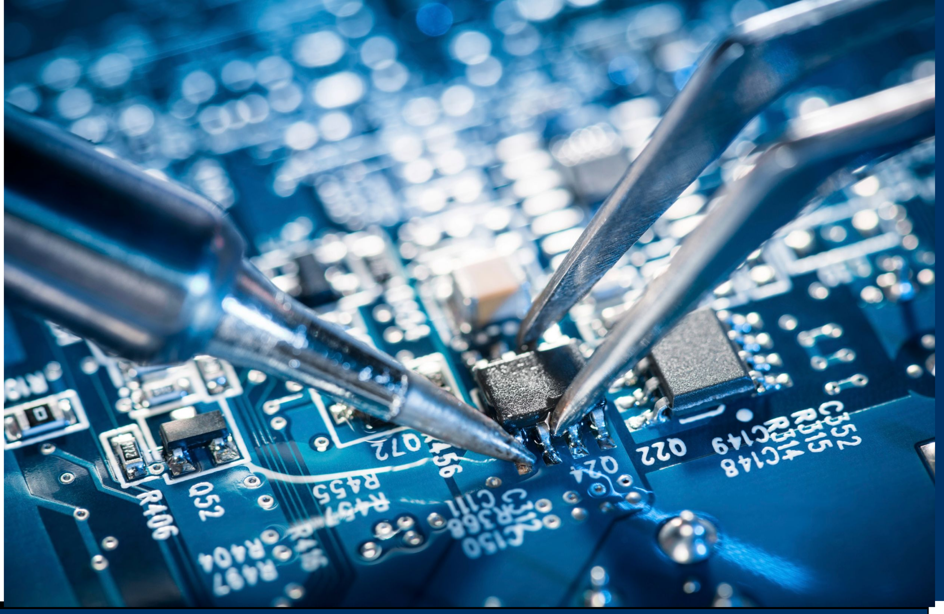

Cu, Au, & Ag in Microelectronic Wiring

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ABSTRACT

The wiring of microelectronic components is fundamental in the construction of smart phones and other devices. The types of elements used play an integral role in the design. It has been noted that gold, silver, and copper are commonly used metals in fashioning micro electric components. The aim of this project is to examine the correlations between these properties, such as malleability, conductivity, and structure in order to determine why these metals are prominently used within a phone's micro-electrical system. As result of highlighting the most useful characteristics these popular metals contribute towards smartphone functionality, further research can investigate alternative materials that are more cost efficient and increase the micro-electrical proficiency of technology.

Footnotes

Composition of the Copper Alloys listed in Table 1

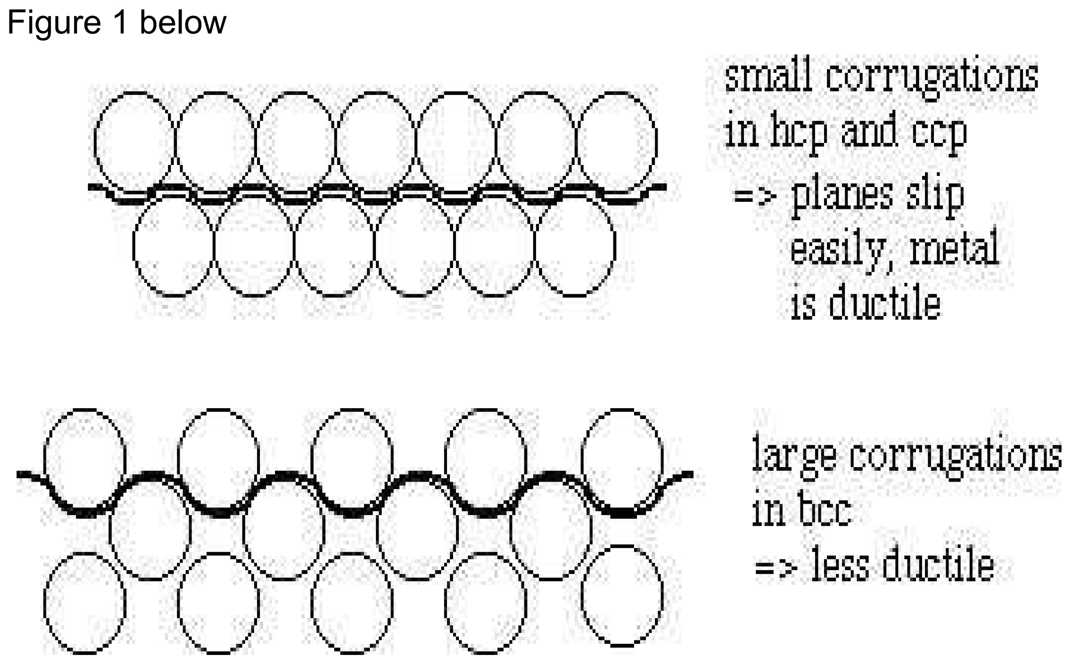
[1]C11000 (99.9% Cu). C26000 (70% Cu, 29% Zn and some Sn, Pb, Fe), C5100 (95% Cu, 5% Sn), C70600 (88.7% Cu, 1.3% Fe, 10% Ni), C75200 (65% Cu, 17% Zn, 18% Ni)

Properties to Consider for Microelectronic Wiring

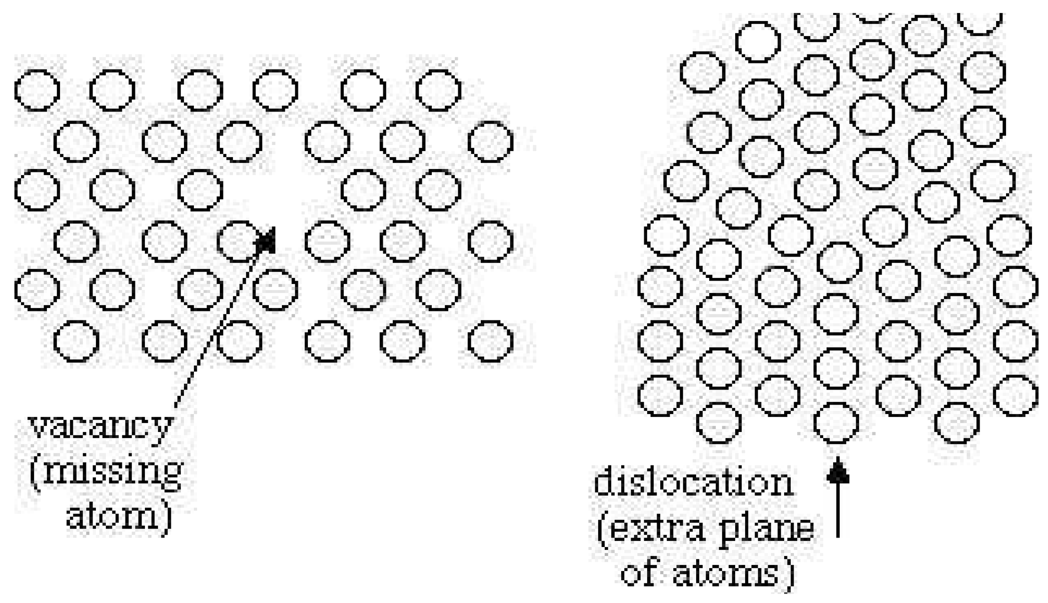
- Structure (for characteristics such as Malleability, ductility, durability and hardness), conductivity.
- Malleability and ductility are crucial to electronic wiring due to easy shape alteration (malleability) and the ability to alter the shape to a high degree without breaking (ductility).
- High Conductivity increases the ability to transmit electricity which can increase a phone's battery life and processing power.

Malleability and Ductility

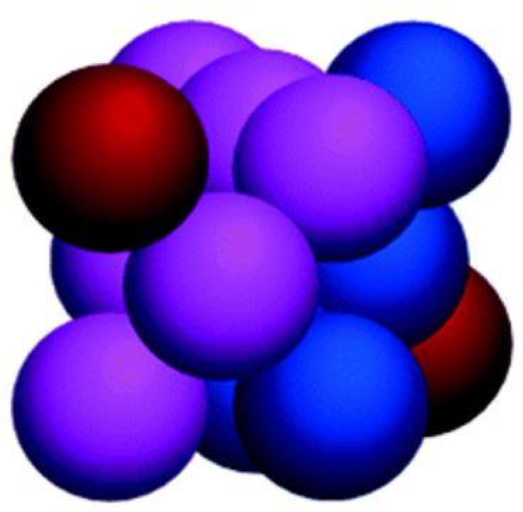
Silver, gold, and copper are all cubic center packing allowing for malleability and ductility
ccp vs bcc:
In ccp, there is very little presence of ridges between the atoms, allowing the row of atoms to slip past each other easier, as shown in Figure 1 below

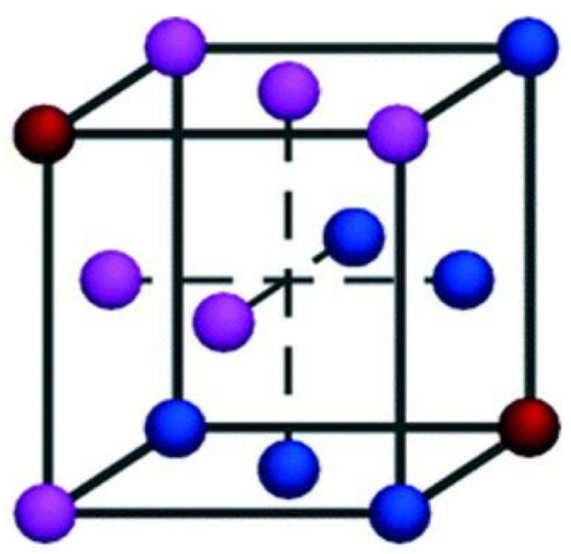


Defects in the structure contribute to malleability ductility, thereby promoting the motion atoms

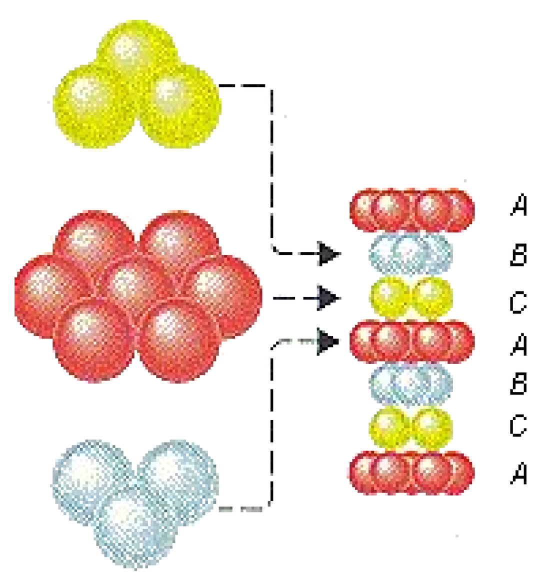


Alloys can help prevent motion defects, strengthening the metal, as demonstrated in Figure 2 (above).





Figures 3 (above) and 4 (right) illustrate a Cubic Close Packed structure



Cubic closest packed structure

Ccp structures allows atoms to move over each other (easier than hcp), allowing delocalization of electrons.

Alloys

Why are Alloys important in microelectronics?
- soldering: metals are joined together to form permanent connection between electronic components

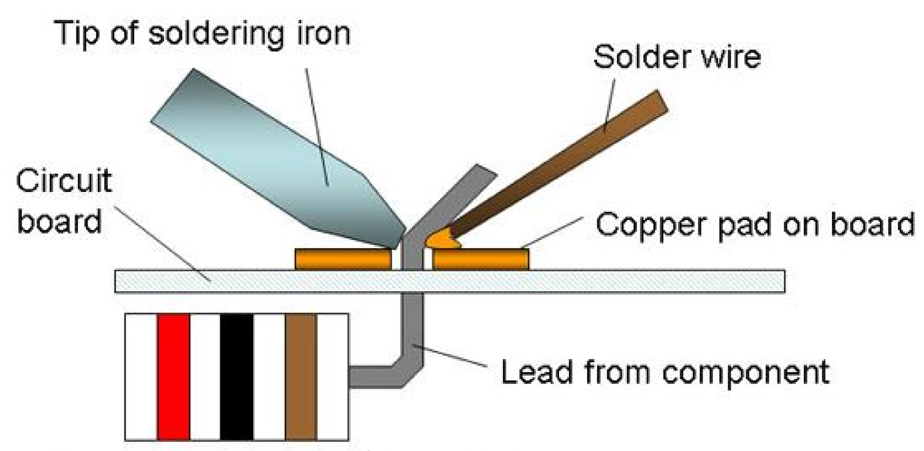


Figure 5 is a diagram of the soldering process

Au(80)Sn(20) Alloy:

- Temperature-soldering occurs 20-30°C over melting point (300-310°C). Eutectic properties speed soldering process.
- High Strength- strong enough to maintain ability to be airtight
- Fluxless-flux helps prevent formation of rust during soldering.

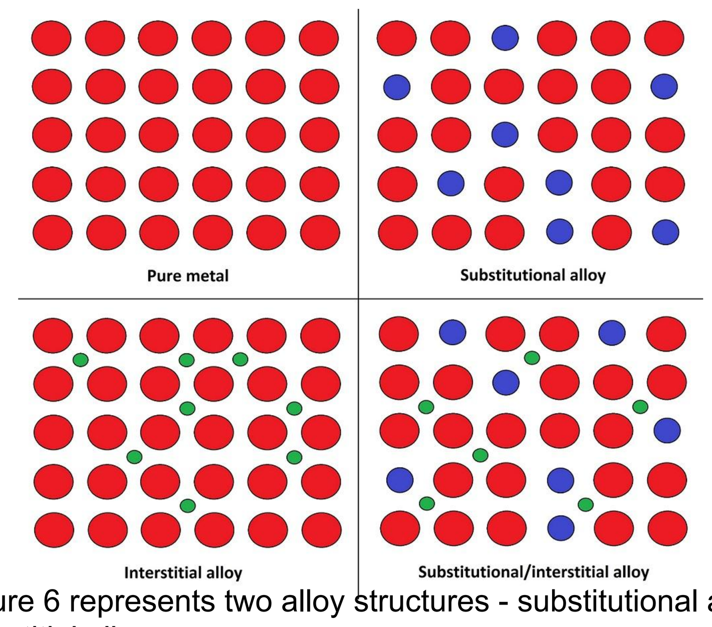


Figure 6 represents two alloy structures - substitutional and interstitial alloys.

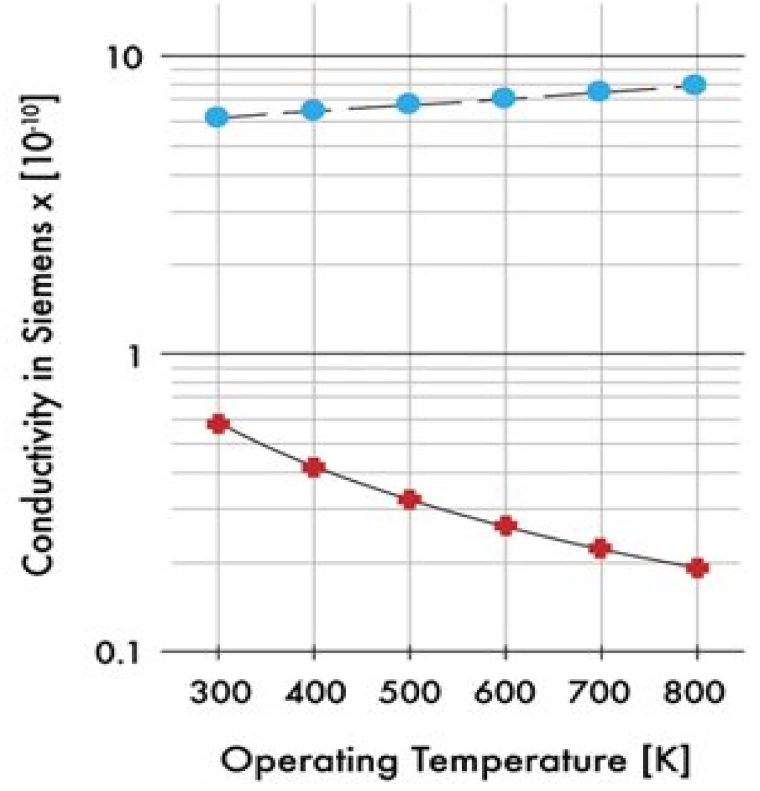
[1]Table 1 demonstrates how the conductivity decreases as the copper concentration in the alloy decreases.

ALLOY UNS No	DENSITY lb/in^3 (g/cm^3)	MELTING POINT (or SOLIDUS) °F (°C)	ELECTRICAL CONDUCTIVITY %IACS (MS/m)	THERMAL CONDUCTIVITY Btu ft/ft^2 hr °F (Wcm/cm^2 °C)	THERMAL EXPANSION COEFFICIENT (Linear) X10^{-6}in/in °F (X10^{-6}cm/cm °C)
C11000	0.322 (8.92)	1949 (1065)	101 (58)	226 (3.94)	9.33 (16.8)
C26000	0.308 (8.53)	1680 (915)	28 (16)	70 (1.21)	11.1 (19.9)
C51000	0.320 (8.86)	1750 (950)	15 (8.7)	40 (0.71)	9.9 (17.8)
C70600	0.323 (8.94)	2010 (1100)	9 (5.2)	26 (0.46)	9.5 (17.1)
C75200	0.316 (8.73)	1960 (1070)	6 (3.5)	19 (0.33)	9.0 (16.2)

Upcoming Innovations

Ultraconductus (Ultraconductors)
- Same electrical resistance as superconductor
- limit the use of expensive/rare materials
- Carbon Nanotubes (CNT's) to increase tensile strength and conductivity

Graph 1: Compares the electrical conductivity of an Ultraconductor and Copper over a temperature range



Conductivity

The energy difference in molecular orbitals for metals is low, and overlap in most metals. This allows the electrons to gain a higher kinetic energy by occupying a higher, empty MO and gives the electron the ability to carry charge quicker, which increases the conductivity, by definition.

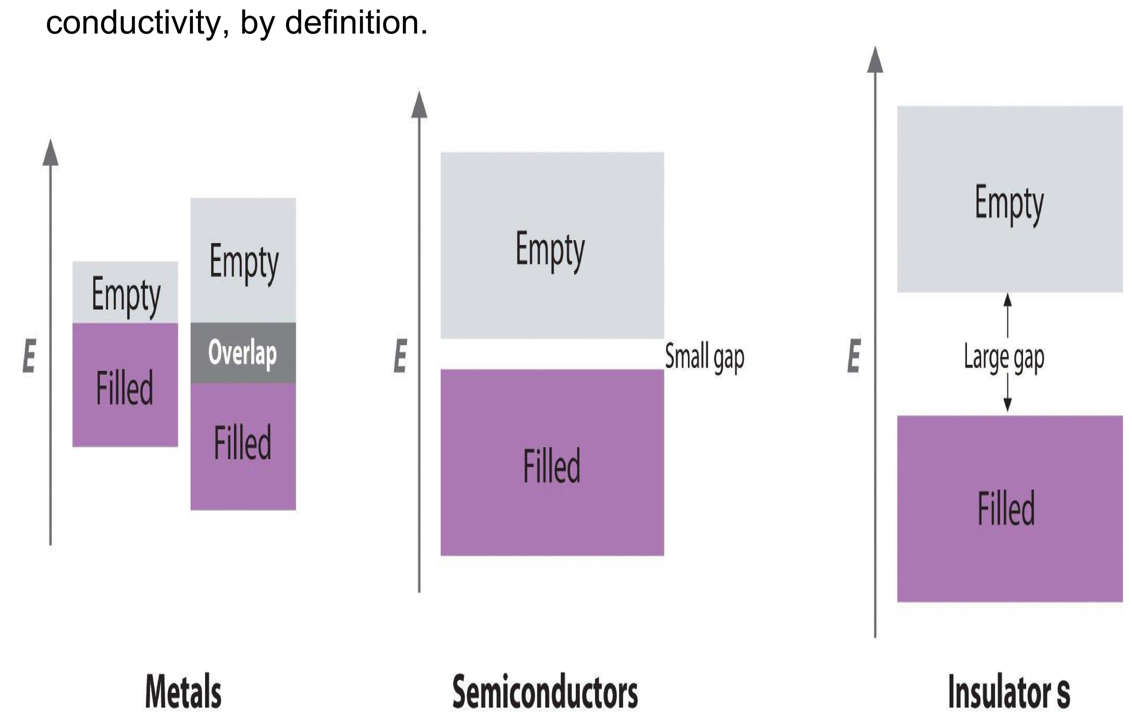
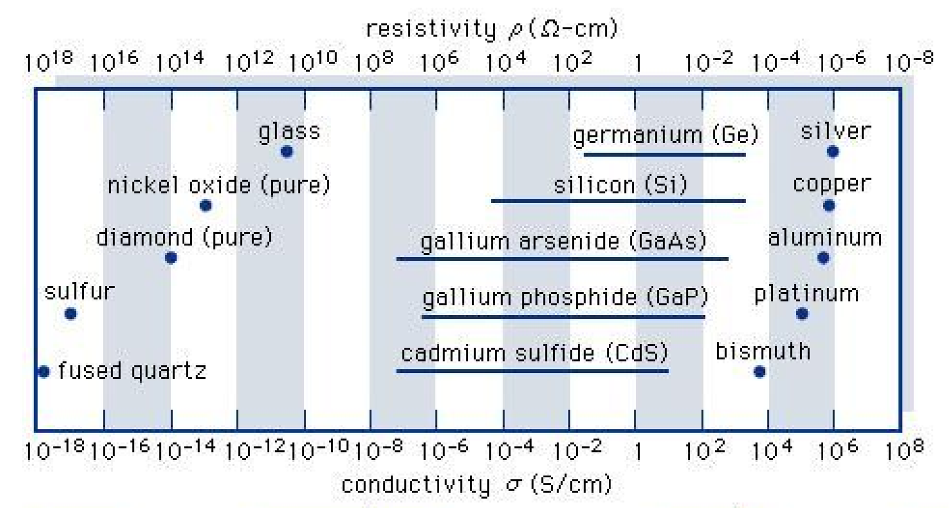


Figure 7 shows the overlap of MOs in band theory.



Graph 2 illustrates the conductivity of various elements.

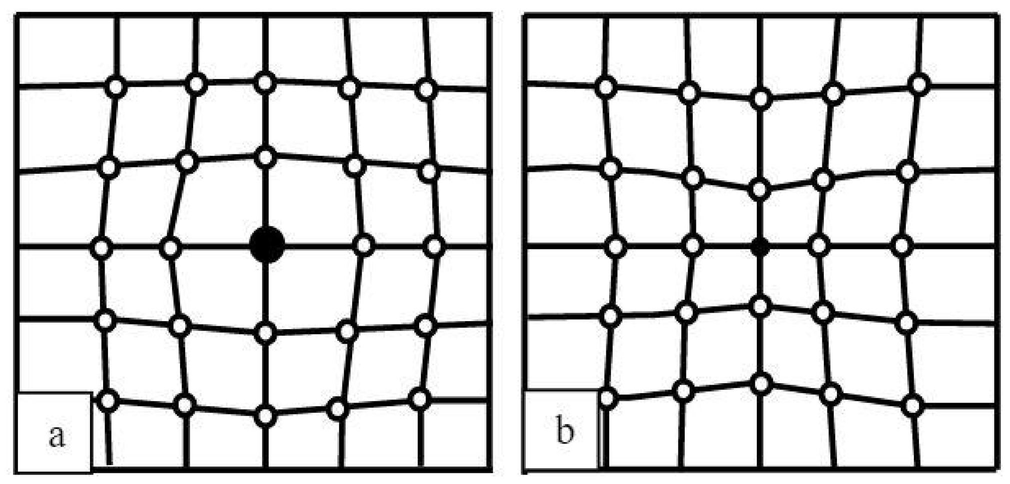


Figure 8 (above) depicts the lattice of the two types of solid solution hardened copper alloys.

Conclusion

The efficiency of microelectronic wiring is dependent upon the types of metals used and their notable physical properties. Gold, Silver, and Copper are often used congruently because they possess the chemical properties of cubic close packing, delocalization of electrons, and orbital overlap, which contributes to their malleability, ductility, conductivity, and ability to alloy. Although these shared properties make them all ideal candidates for wiring, copper is ultimately the best choice because it is abundant and the cheapest, making it the most practical choice.

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