EE 330
Homework 5 Solutions
Fall 2020

Solution 1

From L13

$R(T_2) = R(T_1)[1 + (T_2 - T_1)\frac{TCR}{10^6}]$

So $R(300) = R(273)\left[1 + (27)\frac{1100}{10^6}\right] = 1029.7\Omega$

Solution 2

300 and 320 $R(T) = 5T + 1000 \Rightarrow R(25) = 1125\ and\ R(47) = 1235$

From L13

$1235 = 1125\left[1 + (22)\frac{TCR}{10^6}\right] \Rightarrow TCR = 4444ppm/°C$

Solution 3

From L13

$R(T_2) = R(T_1)[1 + (T_2 - T_1)\frac{TCR}{10^6}]$

So $R_1(T_2) + R_2(T_2) = R_1(T_1)\left[1 + (T_2 - T_1)\frac{TCR_1}{10^6}\right] + R_2(T_1)\left[1 + (T_2 - T_1)\frac{TCR_2}{10^6}\right]$

$= R_1(T_1) + R_2(T_1) + (T_2 - T_1)\left[R_1(T_1)\frac{TCR_1}{10^6} + R_2(T_1)\frac{TCR_2}{10^6}\right]$

$= 5 * 10^3 + (T_2 - T_1)\left[5 * 10^3\frac{360}{10^6}\right]$

$= 5 * 10^3 + 5 * 10^3(T_2 - T_1)\frac{360}{10^6} = 5 * 10^3(1 + (T_2 - T_1)\frac{360}{10^6})$ which means the equivalent TCR is 360ppm/C

Solution 4

$\lambda = 0.3\mu m$ and the minimum width for poly is 2λ

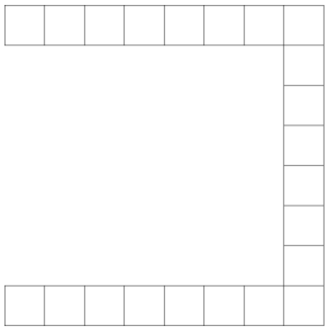
For one square $W = L = 2 * 0.3\mu m = 0.6\mu m$

$A_\square = 0.6\mu m * 0.6\mu m = 0.36\mu m$

$Sheet\ Resistance = 23.5\frac{\Omega}{\square}$

We can start by imagining the letter “c” made from these squares. Each side should have n number of squares to add up so that the total resistance is 500Ω.

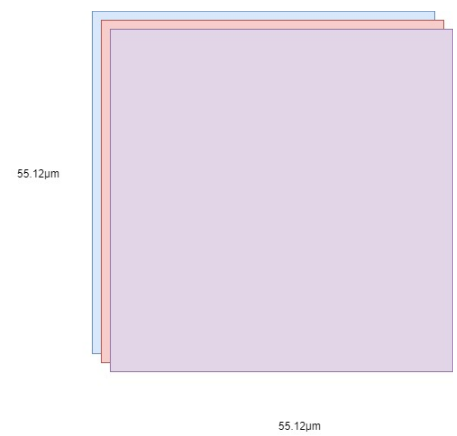
If we take $\frac{500}{23.5} = 21.3$ squares. If we divide by 3 to get how many we will have on each side, we roughly get 7. Since the corners will amount to less, I will check for a square where each side is 8 instead. So let us implement it and check:



Each of the squares that are not a corner are 23.5Ω and the corners are 0.55*23.5Ω.
So total we have:
$(7+6+7)*23.5\Omega+2*0.55*23.5\Omega=495.85\Omega$

Solution 5

I will use M1, M2 and M3 layers.
From M1 to M2 the capacitance is $31aF/\mu m^2$
From M2 to M3 the capacitance is $35aF/\mu m^2$
If we layer all 3 layers on top of each other, we make 2 capacitors in series.



$A_{capM1M2}=\frac{A}{31aF/\mu m^2}$
$A_{capM2M3}=\frac{B}{35aF/\mu m^2}$
where $A+B=100fF$. Since I am shooting for the areas to be the same

$$\frac{B}{35aF/\mu m^2}=\frac{A}{31aF/\mu m^2}\Rightarrow B=1.129A$$

$\frac{1}{A}+\frac{1}{B}=\frac{1}{100fF}\Rightarrow\frac{1.8857}{A}=\frac{1}{100fF}\Rightarrow A=188.57fF$ and $B=212.9fF$
So the total $A=\frac{46.97fF}{31aF/\mu m^2}+\frac{53.03fF}{35aF/\mu m^2}=1515.16+1522.85=3038\mu m^2$
That means each side will be $55.12\mu m$ and the layers will be stacked on themselves with the one side of the capacitor being on Metal 1 and the other on Metal 3.

Solution 6

Recall that the diode through a pn junction diode can be modeled as $I_D=J_SA(e^{\frac{V_D}{V_T}}-1)$.
Assuming that $V_T\approx 26mV$ at room temperature:

$$I_{D,0.5V}=[10^{-15}][75]\left(e^{\frac{0.5}{0.026}}-1\right)=16.9\mu A$$

$$I_{D,0.5V}=[10^{-15}][75]\left(e^{\frac{0.6}{0.026}}-1\right)=789\mu A$$

$$16.9\mu A\le I_D\le 789\mu A$$