
```

% Surface potential v/s channel length plots for 30nm technology node
%initial values for first plot: K= boltzman constant,T=room
%temp=300k,Na=acceptor Conc.,Np=donor conc.,ni=intrinsic carrier conc,Eg=band
%gap,PerSi=Permittivity of Silicon,PerOx=Permittivity of oxide
K=1.38*10^-23;T=300;ni=1.5*10^10;q=1.6*10^-19;Eg=1.1;
PerSi=11.8*8.854*10^-14;PerOx=3.9*8.85*10^-14;Vsb=0.1;Vgsf=0;Vgsb=0;
Vgbf=0;Vgbb=0;Np=1.7*10^18;Lp=6*10^-7;Na=4*10^17;
phiM1=4.5;phiM2=4.4;
%for 30 nm technology tox=oxide thickness ,xj=junction depth
L=40*10^-7;tox=1.5*10^-7;xj=12*10^-7;L1=15*10^-7;Vds=0.2;
Vdb=Vds+Vsb;phit=(K*T)/q;phis=(4.15+ Eg/2+phit*(log(Na/ni)));
VfbfP=-Eg/2-phit*(log(Np/ni));VfbbP=-Eg/2-phit*(log(Np/ni));
Vbi=Eg/2+phit*(log(Na/ni));phifN=phit*(log(Na/ni));
Vfbf1=(phiM1-phis)/q;
Vfbb1=(phiM1-phis)/q;
Vfbf2=(phiM2-phis)/q;
Vfbb2=(phiM2-phis)/q;
VfbfP1=(VfbfP-Vfbf1);
VfbbP1=(VfbbP-Vfbb1);
VfbfP2=(VfbfP-Vfbf2);
VfbbP2=(VfbbP-Vfbb2);
Cox=PerOx/tox;
gammaP=(sqrt(2*q*PerSi*Np))/Cox;
gammaA=(sqrt(2*q*PerSi*Na))/Cox;
SiS1=((-gammaP/2)+sqrt(((gammaP^2)/4)+(Vgbf-VfbfP1)-(Vgbb-VfbbP1)))^2;
SiS2=((-gammaP/2)+sqrt(((gammaP^2)/4)+(Vgbf-VfbfP)-(Vgbb-VfbbP)))^2;
SiS3=((-gammaA/2)+sqrt(((gammaA^2)/4)+(Vgbf-Vfbf1)-(Vgbb-Vfbb1)))^2;
SiS4=((-gammaP/2)+sqrt(((gammaP^2)/4)+(Vgbf-VfbfP2)-(Vgbb-VfbbP2)))^2;
Vgsf1=Vgsf+Vsb-VfbfP1; Vgsf2=Vgsf+Vsb-VfbfP;
Vgsf3=Vgsf+Vsb-Vfbf1; Vgsf4=Vgsf+Vsb-Vfbf2;
Vgsf5=Vgsf+Vsb-VfbfP; Vgsf6=Vgsf+Vsb-VfbfP2;
Vgsb1=Vgsb+Vsb-VfbbP1; Vgsb2=Vgsb+Vsb-VfbbP;
Vgsb3=Vgsb+Vsb-Vfbb1; Vgsb4=Vgsb+Vsb-Vfbb2;
Vgsb5=Vgsb+Vsb-VfbbP; Vgsb6=Vgsb+Vsb-VfbbP2;

Vgs1=Vgsf1-Vgsb1; Vgs2=Vgsf2-Vgsb2;
Vgs3=Vgsf3-Vgsb3; Vgs4=Vgsf4-Vgsb4;
Vgs5=Vgsf5-Vgsb5; Vgs6=Vgsf6-Vgsb6;

V1=Vbi+Vsb; V7=Vbi+Vdb;
xrs=(sqrt((2*PerSi*(V1))/(q*Np)));
xrd=(sqrt((2*PerSi*(V7))/(q*Np)));
cps=4*V1/Vbi;cpd=4*V7/Vbi;
xc=L*xrs/(xrs+xrd);
x1=0;x2=Lp;
y1=(xj+sqrt((2*PerSi*V1)/(q*Np)))/cps;
y2=sqrt((2*PerSi*SiS1)/(q*Np));
a1=(sqrt(y2)-sqrt(y1))/(x2-x1);
b1=((x2*sqrt(y1))-(x1*sqrt(y2)))/(x2-x1);
t1=log(a1*x1+b1);t2=log(a1*x2+b1);
d1=sqrt((1/4)+Cox/(PerSi*(a1^2)));
beta1=(q*Np)/(2*PerSi*a1^2-Cox);

```

```

t111=t1:(-1)*10^-2:t2;
x111=(exp(t111)-b1)/a1;
x3=x2;x4=xc;y3=y2;y4=sqrt((2*PerSi*SiS2)/(q*Np));
a2=(sqrt(y4)-sqrt(y3)) / (x4-x3);
b2=((x4*sqrt(y3))-(x3*sqrt(y4))) / (x4-x3);
t3=log(a2*x3+b2);t4=log(a2*x4+b2);
d2=sqrt((1/4)+Cox/(PerSi*(a2^2)));
beta2=(q*Np) / (2*PerSi*a2^2-Cox);
t222=t3:(-1)*10^-2:t4;
x222=(exp(t222)-b2)/a2;
x5=x4;x6=L1;
y5=y4;
y6=sqrt((2*PerSi*SiS3)/(q*Na));
a3=(sqrt(y6)-sqrt(y5)) / (x6-x5);
b3=((x6*sqrt(y5))-(x5*sqrt(y6))) / (x6-x5);
t5=log(a3*x5+b3);t6=log(a3*x6+b3);
d3=sqrt((1/4)+Cox/(PerSi*(a3^2)));
beta3=(q*Na) / (2*PerSi*a3^2-Cox);
t333=t5:(-1)*10^-2:t6;
x333=(exp(t333)-b3)/a3;
x7=x6;x8=L-xc;y7=y6;
y8=sqrt((2*PerSi*SiS2)/(q*Np));
a4=(sqrt(y8)-sqrt(y7)) / (x8-x7);
b4=((x8*sqrt(y7))-(x7*sqrt(y8))) / (x8-x7);
t7=log(a4*x7+b4);t8=log(a4*x8+b4);
d4=sqrt((1/4)+Cox/(PerSi*(a4^2)));
beta4=(q*Na) / (2*PerSi*a4^2-Cox);
t444=t7:(1)*10^-2:t8;
x444=(exp(t444)-b4)/a4;
x9=x8;x10=L-Lp;y9=y8;
y10=sqrt((2*PerSi*SiS4)/(q*Np));
a5=(sqrt(y10)-sqrt(y9)) / (x10-x9);
b5=((x10*sqrt(y9))-(x9*sqrt(y10))) / (x10-x9);
t9=log(a5*x9+b5);t10=log(a5*x10+b5);
d5=sqrt((1/4)+Cox/(PerSi*(a5^2)));

beta5=(q*Np) / (2*PerSi*a5^2-Cox);
t555=t9:(1)*10^-2:t10;
x555=(exp(t555)-b5)/a5;
%region 6 calculation of a6,b6,d6,beta6
x11=x10;x12=L;y11=y10;
y12=(xj+sqrt((2*PerSi*V7)/(q*Np)))/cpd;
a6=(sqrt(y12)-sqrt(y11)) / (x12-x11);
b6=((x12*sqrt(y11))-(x11*sqrt(y12))) / (x12-x11);
t11=log(a6*x11+b6);t12=log(a6*x12+b6);
d6=sqrt((1/4)+Cox/(PerSi*(a6^2)));
beta6=(q*Np) / (2*PerSi*a6^2-Cox);
t666=t11:(1)*10^-2:t12;
x666=(exp(t666)-b6)/a6;
%calculation of A1,A2,A3,A4 and from that calculation of V2,V3,V4,V5
A1 = (V1-Vgs1-beta1*exp(2*t1)) * (csch((d1*t2)-(d1*t1))) * (d1*a1*exp((-t2-t1)/2));
A1 = A1 - ((Vgs2+beta2*exp(2*t4)) * (csch((d2*t4)-(d2*t3))))* (d2*a2*exp((-t3-t4)/2));

```

```

A1 = A1 + ((Vgs2+beta2*exp(2*t3)) * ((d2*a2*coth((d2*t4)-(d2*t3))-(
(a2/2)))*(exp(-t3))) + 2*a2*beta2*exp(t3);
A1 = A1 + ((Vgs1+beta1*exp(2*t2)) * ((d1*a1*coth((d1*t2)-
(d1*t1)))+(a1/2)))*(exp(-t2))) - 2*a1*beta1*exp(t2);
A2 = -(Vgs3+beta3*exp(2*t6)) * (csch((d3*t6)-(d3*t5))) * (d3*a3*exp((-t5-
t6)/2));
A2 = A2 + ((Vgs3+beta3*exp(2*t5)) * (d3*a3*coth((d3*t6)-(d3*t5))-(a3/2)) *
(exp(-t5))) ;
A2 = A2 + ((Vgs2+beta2*exp(2*t4)) * ((d2*a2*coth((d2*t4)-(d2*t3)))+(a2/2)) *
exp(-t4))) + 2*a3*beta3*exp(t5);
A2 = A2 - ((Vgs2+beta2*exp(2*t3)) * (csch((d2*t4)-(d2*t3))) * (d2*a2*exp((-t4-
t3)/2))) - 2*a2*beta2*exp(t4);
a11 = (d1*a1*(coth((d1*t2)-(d1*t1)))+(a1/2))*(exp(-t2))+(d2*a2*(coth((d2*t4)-
(d2*t3)))-(a1/2))*(exp(-t3));
a12=-(csch((d2*t4)-(d2*t3)))*(d2*a2*exp((-t3-t4)/2));a21=a12;
a22 = ((d2*a2*coth((d2*t4)-(d2*t3)))+(a2/2))*(exp(-t4))+(d3*a3*(coth((d3*t6)-
(d3*t5)))-(a3/2))*(exp(-t5));
a23=(-1)*(csch((d3*t6)-(d3*t5)))*(d3*a3*exp((-t5-t6)/2));
a32=a23;
a33 = ((d3*a3*coth((d3*t6)-(d3*t5)))+(a3/2))*(exp(-t6))+(d4*a4*(coth((d4*t8)-
(d4*t7)))-(a4/2))*(exp(-t7));
a13=0;
a14=0;
a24=0;
a31=0;
a41=0;
a42=0;
a15=0;
a51=0;
a25=0;
a52=0;
a35=0;
a53=0;
a34=-(csch((d4*t8)-(d4*t7)))*(d4*a4*exp((-t7-t8)/2));
a43=a34;
a44=((d4*a4*coth((d4*t8)-(d4*t7)))+(a4/2))*(exp(-t8))+(d5*a5*(coth((d5*t10)-
(d5*t9)))-(a5/2))*(exp(-t9));
a45=-(csch((d5*t10)-(d5*t9)))*(d5*a5*exp((-t9-t10)/2));
a54=a45;
a55=((d5*a5*coth((d5*t10)-(d5*t9)))+(a5/2))*(exp(-
t10))+(d6*a6*(coth((d6*t12)-(d6*t11)))-(a6/2))*(exp(-t11));
A3 = -(Vgs4+beta4*exp(2*t8)) * (csch((d4*t8)-(d4*t7))) * (d4*a4*exp((-t7-
t8)/2));
A3 = A3 + ((Vgs4+beta4*exp(2*t7)) * (d4*a4*coth((d4*t8)-(d4*t7))-(a4/2)) *
(exp(-t7))) ;
A3 = A3 - ((Vgs3+beta3*exp(2*t5)) * (csch((d3*t6)-(d3*t5))) * (d3*a3*exp((-t5-
t6)/2))) + 2*a4*beta4*exp(t7);
A3 = A3 + ((Vgs3+beta3*exp(2*t6)) * (d3*a3*coth((d3*t6)-(d3*t5)))+(a3/2)) *
(exp(-t6))) - 2*a3*beta3*exp(t6);
A4 = -(Vgs5+beta5*exp(2*t10)) * (csch((d5*t10)-(d5*t9))) * (d5*a5*exp((-t10-
t9)/2));
A4 = A4 + ((Vgs5+beta5*exp(2*t9)) * ((d5*a5*coth((d5*t10)-(d5*t9)))-(a5/2)))
*(exp(-t9));

```

```

A4 = A4 + ((Vgs4+beta4*exp(2*t8)) * ((d4*a4*coth((d4*t8)-(d4*t7)))+(a4/2)))
    *(exp(-t8))) + 2*a5*beta5*exp(t9);
A4 = A4 - ((Vgs4+beta4*exp(2*t7)) * (csch((d4*t8)-(d4*t7))) * (d4*a4*exp((-t8-
t7)/2))) - 2*a4*beta4*exp(t8);
A5 = (V7-Vgs6-beta6*exp(2*t12)) * (csch((d6*t12)-(d6*t11))) * (d6*a6*exp((-
t11-t12)/2));
A5 = A5 + ((Vgs6+beta6*exp(2*t11)) * ((d6*a6*coth((d6*t12)-(d6*t11)))-(a6/2)))
    *(exp(-t11)));
A5 = A5 + ((Vgs5+beta5*exp(2*t10)) * ((d5*a5*coth((d5*t10)-(d5*t9)))+(a5/2)))
    *(exp(-t10))) + 2*a6*beta6*exp(t11);
A5 = A5 - ((Vgs5+beta5*exp(2*t9)) * (csch((d5*t10)-(d5*t9))) * (d5*a5*exp((-
t9-t10)/2))) - 2*a5*beta5*exp(t10);
delta=det([a11 a12 a13 a14 a15;a21 a22 a23 a24 a25;a31 a32 a33 a34 a35;a41 a42
a43 a44 a45;a51 a52 a53 a54 a55]);
V2 = det([a11 a12 a13 a14 a15;a21 a22 a23 a24 a25;a31 a32 a33 a34 a35;a41 a42
a43 a44 a45;a51 a52 a53 a54 a55]) / delta;
V3 = det([a11 A1 a13 a14 a15;a21 a22 a23 a24 a25;a31 A3 a33 a34 a35;a41 A4 a43
a44 a45;a51 a52 a53 a54 a55]) / delta;
V4 = det([a11 a12 A1 a14 a15;a21 a22 a23 a24 a25;a31 a32 A3 a34 a35;a41 a42 A4
a44 a45; a51 a52 A5 a54 a55]) / delta;
V5 = det([a11 a12 a13 A1 a15;a21 a22 a23 a24 a25;a31 a32 a33 A3 a35;a41 a42
a43 a44 a45;a51 a52 a53 A5 a55]) / delta;
V6 = det([a11 a12 a13 a14 A1;a21 a22 a23 a24 a25;a31 a32 a33 a34 A3;a41 a42
a43 a44 a45;a51 a52 a53 a54 a55]) / delta;
k1=(1/(sinh((d1*t2)-(d1*t1))));
k2=(V2-Vgs1-(beta1*exp(2*t2)));
k3=sinh((d1*t111)-(d1*t1));
k4=exp((t111-t2)/2);
k5=V1-Vgs1-beta1*(exp(2*t1));
k6=exp((t111-t1)/2);
k7=sinh((d1*t111)-(d1*t2));
Sis_1=k1*(k2*k4.*k3-k5*k6.*k7)+ beta1*exp(2*t111)+Vgs1 ;
% in region 2 surface potential given by Sis2
k1=(1/(sinh((d2*t4)-(d2*t3))));
k2=(V3-Vgs2-(beta2*exp(2*t4)));
k3=sinh((d2*t222)-(d2*t3));
k4=exp((t222-t4)/2);
k5=V2-Vgs2-beta2*(exp(2*t3));
k6=exp((t222-t3)/2);
k7=sinh((d2*t222)-(d2*t4));
Sis_2=k1*(k2*k4.*k3-k5*k6.*k7)+ beta2*exp(2*t222)+Vgs2;
% in region 3 surface potential given by Sis3
k1=(1/(sinh((d3*t6)-(d3*t5))));
k2=(V4-Vgs3-(beta3*exp(2*t6)));
k3=sinh((d3*t333)-(d3*t5));
k4=exp((t333-t6)/2);
k5=V3-Vgs3-beta3*(exp(2*t5));
k6=exp((t333-t5)/2);
k7=sinh((d3*t333)-(d3*t6));
Sis_3=k1*(k2*k4.*k3-k5*k6.*k7)+ beta3*exp(2*t333)+Vgs3;
% in region 4 surface potential given by Sis4
k1=(1/(sinh((d4*t8)-(d4*t7))));
k2=(V5-Vgs4-(beta4*exp(2*t8)));
k3=sinh((d4*t444)-(d4*t7));

```

```

k4=exp((t444-t8)/2);
k5=V4-Vgs4-beta4*(exp(2*t7));
k6=exp((t444-t7)/2);
k7=sinh((d4*t444)-(d4*t8));
Sis_4=k1*(k2*k4.*k3-k5*k6.*k7)+ beta4*exp(2*t444)+Vgs4;
% in region 5 surface potential given by Sis5
k1=(1/(sinh((d5*t10)-(d5*t9))));
k2=(V6-Vgs5-(beta5*exp(2*t10)));
k3=sinh((d5*t555)-(d5*t9));
k4=exp((t555-t10)/2);
k5=V5-Vgs5-beta5*(exp(2*t9));
k6=exp((t555-t9)/2);
k7=sinh((d5*t555)-(d5*t10));
Sis_5=k1*(k2*k4.*k3-k5*k6.*k7)+ beta5*exp(2*t555)+Vgs5;
% in region 6 surface potential given by Sis6
k1=(1/(sinh((d6*t12)-(d6*t11))));
k2=(V7-Vgs6-(beta6*exp(2*t12)));
k3=sinh((d6*t666)-(d6*t11));
k4=exp((t666-t12)/2);
k5=V6-Vgs6-beta6*(exp(2*t11));
k6=exp((t666-t11)/2);
k7=sinh((d6*t666)-(d6*t12));
Sis_6=k1*(k2*k4.*k3-k5*k6.*k7)+ beta6*exp(2*t666)+Vgs6;
% Sis01 is the surface potential for all
%Six region i.e equal to Sis1+Sis2+Sis3+Sis4+Sis5+Sis6 for the first plot
%x01 is the x axis for first plot.
x01=[x111 x222 x333 x444 x555 x666];
Sis01=[Sis_1 Sis_2 Sis_3 Sis_4 Sis_5 Sis_6];
Sis01=Sis01-phit*(log(Na/ni));
% Surface potential v/s channel length plots fo30nm technology node
%initial values for first plot: K=boltzman constant,T=room
%temp=300k,Na=acceptor Conc.,Np=donor conc.,ni=intrinsic carrier conc,Eg=band
%gap,PerSi=Permittivity of Silicon,PerOx=Permittivity of oxide
K=1.38*10^-23;T=300;ni=1.5*10^10;
q=1.6*10^-19;Eg=1.1;PerSi=11.8*8.854*10^-14;PerOx=3.9*8.85*10^-14;
Vsb=0.1;Vgsf=0;Vgsb=0;Vgbf=0;Vgbb=0;Np=1.2*10^18;Lp=6*10^-7;Na=4*10^17;
phiM1=5.25;phiM2=3.5;
%for 30 nm technology tox=oxide thickness ,xj=junction depth
L=30*10^-7;tox=2*10^-7;xj=12*10^-7;L1=15*10^-7;
Vds=0.5;
%calculation of values which will be same for all six regions
%phit=KT/q=thermal voltage, phif=fermi potential, Vfb=flat band
%voltage,Cox=oxide
%capacitance,Vbi=built in potential ,cps=curve fitting parameter by DESIS
%for source,cpd=curve fitting parameter for drain by DESIS for first plot.
Vdb=Vds+Vsb;
phit=(K*T)/q;phis=(4.15+ Eg/2+phit*(log(Na/ni)));
VfbfP=-Eg/2-phit*(log(Np/ni));
VfbbP=-Eg/2-phit*(log(Np/ni));
Vbi=Eg/2+phit*(log(Na/ni));
phifN=phit*(log(Na/ni));
Vfbf1=(phiM1-phis)/q;
Vfbb1=(phiM1-phis)/q;
Vfbf2=(phiM2-phis)/q;

```

```

Vfbb2=(phiM2-phis)/q;
VfbfP1=(VfbfP-Vfbf1);
VfbbP1=(VfbbP-Vfbb1);
VfbfP2=(VfbfP-Vfbf2);
VfbbP2=(VfbbP-Vfbb2);
Cox=PerOx/tox;
gammaP=(sqrt(2*q*PerSi*Np))/Cox;
gammaA=(sqrt(2*q*PerSi*Na))/Cox;
SiS1=((-gammaP/2)+sqrt(((gammaP^2)/4)+(Vgbf-VfbfP1)-(Vgbb-VfbbP1))))^2;
SiS2=((-gammaP/2)+sqrt(((gammaP^2)/4)+(Vgbf-VfbfP)-(Vgbb-VfbbP))))^2;
SiS3=((-gammaA/2)+sqrt(((gammaA^2)/4)+(Vgbf-Vfbf1)-(Vgbb-Vfbb1))))^2;
SiS4=((-gammaP/2)+sqrt(((gammaP^2)/4)+(Vgbf-VfbfP2)-(Vgbb-VfbbP2))))^2;
Vgsf1=Vgsf+Vsb-VfbfP1; Vgsf2=Vgsf+Vsb-VfbfP;
Vgsf3=Vgsf+Vsb-Vfbf1; Vgsf4=Vgsf+Vsb-Vfbf2;
Vgsf5=Vgsf+Vsb-VfbfP; Vgsf6=Vgsf+Vsb-VfbfP2;
Vgsb1=Vgsb+Vsb-VfbbP1; Vgsb2=Vgsb+Vsb-VfbbP;
Vgsb3=Vgsb+Vsb-Vfbb1; Vgsb4=Vgsb+Vsb-Vfbb2;
Vgsb5=Vgsb+Vsb-VfbbP; Vgsb6=Vgsb+Vsb-VfbbP2;
Vgs1=Vgsf1-Vgsb1; Vgs2=Vgsf2-Vgsb2;
Vgs3=Vgsf3-Vgsb3; Vgs4=Vgsf4-Vgsb4;
Vgs5=Vgsf5-Vgsb5; Vgs6=Vgsf6-Vgsb6;
V1=Vbi+Vsb; V7=Vbi+Vdb;
xrs=(sqrt((2*PerSi*(V1))/(q*Np)))/cps;
xrd=(sqrt((2*PerSi*(V7))/(q*Np)))/cps;
cps=4*V1/Vbi;cpd=4*V7/Vbi;
xc=L*xrs/(xrs+xrd);
%region 1 calculation of a1,b1,d1,beta1
x1=0;x2=Lp;
y1=(xj+sqrt((2*PerSi*V1)/(q*Np)))/cps;
y2=sqrt((2*PerSi*SiS1)/(q*Np));
a1=(sqrt(y2)-sqrt(y1))/(x2-x1);
b1=((x2*sqrt(y1))-(x1*sqrt(y2)))/(x2-x1);
t1=log(a1*x1+b1);t2=log(a1*x2+b1);
d1=sqrt((1/4)+Cox/(PerSi*(a1^2)));
beta1=(q*Np)/(2*PerSi*a1^2-Cox);
t111=t1:(-1)*10^-2:t2;
x111=(exp(t111)-b1)/a1;
%region 2 calculation of a2,b2,d2,beta2
x3=x2;x4=xc;
y3=y2
y4=sqrt((2*PerSi*SiS2)/(q*Np));
a2=(sqrt(y4)-sqrt(y3))/(x4-x3);
b2=((x4*sqrt(y3))-(x3*sqrt(y4)))/(x4-x3);
t3=log(a2*x3+b2);t4=log(a2*x4+b2);
d2=sqrt((1/4)+Cox/(PerSi*(a2^2)));
beta2=(q*Np)/(2*PerSi*a2^2-Cox);
t222=t3:(-1)*10^-2:t4;
x222=(exp(t222)-b2)/a2;
%region 3 calculation of a3,b3,d3,beta3
x5=x4;x6=L1;y5=y4;
y6=sqrt((2*PerSi*SiS3)/(q*Na));
a3=(sqrt(y6)-sqrt(y5))/(x6-x5);
b3=((x6*sqrt(y5))-(x5*sqrt(y6)))/(x6-x5);
t5=log(a3*x5+b3);t6=log(a3*x6+b3);

```

```

d3=sqrt((1/4)+Cox/(PerSi*(a3^2)));
beta3=(q*Na) / (2*PerSi*a3^2-Cox);
t333=t5:(-1)*10^-2:t6;
x333=(exp(t333)-b3)/a3;
%region 4 calculation of a4,b4,d4,beta4
x7=x6;x8=L-xc;
y7=y6;
y8=sqrt((2*PerSi*SiS2)/(q*Np));
a4=(sqrt(y8)-sqrt(y7)) / (x8-x7);
b4=((x8*sqrt(y7))-(x7*sqrt(y8))) / (x8-x7);
t7=log(a4*x7+b4);t8=log(a4*x8+b4);
d4=sqrt((1/4)+Cox/(PerSi*(a4^2)));
beta4=(q*Na) / (2*PerSi*a4^2-Cox);
t444=t7:(1)*10^-2:t8;
x444=(exp(t444)-b4)/a4;
%region 5 calculation of a5,b5,d5,beta5
x9=x8;x10=L-Lp;
y9=y8;
y10=sqrt((2*PerSi*SiS4)/(q*Np));
a5=(sqrt(y10)-sqrt(y9)) / (x10-x9);
b5=((x10*sqrt(y9))-(x9*sqrt(y10))) / (x10-x9);
t9=log(a5*x9+b5);t10=log(a5*x10+b5);
d5=sqrt((1/4)+Cox/(PerSi*(a5^2)));
beta5=(q*Np) / (2*PerSi*a5^2-Cox);
t555=t9:(1)*10^-2:t10;
x555=(exp(t555)-b5)/a5;
%region 6 calculation of a6,b6,d6,beta6
x11=x10;x12=L;
y11=y10;
y12=(xj+sqrt((2*PerSi*V7)/(q*Np)))/cpd;
a6=(sqrt(y12)-sqrt(y11)) / (x12-x11);
b6=((x12*sqrt(y11))-(x11*sqrt(y12))) / (x12-x11);
t11=log(a6*x11+b6);t12=log(a6*x12+b6);
d6=sqrt((1/4)+Cox/(PerSi*(a6^2)));
beta6=(q*Np) / (2*PerSi*a6^2-Cox);
t666=t11:(1)*10^-2:t12;
x666=(exp(t666)-b6)/a6;
%calculation of A1,A2,A3,A4 and from that calculation of V2,V3,V4,V5
A1 = (V1-Vgs1-beta1*exp(2*t1)) * (csch((d1*t2)-(d1*t1))) * (d1*a1*exp((-t2-t1)/2));
A1 = A1 - ((Vgs2+beta2*exp(2*t4)) * (csch((d2*t4)-(d2*t3))) * (d2*a2*exp((-t3-4)/2)));
A1 = A1 + ((Vgs2+beta2*exp(2*t3)) * ((d2*a2*coth((d2*t4)-(d2*t3))-(a2/2)) * (exp(-t3))) + 2*a2*beta2*exp(t3);
A1 = A1 + ((Vgs1+beta1*exp(2*t2)) * ((d1*a1*coth((d1*t2)-(d1*t1))+(a1/2)) * (exp(-t2))) - 2*a1*beta1*exp(t2);
A2 = -(Vgs3+beta3*exp(2*t6)) * (csch((d3*t6)-(d3*t5))) * (d3*a3*exp((-t5-t6)/2));
A2 = A2 + ((Vgs3+beta3*exp(2*t5)) * (d3*a3*coth((d3*t6)-(d3*t5))-(a3/2)) * (exp(-t5))) ;
A2 = A2 + ((Vgs2+beta2*exp(2*t4)) * ((d2*a2*coth((d2*t4)-(d2*t3))+(a2/2)) * (exp(-t4))) + 2*a3*beta3*exp(t5);
A2 = A2 - ((Vgs2+beta2*exp(2*t3)) * (csch((d2*t4)-(d2*t3))) * (d2*a2*exp((-t4-t3)/2))) - 2*a2*beta2*exp(t4);

```

```

a11 = (d1*a1*(coth((d1*t2)-(d1*t1)))+(a1/2))*(exp(-t2))+(d2*a2*(coth((d2*t4)-(d2*t3)))-(a1/2))*(exp(-t3));
a12=-(csch((d2*t4)-(d2*t3)))*(d2*a2*exp((-t3-t4)/2));a21=a12;
a22 = ((d2*a2*coth((d2*t4)-(d2*t3)))+(a2/2))*(exp(-t4))+(d3*a3*(coth((d3*t6)-(d3*t5)))-(a3/2))*(exp(-t5));
a23=(-1)*(csch((d3*t6)-(d3*t5)))*(d3*a3*exp((-t5-t6)/2));
a32=a23;
a33 = ((d3*a3*coth((d3*t6)-(d3*t5)))+(a3/2))*(exp(-t6))+(d4*a4*(coth((d4*t8)-(d4*t7)))-(a4/2))*(exp(-t7));
a13=0;
a14=0;
a24=0;
a31=0;
a41=0;
a42=0;
a15=0;
a51=0;
a25=0;
a52=0;
a35=0;
a53=0;
a34=-(csch((d4*t8)-(d4*t7)))*(d4*a4*exp((-t7-t8)/2));
a43=a34;
a44=((d4*a4*coth((d4*t8)-(d4*t7)))+(a4/2))*(exp(-t8))+(d5*a5*(coth((d5*t10)-(d5*t9)))-(a5/2))*(exp(-t9));
a45=-(csch((d5*t10)-(d5*t9)))*(d5*a5*exp((-t9-t10)/2));
a54=a45;
a55=((d5*a5*coth((d5*t10)-(d5*t9)))+(a5/2))*(exp(-t10))+(d6*a6*(coth((d6*t12)-(d6*t11)))-(a6/2))*(exp(-t11));
A3 = -(Vgs4+beta4*exp(2*t8)) * (csch((d4*t8)-(d4*t7)) * (d4*a4*exp((-t7-t8)/2));
A3 = A3 + ((Vgs4+beta4*exp(2*t7)) * (d4*a4*coth((d4*t8)-(d4*t7))-(a4/2)) * (exp(-t7)));
A3 = A3 - ((Vgs3+beta3*exp(2*t5)) * (csch((d3*t6)-(d3*t5)) * (d3*a3*exp((-t5-t6)/2))) + 2*a4*beta4*exp(t7));
A3 = A3 + ((Vgs3+beta3*exp(2*t6)) * (d3*a3*coth((d3*t6)-(d3*t5))+(a3/2)) * (exp(-t6))) - 2*a3*beta3*exp(t6);
A4 = -(Vgs5+beta5*exp(2*t10)) * (csch((d5*t10)-(d5*t9)) * (d5*a5*exp((-t10-t9)/2));
A4 = A4 + ((Vgs5+beta5*exp(2*t9)) * ((d5*a5*coth((d5*t10)-(d5*t9))-(a5/2))) * (exp(-t9)));
A4 = A4 + ((Vgs4+beta4*exp(2*t8)) * ((d4*a4*coth((d4*t8)-(d4*t7)))+(a4/2))) * (exp(-t8)) + 2*a5*beta5*exp(t9);
A4 = A4 - ((Vgs4+beta4*exp(2*t7)) * (csch((d4*t8)-(d4*t7)) * (d4*a4*exp((-t8-t7)/2))) - 2*a4*beta4*exp(t8));
A5 = (V7-Vgs6-beta6*exp(2*t12)) * (csch((d6*t12)-(d6*t11)) * (d6*a6*exp((-t11-t12)/2));
A5 = A5 + ((Vgs6+beta6*exp(2*t11)) * ((d6*a6*coth((d6*t12)-(d6*t11))-(a6/2))) * (exp(-t11)));
A5 = A5 + ((Vgs5+beta5*exp(2*t10)) * ((d5*a5*coth((d5*t10)-(d5*t9)))+(a5/2))) * (exp(-t10)) + 2*a6*beta6*exp(t11);
A5 = A5 - ((Vgs5+beta5*exp(2*t9)) * (csch((d5*t10)-(d5*t9)) * (d5*a5*exp((-t9-t10)/2))) - 2*a5*beta5*exp(t10));

```

```

delta=det([a11 a12 a13 a14 a15;a21 a22 a23 a24 a25;a31 a32 a33 a34 a35;a41 a42
a43 a44 a45;a51 a52 a53 a54 a55;]);
V2 = det([A1 a12 a13 a14 a15;A2 a22 a23 a24 a25;A3 a32 a33 a34 a35;A4 a42 a43
a44 a45;A5 a52 a53 a54 a55;])/ delta;
V3 = det([a11 A1 a13 a14 a15;a21 A2 a23 a24 a25;a31 A3 a33 a34 a35;a41 A4 a43
a44 a45;a51 A5 a53 a54 a55;]) / delta;
V4 = det([a11 a12 A1 a14 a15;a21 a22 A2 a24 a25;a31 a32 A3 a34 a35;a41 a42 A4
a44 a45;a51 a52 A5 a54 a55;]) / delta;
V5 = det([a11 a12 a13 A1 a15;a21 a22 a23 A2 a25;a31 a32 a33 A3 a35;a41 a42 a43
A4 a45;a51 a52 a53 A5 a55;]) / delta;
V6 = det([a11 a12 a13 a14 A1;a21 a22 a23 a24 A2;a31 a32 a33 a34 A3;a41 a42 a43
a44 A4;a51 a52 a53 a54 A5;]) / delta;
% in region 1 surface potential given by Sis1
k1=(1/(sinh((d1*t2)-(d1*t1))));
k2=(V2-Vgs1-(beta1*exp(2*t2)));
k3=sinh((d1*t111)-(d1*t1));
k4=exp((t111-t2)/2);
k5=V1-Vgs1-beta1*(exp(2*t1));
k6=exp((t111-t1)/2);
k7=sinh((d1*t111)-(d1*t2));
Sis_1=k1*(k2*k4.*k3-k5*k6.*k7)+ beta1*exp(2*t111)+Vgs1 ;
% in region 2 surface potential given by Sis2
k1=(1/(sinh((d2*t4)-(d2*t3))));
k2=(V3-Vgs2-(beta2*exp(2*t4)));
k3=sinh((d2*t222)-(d2*t3));
k4=exp((t222-t4)/2);
k5=V2-Vgs2-beta2*(exp(2*t3));
k6=exp((t222-t3)/2);
k7=sinh((d2*t222)-(d2*t4));
Sis_2=k1*(k2*k4.*k3-k5*k6.*k7)+ beta2*exp(2*t222)+Vgs2;
% in region 3 surface potential given by Sis3
k1=(1/(sinh((d3*t6)-(d3*t5))));
k2=(V4-Vgs3-(beta3*exp(2*t6)));
k3=sinh((d3*t333)-(d3*t5));
k4=exp((t333-t6)/2);
k5=V3-Vgs3-beta3*(exp(2*t5));
k6=exp((t333-t5)/2);
k7=sinh((d3*t333)-(d3*t6));
Sis_3=k1*(k2*k4.*k3-k5*k6.*k7)+ beta3*exp(2*t333)+Vgs3;
% in region 4 surface potential given by Sis4
k1=(1/(sinh((d4*t8)-(d4*t7))));
k2=(V5-Vgs4-(beta4*exp(2*t8)));
k3=sinh((d4*t444)-(d4*t7));
k4=exp((t444-t8)/2);
k5=V4-Vgs4-beta4*(exp(2*t7));
k6=exp((t444-t7)/2);
k7=sinh((d4*t444)-(d4*t8));
Sis_4=k1*(k2*k4.*k3-k5*k6.*k7)+ beta4*exp(2*t444)+Vgs4;
% in region 5 surface potential given by Sis5
k1=(1/(sinh((d5*t10)-(d5*t9))));
k2=(V6-Vgs5-(beta5*exp(2*t10)));
k3=sinh((d5*t555)-(d5*t9));
k4=exp((t555-t10)/2);
k5=V5-Vgs5-beta5*(exp(2*t9));

```

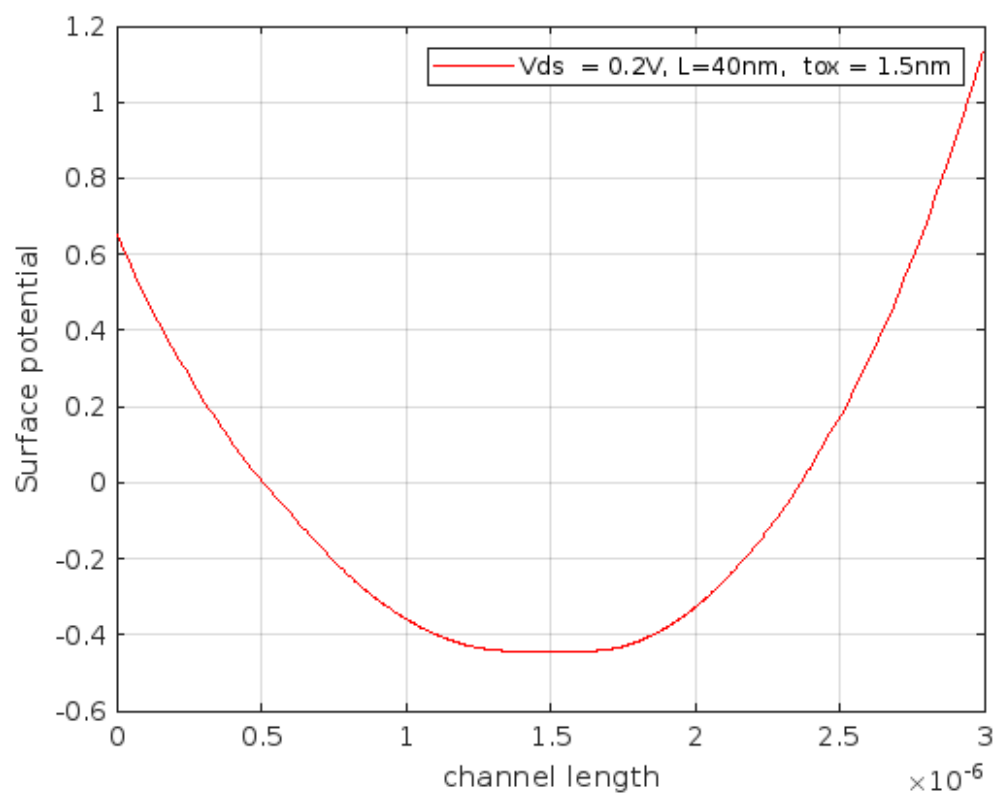
```

k6=exp((t555-t9)/2);
k7=sinh((d5*t555)-(d5*t10));
Sis_5=k1*(k2*k4.*k3-k5*k6.*k7)+ beta5*exp(2*t555)+Vgs5;
% in region 6 surface potential given by Sis6
k1=(1/(sinh((d6*t12)-(d6*t11))));
k2=(V7-Vgs6-(beta6*exp(2*t12)));
k3=sinh((d6*t666)-(d6*t11));
k4=exp((t666-t12)/2);
k5=V6-Vgs6-beta6*(exp(2*t11));
k6=exp((t666-t11)/2);
k7=sinh((d6*t666)-(d6*t12));
Sis_6=k1*(k2*k4.*k3-k5*k6.*k7)+ beta6*exp(2*t666)+Vgs6;
% Sis02 is the surface potential for all
%three region i.e equal to Sis1+Sis2+Sis3+Sis4+Sis5+Sis6 for the first plot
%x01 is the x axis for first plot.
x01=[x111 x222 x333 x444 x555 x666];
Sis01=[Sis_1 Sis_2 Sis_3 Sis_4 Sis_5 Sis_6];
Sis01=Sis01-phit*(log(Na/ni));
arp=plot(x01,Sis01,'r');
xlabel('channel length')
ylabel('Surface potential')
grid on
legend([arp], 'Vds = 0.2V, L=40nm, tox = 1.5nm');

```

y3 =

6.0540e-07



Published with MATLAB® R2022a