REPORT

2^{nd} Homework

Subject	Computational Microelectronics
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<Selection of the model>

I choose the distance of material that these are set to be 100nm with half silicon layer and half SiO_2 layer. Through calculating of the general Poisson equation, the analytic solution per area is below

$$C = \left(\frac{t_{ox}}{\varepsilon_{ox}} + \frac{t_{si}}{\varepsilon_{si}}\right)^{-1} = 5.175 \times 10^{-4}\ F/m^2\ \ (= 517.503\ \mu F/m^2)$$

- ε_o = 8.85 * 10-12

  ε_{ox} = 3.9 * 8.85 * 10-12

  ε_{si} = 11.68 * 8.85 * 10-12

  t_{ox} = 50 * 10-9 m

  t_{si} = 50 * 10-9 m

<MATLAB Simulation>

The discrete number is 1001-point and the electrostatic potential boundaries of $\phi(1)$ and $\phi(1001)$ are selected by 1 and 0 respectively. The first layer is SiO_2. Through the derived discretization equation from the general Poisson equation, I can figure out the total charge per area by the law of coulomb.

$$Q = C \cdot V\ \ (V = 1) = C$$

$$= \varepsilon_{ox} * \frac{\phi(1) - \phi(2)}{\Delta x} \quad or \quad \varepsilon_{si} * \frac{\phi((N+1)/2) - \phi((N+3)/2)}{\Delta x}$$

$$= \varepsilon_{ox} * \frac{\phi((N-1)/2) - \phi((N+1)/2)}{\Delta x} \quad or \quad \varepsilon_{si} * \frac{\phi(1000) - \phi(1001)}{\Delta x}$$

The capacitance per area is solution of the above equation. Since the boundary condition voltage is set by 1. Both the analytic solution and MATLAB simulation are almost same results that the capacitance is '5.1776×10^{-4} F/m^2 (=517.50 $\mu F/m^2$)'.

So I confirm that the analytic and the general Poisson equation are almost same and valid for calculating the unit area capacitance.

** The MATLAB code is shown in the next page.

```
clc; clear all;

E_0 = 8.85*10^(-12);     % permutivity of vacume state
E_ox = 3.9 * E_0;        % permutivity of silicon di-oxide
E_si = 11.68 * E_0;      % permutivity of silicon
d = 100 * 10^(-9);       % Total distance of tox and tsi junction
N = 1001;                % The number of digitation point
delx = d/(N-1);          % The digitization step (unit distance)

k_si = (-E_si);
k_ox = (-E_ox);

A_V = zeros(N,N);        % set the LSH vector using general poisson equation
A_V(1,1) = 1;
A_V(N,N) = 1;
B = zeros(N,1);          % set the RHS vector using Boundary condition
B(1,1) = 1;

for i = 2 : (N+1)/2
    if i == (N+1)/2
        A_V(i,i+1) = k_si;
        A_V(i,i) = -(k_ox + k_si);
        A_V(i,i-1) = k_ox;
    else
        A_V(i,i-1) = k_ox;
        A_V(i,i) = (-2)*k_ox;
        A_V(i,i+1) = k_ox;
    end
end
for i = (N+1)/2+1 : N-1
    A_V(i,i-1) = k_si;
    A_V(i,i) = (-2)*k_si;
    A_V(i,i+1) = k_si;
end

X = A_V₩B;                                   % Calculation for psi vector
Q_ox_1 =  E_ox*((X(1,1)-X(2,1))/delx);
Q_ox_2 =  E_ox*((X(500,1)-X(501,1))/delx);
Q_si_1 =  E_si*((X(501,1)-X(502,1))/delx);
Q_si_2 =  E_si*((X(N-1,1)-X(N,1))/delx);
% Calculation of Discretization
% that it is derived from the general poisson equation

Analytic_sol = 1/(d/2*(1/E_ox + 1/E_si));   % Analytic solution for comparison
```