Experiment No:- 2 (A)

Aim of the Experiment:-

To simulate variation of Threshold voltage versus change in channel width under narrow width effect using MATLAB Tool.

Theory:-

Narrow width effects occur when the channel width W is decreased to small values. With regards to the threshold voltage, narrow-width MOSFETs exhibit threshold voltages that are larger than that predicted with the gradual channel approximation. The amount of increase $(\Delta V_{Th})_{NWE} > 0$ of the threshold voltage is due to bulk charge outside of the gate region that is ignored in a simple analysis.

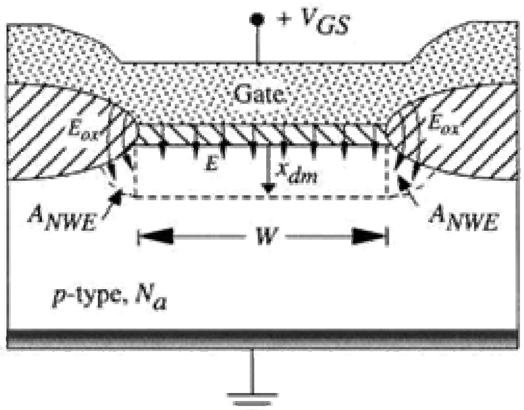


Figure 1 Charge distribution for narrow width

Above figure illustrates the basic problem: fringing electric fields deplete the silicon beyond the gate region as defined by the channel width W. Since the corresponding bulk charge was ignored, expression for VTh will underestimate the contribution due to Q_B.

In general, we may write the total bulk charge in Coulombs using

$$|Q_B|A_c = qN_a x_{dm} A_C \quad (1)$$

where A_c is the total area of the region. Explicitly,

$$A_C = x_{dm} W + 2A_{NWE} \quad (2)$$

With the total area of the charge that causes the NWE correction, the basic threshold voltage expression now becomes,

$$V_{Tn} = V_{FB} + 2|\phi_F| + \frac{1}{C_{ox}} \sqrt{2q\varepsilon_{Si} N_a (2|\phi_F|)}\, g \quad (3)$$

Where

$$g = 1 + \frac{A_{NWE}}{x_{dm} W} > 1$$

And g is known as the NWE form factor.

Since it is not possible to accurately determine the boundary without a detailed numerical calculation, the value of is estimated by assuming a geometrical shape for the depletion edge (Shown in Figure 2). A simple choice is to use a circular boundary that has a radius since the area for both contributions is

$$2\left(\frac{\pi x_{dm}^{2}}{4}\right) \quad (4)$$

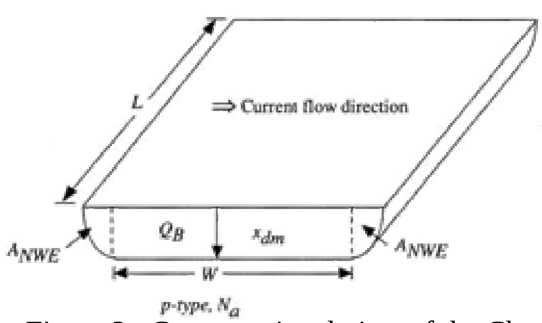


Figure 2 : Cross-sectional view of the Channel

Hence, the NWE factor become,

$$g \approx 1 + \frac{\pi x_{dm}}{2W} . \tag{5}$$

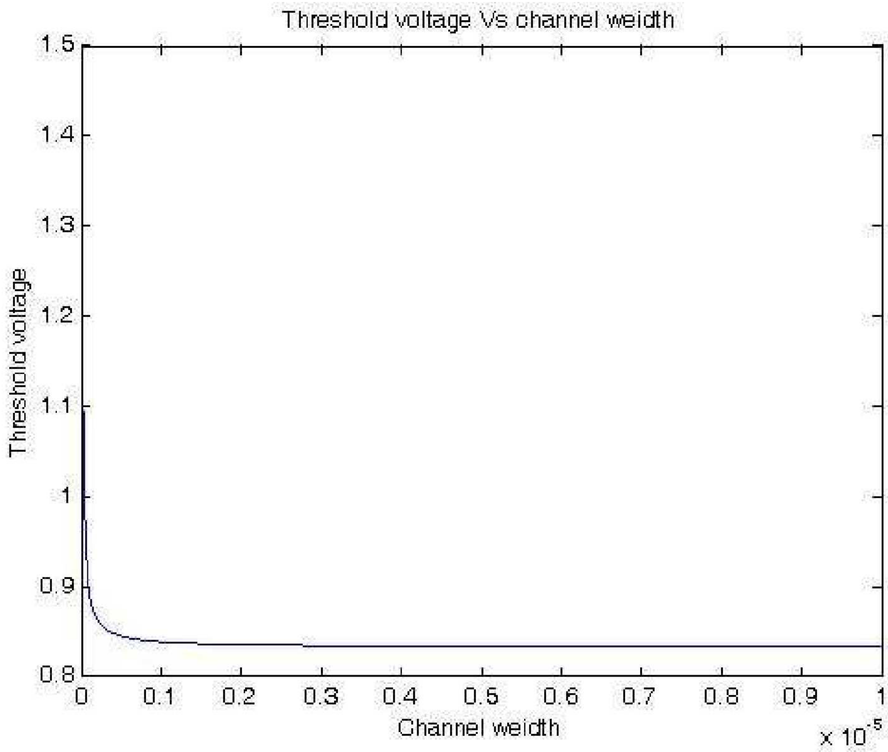
From equation 3 & 5 we can simulate the plot of threshold voltage & channel width using MATLAB Tool.

MATLAB Program to simulate Vth Vs W:

```
%Program to plot a curve between channel
%width (W) and Threshold Voltage (Vth).
%---------------------------------------------------------------------------

 clc;
 close all;
 clear all;
 w=linspace(10*10^(-9),10^(-5),1000);
 ni=1.45*10^16;
 q=1.6*10^(-19);
 eox=3.9*8.854*10^(-14)
 cox=eox/10^(-9);
 na=10^22; xj=50*10^-9;
 esi=11.2*8.854*10^(-14);
 fi=0.0259*log(na/ni);
 xdm=sqrt((4*fi*esi)/(na*q));
 qb=sqrt(q*4*na*esi*fi);
 k=2*w
 g=1+xdm*3.14./k;
 vt=2*fi+qb*g/cox;
 plot(w,vt);
 title('Threshold voltage Vs channel weidth');
 xlabel('Channel weidth');
 ylabel('Threshold  voltage');
```

Graph Obtained from the MATLAB Program:



Conclusion :

It is observed from the plot that the Threshold Voltage due to narrow width effect decreases with channel width to an extent and then maintain a constant value in between 0.8 to 0.9eV.

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