

ECE 3030: Physical Foundations of Computer Engineering

Fall 2022

Homework 2—Total points 100

Due on Tue 9/6/2022 at 11.59am.

- Q1 Figure 1 shows the cross-section of an Intel Broadwell chip (2014). Clearly identify different classes materials in this cross-section. How many layers of metal are there in this chip as visible in this cross-sectional image? [20 pts]

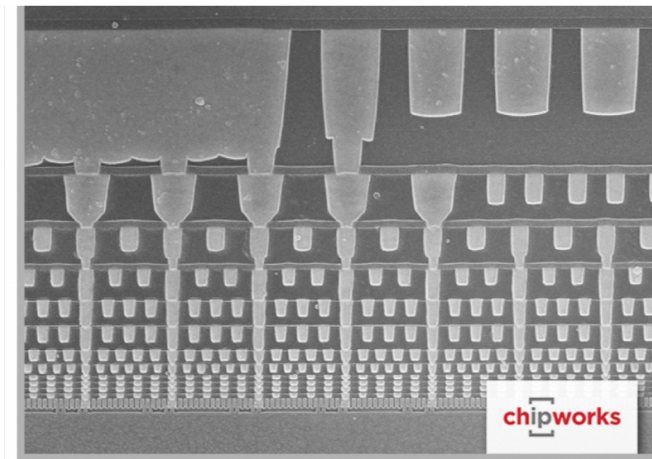


Figure 1: Image source: Extremetech

- Q2 Starting with the Ohm's law derive the equation $v = \mu E$. All variables carry their usual meanings. Explicitly state the meaning of all variables used in the derivation. [20 pts]
- Q3 Show that $\sigma = \frac{n\tau q^2}{m}$. All variables carry their usual meanings. Explicitly state the meaning of all variables used in the derivation. [20 pts]
- Q4 The mobility and carrier density of Al are $1.2 \times 10^{-3} \text{ m}^2/\text{Vs}$ and $1.98 \times 10^{29} \text{ m}^{-3}$, respectively. The mobility and carrier density of Cu are $4.32 \times 10^{-3} \text{ m}^2/\text{Vs}$ and $8.5 \times 10^{29} \text{ m}^{-3}$, respectively. Which one would you use as interconnects in advanced CMOS nodes? [20 pts]

Q5 Say you doped a wafer of pure (intrinsic) Si with P (doping density= 10^{23} m^{-3}). Now the wafer has a lot more free electrons than it had before. Do you expect the piece of Si wafer to be charge neutral? Why or why not? Will your answer change had you doped it with Al? [20 pts]