frac{1}{2}\frac{2E-V_0}{\sqrt{E(V_0-E)}}\ sinh(\beta Lc)\ cosh(\beta Lc)$$

$$+\frac{1}{4}\frac{{V_0}^2}{E(V_0-E)}\ sinh(\beta Lb) sinh(\beta Lc) si\,n(2\alpha L_s)$$

(Q1.22)

Sehingga diperoleh persamaan koefisien transmisi:[5]

$$T^{*}T = \left[Re^2\left(\frac{A_1}{A_5}\right) + Im^2\left(\frac{A_1}{A_5}\right)\right]^{-1}$$

(Q1.23)

**Lampiran 2 Penurunan Persamaan Rapat Arus**

Setelah mendapatkan persamaan (2.55), selanjutnya akan diuraikan fungsi *F(E)* dan *F(E')* seperti sebagai berikut:

$$A=\int_0^{\infty} \frac{1}{exp\left(\frac{E_t+E_l-Ef}{K_B\otimes}\right)+1}\, dE_t$$

(Q2.1)

untuk fungsi *F(E)*, dan

$$B= \int_0^{\infty} \frac{1}{exp\left(\frac{E_t+E_l+eV-Ef}{K_B\otimes}\right)+1}\, dE_t$$

(Q2.2)

untuk *F(E')*.

Sehingga:

$$J = \frac{e}{4\pi^2\hbar^3}\int_0^{\infty} dE_l T(E_l)(A+B)$$

(Q2.3)

Selanjutnya diselesaikan integral bagian A dan B

1. Integral bagian A

   Misal :U=exp(M)+1

   $$\frac{dU}{dE_t} = \frac{dU}{dM}\frac{dM}{dE_t}$$

   $$dE_t = \frac{K_B\otimes}{U-1}\, dU$$

   $$A = K_B\otimes\int_0^{\infty} \frac{1}{U^2-1}$$

   $$A=K_B\otimes\left[\int_0^{\infty}\frac{-1}{U}dU + \int_0^{\infty}\frac{1}{U-1}dU\right]$$

   $$A= K_B\otimes[LnU|_0^{\infty} + Ln(U-1)|_0^{\infty}]$$

$$A= K_B\otimes\left[Ln\left\{exp\left(\frac{E_t+E_l-E_f}{K_B\otimes}\right)+1\right\}\Big|_0^\infty + Ln\left\{exp\left(\frac{E_t+E_l+eV-E_f}{K_B\otimes}\right)+1\right\}\Big|_0^\infty\right]$$

$$A=K_B\otimes Ln\left[\exp\left(\frac{E_f-E_t}{K_B\otimes}\right)+1\right]$$

(Q2.4)

Dengan cara yang sama seperti menyelesaikan integral A diperoleh:

2. $B = K_B\otimes Ln\left[1+\exp\left(\frac{E_f-E_t-eV}{K_B\otimes}\right)\right]$

(Q2.5)

Hasil subsitusi persamaan (Q2.4) dan (Q2.5) akan menghasilkan:[5]

$$J=\frac{em^*K_B\otimes}{2\pi^2\hbar^3}\int_0^\infty Ln\left(\frac{1+exp\left(\frac{Ef-E_l}{K_B\otimes}\right)}{1+exp\left(\frac{Ef-E_l-eV}{K_B\otimes}\right)}\right)T(E_l)\,dE_l$$

(Q2.5)

**Lampiran 3**

Tabel Hasil Koefisien Transmisi dengan $L_S$ = 4,5 nm

| No | Energi (eV) | Koefisien Transmisi | No | Energi (eV) | Koefisien Transmisi |
|---|---|---|---|---|---|
| 1 | 0.0001 | -24.68984124 | 41 | 0.4 | -9.276568413 |
| 2 | 0.01 | -19.77561297 | 42 | 0.41 | -9.014283649 |
| 3 | 0.02 | -18.75740244 | 43 | 0.42 | -8.736130238 |
| 4 | 0.03 | -18.01193797 | 44 | 0.43 | -8.439997375 |
| 5 | 0.04 | -17.36679789 | 45 | 0.44 | -8.123097651 |
| 6 | 0.05 | -16.7654836 | 46 | 0.45 | -7.781683554 |
| 7 | 0.06 | -16.17998872 | 47 | 0.46 | -7.410590348 |
| 8 | 0.07 | -15.59186639 | 48 | 0.47 | -7.002462495 |
| 9 | 0.08 | -14.98552236 | 49 | 0.48 | -6.546362392 |
| 10 | 0.09 | -14.34462493 | 50 | 0.49 | -6.025065741 |
| 11 | 0.1 | -13.64924408 | 51 | 0.5 | -5.409240597 |
| 12 | 0.11 | -12.87374809 | 52 | 0.51 | -4.643089641 |
| 13 | 0.12 | -11.99322649 | 53 | 0.52 | -3.602072754 |
| 14 | 0.13 | -11.05625602 | 54 | 0.53 | -1.972138269 |
| 15 | **0.14** | **-10.48740301** | 55 | **0.54** | **-1.310041545** |
| 16 | 0.15 | -10.69205399 | 56 | 0.55 | -2.838937527 |
| 17 | 0.16 | -11.11519581 | 57 | 0.56 | -3.697990678 |
| 18 | 0.17 | -11.44887514 | 58 | 0.57 | -4.223798707 |
| 19 | 0.18 | -11.67610471 | 59 | 0.58 | -4.575793217 |
| 20 | 0.19 | -11.82162327 | 60 | 0.59 | -4.82186504 |
| 21 | 0.2 | -11.90665825 | 61 | 0.6 | -4.996395855 |
| 22 | 0.21 | -11.94599428 | 62 | 0.61 | -5.119060442 |
| 23 | 0.22 | -11.94975028 | 63 | 0.62 | -5.202123933 |
| 24 | 0.23 | -11.92497181 | 64 | 0.63 | -5.253724379 |
| 25 | 0.24 | -11.87667852 | 65 | 0.64 | -5.279520972 |
| 26 | 0.25 | -11.80852342 | 66 | 0.65 | -5.28359386 |
| 27 | 0.26 | -11.7232111 | 67 | 0.66 | -5.268968576 |
| 28 | 0.27 | -11.62276851 | 68 | 0.67 | -5.237938119 |
| 29 | 0.28 | -11.5087242 | 69 | 0.68 | -5.192269352 |
| 30 | 0.29 | -11.38222944 | 70 | 0.69 | -5.133339984 |
| 31 | 0.3 | -11.24414128 | 71 | 0.7 | -5.062232115 |
| 32 | 0.31 | -11.09507977 | | | |
| 33 | 0.32 | -10.93546737 | | | |
| 34 | 0.33 | -10.76555506 | | | |
| 35 | 0.34 | -10.58543846 | | | |
| 36 | 0.35 | -10.39506559 | | | |
| 37 | 0.36 | -10.19423709 | | | |
| 38 | 0.37 | -9.982598939 | | | |
| 39 | 0.38 | -9.759626985 | | | |
| 40 | 0.39 | -9.524601432 | | | |

**Lampiran 4**

Tabel Hasil Koefisien Transmisi dengan $L_S$ = 5,5 nm

| No | Energi (eV) | Koefisien Transmisi | No | Energi (eV) | Koefisien Transmisi |
|---|---|---|---|---|---|
| 1 | 0.0001 | -25.01551109 | 41 | 0.4 | -4.457984538 |
| 2 | 0.01 | -20.02304736 | 42 | **0.41** | **-0.436088961** |
| 3 | 0.02 | -18.91614929 | 43 | 0.42 | -4.459609034 |
| 4 | 0.03 | -18.06942952 | 44 | 0.43 | -5.600384829 |
| 5 | 0.04 | -17.30630266 | 45 | 0.44 | -6.217447545 |
| 6 | 0.05 | -16.56400041 | 46 | 0.45 | -6.608923245 |
| 7 | 0.06 | -15.80470546 | 47 | 0.46 | -6.873033805 |
| 8 | 0.07 | -14.99407246 | 48 | 0.47 | -7.054444779 |
| 9 | 0.08 | -14.09075405 | 49 | 0.48 | -7.177241487 |
| 10 | 0.09 | -13.04605105 | 50 | 0.49 | -7.255879637 |
| 11 | 0.1 | -11.91156165 | 51 | 0.5 | -7.299697093 |
| 12 | **0.11** | **-11.4120981** | 52 | 0.51 | -7.315054537 |
| 13 | 0.12 | -11.8417817 | 53 | 0.52 | -7.306458552 |
| 14 | 0.13 | -12.29566135 | 54 | 0.53 | -7.277197021 |
| 15 | 0.14 | -12.58993852 | 55 | 0.54 | -7.229720286 |
| 16 | 0.15 | -12.76160125 | 56 | 0.55 | -7.165880599 |
| 17 | 0.16 | -12.84781981 | 57 | 0.56 | -7.087088166 |
| 18 | 0.17 | -12.87258889 | 58 | 0.57 | -6.994415718 |
| 19 | 0.18 | -12.85110477 | 59 | 0.58 | -6.888670007 |
| 20 | 0.19 | -12.79326483 | 60 | 0.59 | -6.77044118 |
| 21 | 0.2 | -12.70571087 | 61 | 0.6 | -6.640136784 |
| 22 | 0.21 | -12.59299855 | 62 | 0.61 | -6.498004608 |
| 23 | 0.22 | -12.45828336 | 63 | 0.62 | -6.344147005 |
| 24 | 0.23 | -12.30373425 | 64 | 0.63 | -6.178528301 |
| 25 | 0.24 | -12.13078794 | 65 | 0.64 | -6.000976175 |
| 26 | 0.25 | -11.94030448 | 66 | 0.65 | -5.811177346 |
| 27 | 0.26 | -11.73265759 | 67 | 0.66 | -5.608667456 |
| 28 | 0.27 | -11.50777747 | 68 | 0.67 | -5.392814611 |
| 29 | 0.28 | -11.26515382 | 69 | 0.68 | -5.162795719 |
| 30 | 0.29 | -11.00379972 | 70 | 0.69 | -4.917564404 |
| 31 | 0.3 | -10.72216933 | 71 | 0.7 | -4.65580929 |
| 32 | 0.31 | -10.41801272 | | | |
| 33 | 0.32 | -10.08813485 | | | |
| 34 | 0.33 | -9.727995791 | | | |
| 35 | 0.34 | -9.331027427 | | | |
| 36 | 0.35 | -8.887403 | | | |
| 37 | 0.36 | -8.381649951 | | | |
| 38 | 0.37 | -7.787512763 | | | |
| 39 | 0.38 | -7.055120926 | | | |
| 40 | 0.39 | -6.0705209 | | | |

**Lampiran 5**

Tabel Hasil Koefisien Transmisi dengan $L_S$ = 6,5 nm

| No | Energi (eV) | Koefisien Transmisi | No | Energi (eV) | Koefisien Transmisi |
|---|---|---|---|---|---|
| 1 | 0.0001 | -25.29519769 | 41 | 0.4 | -9.022329261 |
| 2 | 0.01 | -20.21168999 | 42 | 0.41 | -9.036192077 |
| 3 | 0.02 | -18.99747222 | 43 | 0.42 | -9.021958952 |
| 4 | 0.03 | -18.02160694 | 44 | 0.43 | -8.983602146 |
| 5 | 0.04 | -17.09685048 | 45 | 0.44 | -8.924006145 |
| 6 | 0.05 | -16.14153149 | 46 | 0.45 | -8.845288663 |
| 7 | 0.06 | -15.08224823 | 47 | 0.46 | -8.749003009 |
| 8 | 0.07 | -13.8217191 | 48 | 0.47 | -8.636268775 |
| 9 | 0.08 | -12.3832951 | 49 | 0.48 | -8.507856812 |
| 10 | **0.09** | **-12.11877726** | 50 | 0.49 | -8.364243304 |
| 11 | 0.1 | -12.79344036 | 51 | 0.5 | -8.205641425 |
| 12 | 0.11 | -13.23797182 | 52 | 0.51 | -8.032015161 |
| 13 | 0.12 | -13.47201007 | 53 | 0.52 | -7.843077224 |
| 14 | 0.13 | -13.5736914 | 54 | 0.53 | -7.638270727 |
| 15 | 0.14 | -13.58727701 | 55 | 0.54 | -7.416732035 |
| 16 | 0.15 | -13.53761058 | 56 | 0.55 | -7.177229227 |
| 17 | 0.16 | -13.43935946 | 57 | 0.56 | -6.918066201 |
| 18 | 0.17 | -13.3015088 | 58 | 0.57 | -6.636935029 |
| 19 | 0.18 | -13.12960496 | 59 | 0.58 | -6.330685888 |
| 20 | 0.19 | -12.92692401 | 60 | 0.59 | -5.994958373 |
| 21 | 0.2 | -12.69508518 | 61 | 0.6 | -5.623565767 |
| 22 | 0.21 | -12.43434303 | 62 | 0.61 | -5.207408132 |
| 23 | 0.22 | -12.14365749 | 63 | 0.62 | -4.732408246 |
| 24 | 0.23 | -11.82056362 | 64 | 0.63 | -4.175188423 |
| 25 | 0.24 | -11.4607964 | 65 | 0.64 | -3.4926823 |
| 26 | 0.25 | -11.05753066 | 66 | 0.65 | -2.591396184 |
| 27 | 0.26 | -10.59990014 | 67 | 0.66 | -1.196342376 |
| 28 | 0.27 | -10.06996869 | 68 | **0.67** | **2.397371891** |
| 29 | 0.28 | -9.435859032 | 69 | 0.68 | -0.41303565 |
| 30 | 0.29 | -8.633335096 | 70 | 0.69 | -1.761144205 |
| 31 | 0.3 | -7.500463613 | 71 | 0.7 | -2.455526085 |
| 32 | 0.31 | -5.354553065 | | | |
| 33 | **0.32** | **-4.574801573** | | | |
| 34 | 0.33 | -6.797590369 | | | |
| 35 | 0.34 | -7.685680612 | | | |
| 36 | 0.35 | -8.196542892 | | | |
| 37 | 0.36 | -8.524176061 | | | |
| 38 | 0.37 | -8.741907879 | | | |
| 39 | 0.38 | -8.885427043 | | | |
| 40 | 0.39 | -8.974781693 | | | |

**Lampiran 6**

Tabel Hasil Koefisien Transmisi dengan $L_S$ = 7,5 nm

| No | Energi (eV) | Koefisien Transmisi | No | Energi (eV) | Koefisien Transmisi |
|---|---|---|---|---|---|
| 1 | 0.0001 | -25.54021769 | 41 | 0.4 | -9.751838166 |
| 2 | 0.01 | -20.35174658 | 42 | 0.41 | -9.584138834 |
| 3 | 0.02 | -19.00748365 | 43 | 0.42 | -9.396794059 |
| 4 | 0.03 | -17.86325201 | 44 | 0.43 | -9.189431987 |
| 5 | 0.04 | -16.70338308 | 45 | 0.44 | -8.961213704 |
| 6 | 0.05 | -15.38240322 | 46 | 0.45 | -8.710757616 |
| 7 | 0.06 | -13.69260898 | 47 | 0.46 | -8.43600592 |
| 8 | **0.07** | **-12.36529139** | 48 | 0.47 | -8.134003963 |
| 9 | 0.08 | -13.24404529 | 49 | 0.48 | -7.800537243 |
| 10 | 0.09 | -13.84024016 | 50 | 0.49 | -7.429518531 |
| 11 | 0.1 | -14.10820948 | 51 | 0.5 | -7.011903456 |
| 12 | 0.11 | -14.19544056 | 52 | 0.51 | -6.533639058 |
| 13 | 0.12 | -14.17010142 | 53 | 0.52 | -5.971413842 |
| 14 | 0.13 | -14.0658763 | 54 | 0.53 | -5.282687018 |
| 15 | 0.14 | -13.90068022 | 55 | 0.54 | -4.377845218 |
| 16 | 0.15 | -13.68415036 | 56 | 0.55 | -3.023413908 |
| 17 | 0.16 | -13.42088004 | 57 | **0.56** | **-1.041343023** |
| 18 | 0.17 | -13.11178792 | 58 | 0.57 | -2.542818262 |
| 19 | 0.18 | -12.75445611 | 59 | 0.58 | -3.669672799 |
| 20 | 0.19 | -12.3426244 | 60 | 0.59 | -4.303538506 |
| 21 | 0.2 | -11.86455819 | 61 | 0.6 | -4.706377823 |
| 22 | 0.21 | -11.29923154 | 62 | 0.61 | -4.97643257 |
| 23 | 0.22 | -10.60711755 | 63 | 0.62 | -5.159490943 |
| 24 | 0.23 | -9.704508265 | 64 | 0.63 | -5.280375379 |
| 25 | 0.24 | -8.374457191 | 65 | 0.64 | -5.35397168 |
| 26 | **0.25** | **-6.287650261** | 66 | 0.65 | -5.389858249 |
| 27 | 0.26 | -7.593177101 | 67 | 0.66 | -5.394517968 |
| 28 | 0.27 | -8.755649364 | 68 | 0.67 | -5.372501 |
| 29 | 0.28 | -9.385721423 | 69 | 0.68 | -5.327082141 |
| 30 | 0.29 | -9.77115312 | 70 | 0.69 | -5.260653918 |
| 31 | 0.3 | -10.01745358 | 71 | 0.7 | -5.174972105 |
| 32 | 0.31 | -10.17303167 | | | |
| 33 | 0.32 | -10.26386838 | | | |
| 34 | 0.33 | -10.30542415 | | | |
| 35 | 0.34 | -10.30757075 | | | |
| 36 | 0.35 | -10.27692476 | | | |
| 37 | 0.36 | -10.21806351 | | | |
| 38 | 0.37 | -10.13420572 | | | |
| 39 | 0.38 | -10.02761225 | | | |
| 40 | 0.39 | -9.899829575 | | | |

**Lampiran 7**

Tabel Hasil Koefisien Transmisi dengan $L_S$ = 8,5 nm

| No | Energi (eV) | Koefisien Transmisi | No | Energi (eV) | Koefisien Transmisi |
|---|---|---|---|---|---|
| 1 | 0.0001 | -25.75815568 | 41 | 0.4 | -8.873801782 |
| 2 | 0.01 | -20.44962059 | 42 | 0.41 | -8.435727474 |
| 3 | 0.02 | -18.94690154 | 43 | 0.42 | -7.924342112 |
| 4 | 0.03 | -17.57514743 | 44 | 0.43 | -7.308088584 |
| 5 | 0.04 | -16.03624523 | 45 | 0.44 | -6.523710629 |
| 6 | 0.05 | -13.94343409 | 46 | 0.45 | -5.412745352 |
| 7 | **0.06** | **-12.89197445** | 47 | 0.46 | -3.314253097 |
| 8 | 0.07 | -14.07636149 | 48 | **0.47** | **-2.333018849** |
| 9 | 0.08 | -14.56702326 | 49 | 0.48 | -4.668048198 |
| 10 | 0.09 | -14.72569555 | 50 | 0.49 | -5.575469155 |
| 11 | 0.1 | -14.70816994 | 51 | 0.5 | -6.094027301 |
| 12 | 0.11 | -14.57720728 | 52 | 0.51 | -6.424214841 |
| 13 | 0.12 | -14.3615258 | 53 | 0.52 | -6.640908678 |
| 14 | 0.13 | -14.07411843 | 54 | 0.53 | -6.780295066 |
| 15 | 0.14 | -13.71868019 | 55 | 0.54 | -6.86257281 |
| 16 | 0.15 | -13.29143689 | 56 | 0.55 | -6.900096937 |
| 17 | 0.16 | -12.7800983 | 57 | 0.56 | -6.900899975 |
| 18 | 0.17 | -12.15917412 | 58 | 0.57 | -6.870417077 |
| 19 | 0.18 | -11.37749579 | 59 | 0.58 | -6.812409336 |
| 20 | 0.19 | -10.32586439 | 60 | 0.59 | -6.729490049 |
| 21 | 0.2 | -8.829771871 | 61 | 0.6 | -6.623437085 |
| 22 | **0.21** | **-8.440632816** | 62 | 0.61 | -6.495380963 |
| 23 | 0.22 | -9.590379965 | 63 | 0.62 | -6.345914677 |
| 24 | 0.23 | -10.30744246 | 64 | 0.63 | -6.175149193 |
| 25 | 0.24 | -10.73515164 | 65 | 0.64 | -5.982725905 |
| 26 | 0.25 | -10.99709131 | 66 | 0.65 | -5.767788901 |
| 27 | 0.26 | -11.15231597 | 67 | 0.66 | -5.528912502 |
| 28 | 0.27 | -11.2320848 | 68 | 0.67 | -5.263971047 |
| 29 | 0.28 | -11.25459589 | 69 | 0.68 | -4.969925413 |
| 30 | 0.29 | -11.23118159 | 70 | 0.69 | -4.642480172 |
| 31 | 0.3 | -11.16920708 | 71 | 0.7 | -4.275528927 |
| 32 | 0.31 | -11.07355092 | | | |
| 33 | 0.32 | -10.9474096 | | | |
| 34 | 0.33 | -10.79274787 | | | |
| 35 | 0.34 | -10.6105442 | | | |
| 36 | 0.35 | -10.40090176 | | | |
| 37 | 0.36 | -10.16305353 | | | |
| 38 | 0.37 | -9.895261938 | | | |
| 39 | 0.38 | -9.594585037 | | | |
| 40 | 0.39 | -9.256438623 | | | |

**Lampiran 8**

Tabel Hasil Rapat Arus dengan $L_S$ = 7 nm

| No | Vbias (V) | Rapat Arus (A/m$^2$) | No | Vbias (V) | Rapat Arus (A/m$^2$) |
|---|---|---|---|---|---|
| 1 | 0.0001 | 0 | 41 | 0.4 | 2.05945787546506E+28 |
| 2 | 0.01 | 1.9500186782285E+27 | 42 | 0.41 | 2.05960630945679E+28 |
| 3 | 0.02 | 3.82831447442333E+27 | 43 | 0.42 | 2.05970874994031E+28 |
| 4 | 0.03 | 5.63057900897671E+27 | 44 | 0.43 | 2.0597791307863E+28 |
| 5 | 0.04 | 7.35033170594432E+27 | 45 | 0.44 | 2.05982732589192E+28 |
| 6 | 0.05 | 8.97884563776049E+27 | 46 | 0.45 | 2.05986025048993E+28 |
| 7 | 0.06 | 1.05053398015057E+28 | 47 | 0.46 | 2.05988270526865E+28 |
| 8 | 0.07 | 1.19176483442176E+28 | 48 | 0.47 | 2.05989800160044E+28 |
| 9 | 0.08 | 1.32035511417403E+28 | 49 | 0.48 | 2.05990841308102E+28 |
| 10 | 0.09 | 1.43527662129527E+28 | 50 | 0.49 | 2.05991549570701E+28 |
| 11 | 0.1 | 1.53592413290733E+28 | 51 | 0.5 | 2.05992031195883E+28 |
| 12 | 0.11 | 1.62230049716641E+28 | | | |
| 13 | 0.12 | 1.69507832608237E+28 | | | |
| 14 | 0.13 | 1.75550587618238E+28 | | | |
| 15 | 0.14 | 1.80519729336274E+28 | | | |
| 16 | 0.15 | 1.84589149406676E+28 | | | |
| 17 | 0.16 | 1.87925424732478E+28 | | | |
| 18 | 0.17 | 1.90675665180406E+28 | | | |
| 19 | 0.18 | 1.92962550358458E+28 | | | |
| 20 | 0.19 | 1.94884336149171E+28 | | | |
| 21 | 0.2 | 1.96517511633162E+28 | | | |
| 22 | 0.21 | 1.97920423703685E+28 | | | |
| 23 | 0.22 | 1.99136899488823E+28 | | | |
| 24 | 0.23 | 2.00199425063606E+28 | | | |
| 25 | 0.24 | 2.01131758049297E+28 | | | |
| 26 | 0.25 | 2.01951017992795E+28 | | | |
| 27 | 0.26 | 2.02669371852893E+28 | | | |
| 28 | 0.27 | 2.03295450745127E+28 | | | |
| 29 | 0.28 | 2.038356132049E+28 | | | |
| 30 | 0.29 | 2.04295110838148E+28 | | | |
| 31 | 0.3 | 2.04679121420368E+28 | | | |
| 32 | 0.31 | 2.04993527308785E+28 | | | |
| 33 | 0.32 | 2.05245294961306E+28 | | | |
| 34 | 0.33 | 2.0544239486691E+28 | | | |
| 35 | 0.34 | 2.05593352258019E+28 | | | |
| 36 | 0.35 | 2.05706635567835E+28 | | | |
| 37 | 0.36 | 2.05790097649511E+28 | | | |
| 38 | 0.37 | 2.05850600712491E+28 | | | |
| 39 | 0.38 | 2.05893851884708E+28 | | | |
| 40 | 0.39 | 2.0592440814208E+28 | | | |

**Lampiran 9**

Tabel Hasil Rapat Arus dengan $L_S$ = 7,5 nm

| No | Vbias (V) | Rapat Arus (A/m$^2$) |
|---|---|---|
| 1 | 0.0001 | 0 |
| 2 | 0.01 | 1.35814387534987E+27 |
| 3 | 0.02 | 2.66098849711016E+27 |
| 4 | 0.03 | 3.91095431789718E+27 |
| 5 | 0.04 | 5.10912567571237E+27 |
| 6 | 0.05 | 6.25528883770145E+27 |
| 7 | 0.06 | 7.34792928406718E+27 |
| 8 | 0.07 | 8.38422820303655E+27 |
| 9 | 0.08 | 9.36011902676213E+27 |
| 10 | 0.09 | 1.02704894422279E+28 |
| 11 | 0.1 | 1.11096270830824E+28 |
| 12 | 0.11 | 1.18719781735047E+28 |
| 13 | 0.12 | 1.25531856579772E+28 |
| 14 | 0.13 | 1.31512020949469E+28 |
| 15 | 0.14 | 1.36671204753203E+28 |
| 16 | 0.15 | 1.41053769640575E+28 |
| 17 | 0.16 | 1.44732146639592E+28 |
| 18 | 0.17 | 1.47796213781481E+28 |
| 19 | 0.18 | 1.50341374368328E+28 |
| 20 | 0.19 | 1.52458766574649E+28 |
| 21 | 0.2 | 1.54229149724969E+28 |
| 22 | 0.21 | 1.55720289830854E+28 |
| 23 | 0.22 | 1.56986825281103E+28 |
| 24 | 0.23 | 1.58071512185959E+28 |
| 25 | 0.24 | 1.59007027157935E+28 |
| 26 | 0.25 | 1.59817841903684E+28 |
| 27 | 0.26 | 1.60521948245175E+28 |
| 28 | 0.27 | 1.61132380437823E+28 |
| 29 | 0.28 | 1.61658568320118E+28 |
| 30 | 0.29 | 1.62107575414778E+28 |
| 31 | 0.3 | 1.62485240063634E+28 |
| 32 | 0.31 | 1.62797162750102E+28 |
| 33 | 0.32 | 1.63049414125299E+28 |
| 34 | 0.33 | 1.63248839906704E+28 |
| 35 | 0.34 | 1.63402939359203E+28 |
| 36 | 0.35 | 1.63519438307003E+28 |
| 37 | 0.36 | 1.63605763993683E+28 |
| 38 | 0.37 | 1.63668607029455E+28 |
| 39 | 0.38 | 1.63713663376579E+28 |
| 40 | 0.39 | 1.6374555815797E+28 |
| 41 | 0.4 | 1.63767903201371E+28 |
| 42 | 0.41 | 1.637834301443E+28 |
| 43 | 0.42 | 1.63794151781394E+28 |
| 44 | 0.43 | 1.63801520590272E+28 |
| 45 | 0.44 | 1.63806567733709E+28 |
| 46 | 0.45 | 1.63810016222456E+28 |
| 47 | 0.46 | 1.63812368348309E+28 |
| 48 | 0.47 | 1.63813970737574E+28 |
| 49 | 0.48 | 1.63815061455946E+28 |
| 50 | 0.49 | 1.63815803462084E+28 |
| 51 | 0.5 | 1.63816308043422E+28 |

**Lampiran 10**

Tabel Hasil Rapat Arus dengan $L_S$ = 8 nm

| No | Vbias (V) | Rapat Arus (A/m$^2$) | No | Vbias (V) | Rapat Arus (A/m$^2$) |
|---|---|---|---|---|---|
| 1 | 0.0001 | 0 | 41 | 0.4 | 1.38812269906756E+28 |
| 2 | 0.01 | 1.11911459174834E+27 | 42 | 0.41 | 1.38828359855535E+28 |
| 3 | 0.02 | 2.17109507470665E+27 | 43 | 0.42 | 1.38839479491657E+28 |
| 4 | 0.03 | 3.16496259465597E+27 | 44 | 0.43 | 1.38847126108223E+28 |
| 5 | 0.04 | 4.10732478517851E+27 | 45 | 0.44 | 1.3885236549814E+28 |
| 6 | 0.05 | 5.00287523473976E+27 | 46 | 0.45 | 1.38855946245268E+28 |
| 7 | 0.06 | 5.85473840924336E+27 | 47 | 0.46 | 1.38858388997553E+28 |
| 8 | 0.07 | 6.66469906180043E+27 | 48 | 0.47 | 1.38860053317902E+28 |
| 9 | 0.08 | 7.43335101178963E+27 | 49 | 0.48 | 1.38861186279984E+28 |
| 10 | 0.09 | 8.16020115838622E+27 | 50 | 0.49 | 1.38861957064849E+28 |
| 11 | 0.1 | 8.84377128378511E+27 | 51 | 0.5 | 1.38862481235156E+28 |
| 12 | 0.11 | 9.48175081887983E+27 | | | |
| 13 | 0.12 | 1.00712613840196E+28 | | | |
| 14 | 0.13 | 1.06092840702155E+28 | | | |
| 15 | 0.14 | 1.10932544326189E+28 | | | |
| 16 | 0.15 | 1.15217422017077E+28 | | | |
| 17 | 0.16 | 1.18950358143932E+28 | | | |
| 18 | 0.17 | 1.22154198023256E+28 | | | |
| 19 | 0.18 | 1.2487023004388E+28 | | | |
| 20 | 0.19 | 1.27152916404762E+28 | | | |
| 21 | 0.2 | 1.29062857550488E+28 | | | |
| 22 | 0.21 | 1.30660211581757E+28 | | | |
| 23 | 0.22 | 1.31999971207161E+28 | | | |
| 24 | 0.23 | 1.33129422307938E+28 | | | |
| 25 | 0.24 | 1.34087386883979E+28 | | | |
| 26 | 0.25 | 1.34904615666184E+28 | | | |
| 27 | 0.26 | 1.35604772676482E+28 | | | |
| 28 | 0.27 | 1.36205643352538E+28 | | | |
| 29 | 0.28 | 1.36720376891794E+28 | | | |
| 30 | 0.29 | 1.37158693619288E+28 | | | |
| 31 | 0.3 | 1.37528038329489E+28 | | | |
| 32 | 0.31 | 1.37834646329727E+28 | | | |
| 33 | 0.32 | 1.38084435843904E+28 | | | |
| 34 | 0.33 | 1.38283601431756E+28 | | | |
| 35 | 0.34 | 1.38438816307609E+28 | | | |
| 36 | 0.35 | 1.38557064646215E+28 | | | |
| 37 | 0.36 | 1.38645248968594E+28 | | | |
| 38 | 0.37 | 1.38709765504045E+28 | | | |
| 39 | 0.38 | 1.38756192215256E+28 | | | |
| 40 | 0.39 | 1.38789143132173E+28 | | | |

## Lampiran 11

Tabel Hasil Rapat Arus dengan $L_S$ = 8,5 nm

| No | Vbias (V) | Rapat Arus ($A/m^2$) | No | Vbias (V) | Rapat Arus ($A/m^2$) |
|---|---|---|---|---|---|
| 1 | 0.0001 | 0 | 41 | 0.4 | 1.25661662358812E+28 |
| 2 | 0.01 | 1.09587356607832E+27 | 42 | 0.41 | 1.25677859996041E+28 |
| 3 | 0.02 | 2.08653638672557E+27 | 43 | 0.42 | 1.25689064979279E+28 |
| 4 | 0.03 | 2.99212238399059E+27 | 44 | 0.43 | 1.25696775487722E+28 |
| 5 | 0.04 | 3.82788568537469E+27 | 45 | 0.44 | 1.2570206110606E+28 |
| 6 | 0.05 | 4.60527878140039E+27 | 46 | 0.45 | 1.25705674593318E+28 |
| 7 | 0.06 | 5.33280793361681E+27 | 47 | 0.46 | 1.25708140214479E+28 |
| 8 | 0.07 | 6.01668446146873E+27 | 48 | 0.47 | 1.25709820363978E+28 |
| 9 | 0.08 | 6.66130489173672E+27 | 49 | 0.48 | 1.25710964216416E+28 |
| 10 | 0.09 | 7.26959577059616E+27 | 50 | 0.49 | 1.25711742463463E+28 |
| 11 | 0.1 | 7.84325804393111E+27 | 51 | 0.5 | 1.25712271733001E+28 |
| 12 | 0.11 | 8.38294570206605E+27 | | | |
| 13 | 0.12 | 8.88841590534071E+27 | | | |
| 14 | 0.13 | 9.35869265311236E+27 | | | |
| 15 | 0.14 | 9.79228912202771E+27 | | | |
| 16 | 0.15 | 1.01875260151309E+28 | | | |
| 17 | 0.16 | 1.05429528555382E+28 | | | |
| 18 | 0.17 | 1.08578220293284E+28 | | | |
| 19 | 0.18 | 1.11325012766378E+28 | | | |
| 20 | 0.19 | 1.1368685264546E+28 | | | |
| 21 | 0.2 | 1.15693195595806E+28 | | | |
| 22 | 0.21 | 1.17382632537161E+28 | | | |
| 23 | 0.22 | 1.1879816565127E+28 | | | |
| 24 | 0.23 | 1.19982643044745E+28 | | | |
| 25 | 0.24 | 1.20975375953726E+28 | | | |
| 26 | 0.25 | 1.21810242145807E+28 | | | |
| 27 | 0.26 | 1.22515060701678E+28 | | | |
| 28 | 0.27 | 1.23111829280225E+28 | | | |
| 29 | 0.28 | 1.23617448583241E+28 | | | |
| 30 | 0.29 | 1.24044679401705E+28 | | | |
| 31 | 0.3 | 1.24403188489663E+28 | | | |
| 32 | 0.31 | 1.2470059585823E+28 | | | |
| 33 | 0.32 | 1.24943433672475E+28 | | | |
| 34 | 0.33 | 1.25137898401042E+28 | | | |
| 35 | 0.34 | 1.25290281276158E+28 | | | |
| 36 | 0.35 | 1.25407037052628E+28 | | | |
| 37 | 0.36 | 1.25494569740494E+28 | | | |
| 38 | 0.37 | 1.25558897229028E+28 | | | |
| 39 | 0.38 | 1.25605352941475E+28 | | | |
| 40 | 0.39 | 1.2563841325049E+28 | | | |

**Lampiran 12**

Program Simulasi untuk Koefisien Transmisi

```
clear all
%MENGHITUNG KOEFISIEN TRANSMISI Ls DIVARIASIAKAN

% memasukkan variabel ketetapan
Me=9.1e-31
phi=3.14
h=6.626*10^-34
hcoret=h/(2*phi)
hcoretkuadrat=(hcoret)^2
%variabel yang dimasukkan
x=0.68
InP=1.35
InGaAs=0.324+0.7*(1-x)+0.4*(1-x)^2;
v0=(InP-InGaAs)*1.6e-19;
Ef=v0/2;
mstar=0.067*Me
% menentukan titik
Lb=40e-10
Ls=45e-10 % divariasikan 5,5, 6,5, 7,5, 8,5 nm
Lc=30e-10
X1=0
X2=Lb
X3=Lb+Ls
X4=Lb+Ls+Lc
E2=0:0.01:0.7;
E2(1,1)=0.0001;
E1=E2*1.6e-19;
for e1=1:length(E1)
    E=E1(1,e1);
    alfa(1,e1)=sqrt((2*mstar*E)/hcoretkuadrat);
    beta(1,e1)=sqrt((2*mstar*(v0-E))/hcoretkuadrat);
    S1(1,e1)= cosh(beta(1,e1)*Lb)*cosh(beta(1,e1)*Lc);
    S2(1,e1)=((2*E-v0)^2/(4*E*(v0-
E)))*sinh(beta(1,e1)*Lb)*sinh(beta(1,e1)*Lc);
    S3(1,e1)=((v0)^2/(4*E*(v0-
E)))*sinh(beta(1,e1)*Lb)*sinh(beta(1,e1)*Lc)*cos(2*alfa(1,e1)*Ls);

    ReA1A5(1,e1)= S1(1,e1)-S2(1,e1)+S3(1,e1);
    K1(1,e1)=-((2*E)-v0)/(2*sqrt(E*(v0-
E)))*sinh(beta(1,e1)*Lb)*cosh(beta(1,e1)*Lc);
    K2(1,e1)=((2*E)-v0)/(2*sqrt(E*(v0-
E)))*sinh(beta(1,e1)*Lc)*cosh(beta(1,e1)*Lc);
    K3(1,e1)=((v0)^2/(4*E*(v0-
E)))*sinh(beta(1,e1)*Lb)*sinh(beta(1,e1)*Lc)*sin(2*alfa(1,e1)*Ls);

    ImA1A5(1,e1)= K1(1,e1)-K2(1,e1)+K3(1,e1);

%jadi,
Tkuadrat(1,e1)=1/[(ReA1A5(1,e1))^2+(ImA1A5(1,e1))^2];
LT=(log(Tkuadrat))'
```

```
end

 % subplot(2,2,1)
plot(E2,LT)
xlabel('Energi')
ylabel('Koefisien Transmisi')
title('Koefisien Transmisi(Ls=4,5nm)')
```

## Lampiran 13

Program Simulasi untuk Rapat Arus

```
clear all
% memasukkan variabel ketetapan
Me=9.1e-31
phi=3.14
h=6.626*10^-34
hcoret=h/(2*phi)
hcoretkuadrat=(hcoret)^2
x=0.68
InP=1.35
InGaAs=0.324+0.7*(1-x)+0.4*(1-x)^2;
v0=(InP-InGaAs)*1.6e-19;
Ef=v0/2;
mstar=0.067*Me

% menentukan titik
Lb=40e-10
Ls=70e-10 % divariasikan 7,5, 8, 8,5 nm
Lc=30e-10
X1=0
X2=Lb
X3=Lb+Ls
X4=Lb+Ls+Lc
E2=0:0.01:0.7
E2(1,1)=0.0001;
E1=E2*1.6e-19;
for e1=1:length(E1)
    E=E1(1,e1);
    alfa(1,e1)=sqrt((2*mstar*E)/hcoretkuadrat);
    beta(1,e1)=sqrt((2*mstar*(v0-E))/hcoretkuadrat);
    S1(1,e1)= cosh(beta(1,e1)*Lb)*cosh(beta(1,e1)*Lc);
    S2(1,e1)=((2*E-v0)^2/(4*E*(v0-
E)))*sinh(beta(1,e1)*Lb)*sinh(beta(1,e1)*Lc);
    S3(1,e1)=((v0)^2/(4*E*(v0-
E)))*sinh(beta(1,e1)*Lb)*sinh(beta(1,e1)*Lc)*cos(2*alfa(1,e1)*Ls);

    ReA1A5(1,e1)= S1(1,e1)-S2(1,e1)+S3(1,e1);
    K1(1,e1)=-((2*E)-v0)/(2*sqrt(E*(v0-
E)))*sinh(beta(1,e1)*Lb)*cosh(beta(1,e1)*Lc);
    K2(1,e1)=((2*E)-v0)/(2*sqrt(E*(v0-
E)))*sinh(beta(1,e1)*Lc)*cosh(beta(1,e1)*Lc);
    K3(1,e1)=((v0)^2/(4*E*(v0-
E)))*sinh(beta(1,e1)*Lb)*sinh(beta(1,e1)*Lc)*sin(2*alfa(1,e1)*Ls);

    ImA1A5(1,e1)= K1(1,e1)-K2(1,e1)+K3(1,e1);

%jadi,
Tkuadrat(1,e1)=1/[(ReA1A5(1,e1))^2+(ImA1A5(1,e1))^2];

end
%perhitungan rapat arus-tegangan
```

```
Kb=1.38*10^-23
suhu=300;
phi=3.14;
V1=[0:0.01:0.5]
for m1=1:length(V1)
    v2=V1(1,m1)*1.6e-19;
for e1=1:length(E1)
    N1(1,e1)=(sqrt(Tkuadrat(1,e1)));%
    N2(1,e1)=log((1+(exp((Ef-E1(1,e1))/(Kb*suhu))))/(1+(exp((Ef-
E1(1,e1)-(v2*1))/(Kb*suhu)))));
    N(1,e1)=N1(1,e1)*N2(1,e1);
end
%Hitung luas
A=0;
for m3=1:length(E1)-1
    A7=(E1(1,m3+1)-E1(1,m3))*(N(1,m3+1)+N(1,m3))/2;
    A=A7+A;
end
A0(1,m1)=A;
J(1,m1)=((1*mstar*Kb*suhu)/(2*phi^2*hcoret^3))*A0 (1,m1);
R1 = (J)'
end


plot(V1,J)
xlabel('Vbias (eV)')
ylabel('rapat arus')
title('Grafik Rapat Arus Ls = 7 nm')
```