Homework 4 Spring 2019 TA: Abdullah Al-Obaidi

Notes:

- This is a short assignment and will only be worth 50 points
- There are multiple correct solutions to Problems 5 & 6

Problem 1:

For the 248 nm UV machine, the total amount of wafers that can be made its lifetime:

$$N_w = 80 * 24 * 365 * \frac{4}{10} = 280{,}320\ wafers$$

Cost per wafer: $C_w = \frac{10M}{N_w} = \$35.67$

Number of chips per wafer: $N_c = \frac{A_w}{A_{chip}} = \frac{150^2\ \pi}{50} = 1413$

Cost per chip: $C_c = \frac{35.67}{1413} = \$0.025$

For the 193nm UV machine:
Wafers per lifetime: $N_{w2} = 70080$
Cost per wafer: $C_{w2} = \$570.78$
Chips per wafer: $N_{c2} = 1413 * \left(\frac{90}{50}\right)^2 = 4578$

$\left(\frac{90}{50}\right)^2$ *is the resolution difference*

Cost per chip: $C_{c2} = \$0.125$

Cost difference $C_\Delta = 0.125 - 0.025 = \$0.1/chip$

Problem 2:

The dielectric constant of SiO_2 = $K_s = 3.9$
The dielectric constant of HfO_2 = $K_H = 25$

Any K_H between 15 – 25 is accepted

-> Thickness of HfO2: $t_{HfO_2} = \frac{25}{3.9} * t_{SiO_2} = 12.82\ nm$

Problem 3:

Resistivity of Aluminum = $2.8 * 10^{-8} \Omega * m$

Resistance of the interconnect $R_{Al} = \frac{\rho l}{wt} \rightarrow t = \frac{\rho l}{wR} = \frac{2.8*10^{-8}*250*10^{-6}}{3*10^{-6}*25} = 93.3 * 10^{-9} m =$ $93.3 nm$

Sheet resistance $= \frac{\rho}{t} = \frac{2.8*10^{-8}}{93.3*10^{-9}} =$ $0.3\ \Omega/■$

Problem 4:

Resistivity of Copper = $1.7 * 10^{-8} \Omega * m$

$$R_{Al} = \frac{\rho l}{wt} \rightarrow l = \frac{Rwt}{\rho} = \frac{3 * 10^{-6} * 25 * 93.3 * 10^{-9}}{1.7 * 10^{-8}} = 412\ \mu m$$

Problem 5:

Poly 1: $7.7 \Omega/■$

P+: $7.5 \Omega/■$

For 10k Ohms

Poly1: $\frac{5{,}000}{7.7} =$ 649.4 ■'s

P+: $\frac{5{,}000}{7.5} =$ 666.7 ■'s

There are a lot of different ways to create the serpentine layout, depending on how many rows you want to make, but it will take approximately 2.3x the area for the P+ resistor. The main reason for this is that a P+ ■is 0.3x0.3 microns while a Poly ■ is 0.2x0.2 microns

Problem 6:

Code for 4 bit invertor:

```
module inverter_4bit (A, F);
input[3:0] A;
output[3:0] F;
assign F = ~ A;
endmodule
```

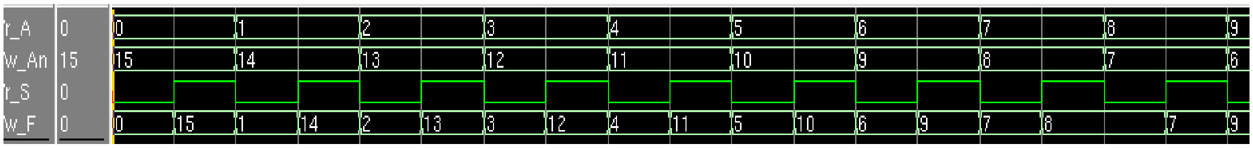
Code for Mux combination:

```
module Mux4_2_1 (A,B, SEL, F);
input[3:0] A,B;
input SEL;
output[3:0] F;

MUX mux0(.A(A[1:0]), .B(B[1:0]), .SEL(SEL), .F(F[1:0]));
MUX mux1(.A(A[3:2]), .B(B[3:2]), .SEL(SEL), .F(F[3:2]));

endmodule
```

Test Bench:

```
module hw4_tb();
reg[3:0] A;
reg S;
wire [3:0] W, F; //w is wire connection inverters to mux, f is output

initial
begin
A = 4'b0000;
S = 1'b0;
end

always
#10 S = ~S;
always
#20 A = A+1;

inverter_4bit inv0(.A(A), .F(W));
Mux4_2_1 mux0(.A(W), .B(A), .SEL(S), .F(F));

endmodule
```

Waveform:



Numbers are shown in unsigned convention