Copper-Nickel Alloys

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Abstract

Different compositions of Cuprinickels have been used for various engeneering purposes. Recently Cu-Ni alloys containing small amounts of impurities have made an impact in the Material Science field. This review summarizes the structure, properties and applications of Cu-Ni alloys

Because Cu and Ni are completely miscible in the solid state, it can form a complete series of solid solutions of different compositions.

eg. The alloys formed with 40 to 45 percent Ni is commanly known as Constantan. It has high electric resistance which remain constant over a wide range of temperatures.

Monel Metal contains 65 to 70 percent Ni, Fe and Mn in small amounts. It has been widely used for various engineering and ornamental purposes.

1 Composition and Structure

The solidification of Cu-Ni Liquid solution occurs over a range of temperatures, with the solid and liquid phases continually changing composition. The proportions of each phase in a mixuture of two phases, is given by the Lever Rule[2].

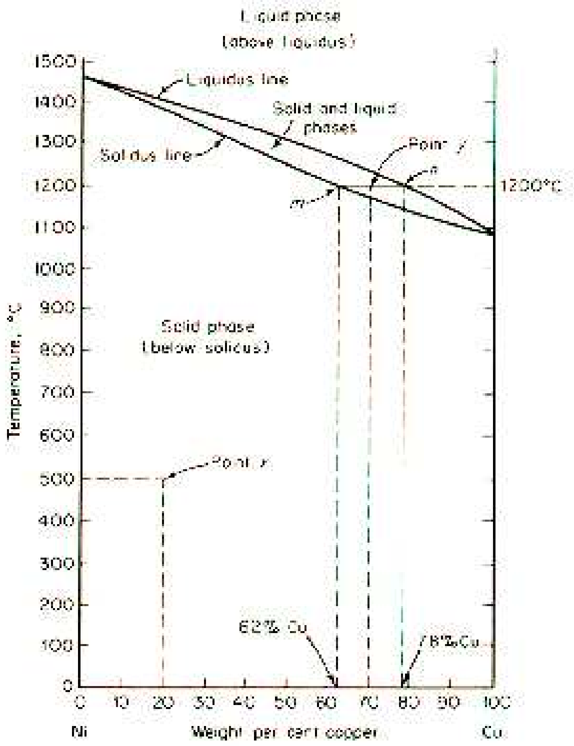

Figure 1: *Phase digram for Cu-Ni Alloys*

A solid solution is a single homogeneous pahse containing Cu and Ni atomically dispersed in a single crystaline structure. For all the compositions Cu-Ni alloys form a face centered cubic lattice with no super strucure. The Copper atom (Z=29) contains one electron more than the Nickel (Z=28). Therefore to a first approximation, if a Nickel atom is replaced by a Copper atom in an alloy we may suppose that the lattice is unaltered except that an extra electron is added[4]. In a disorded type of solid soution Ni (solute) atoms are substituted for the Cu (solvant) at random points on its lattice.

2 Mechanical Properties

The Properties of Cu-Ni Alloys show a gradual and continuous change as the concentration of solute is increased: the strength increases and the ductility usually decreases[3]. Typical data for Cu-Ni alloys are shown in Figure(2). Note that Monel metal is at the maximum strength accounting for its wide uses in industry.

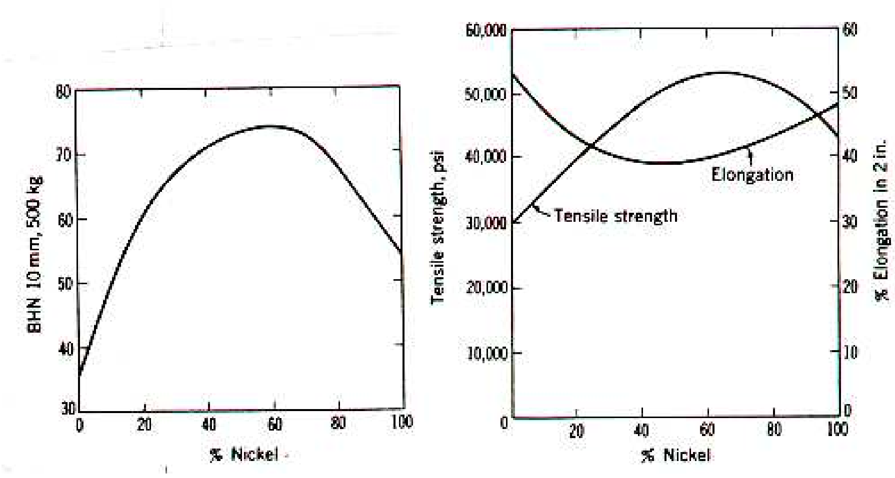

Figure 2: *Strength and Ductility*

3 Resistivity

It can be shown theoritically that the dependence of resistivity on concentration of solute in a solid solution is that

$Resistivity = kc(1-c)$

Where k is a constant and c is the atomic percentage of solute[3]. Figure (3) shows resistivity data Cu-Ni alloys

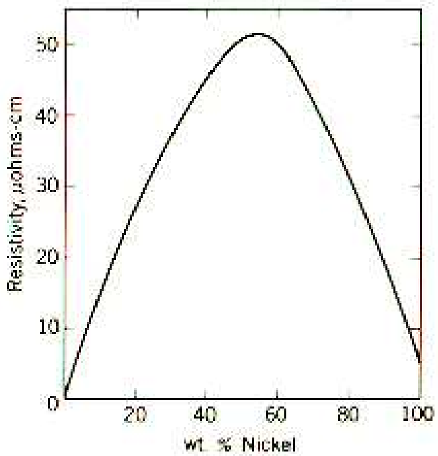

Figure 3: *Resistivity measured at 0 ^0C*

4 Specific Heat

The extra electron added Nickel atom is replced by a Copper atom goes in to the d band of Nickel. The number of vacent sites there is 0.6 per atom (=Bhor Magneton). Therefore for an alloy with 60 percent Copper, the d band will be just full. Grew found that the excess specific heat ΔC_v above the curie point tends to zero exactly at this composition Figure(4). This is because ΔC_v is cused by the presence of positive holes in the d band.

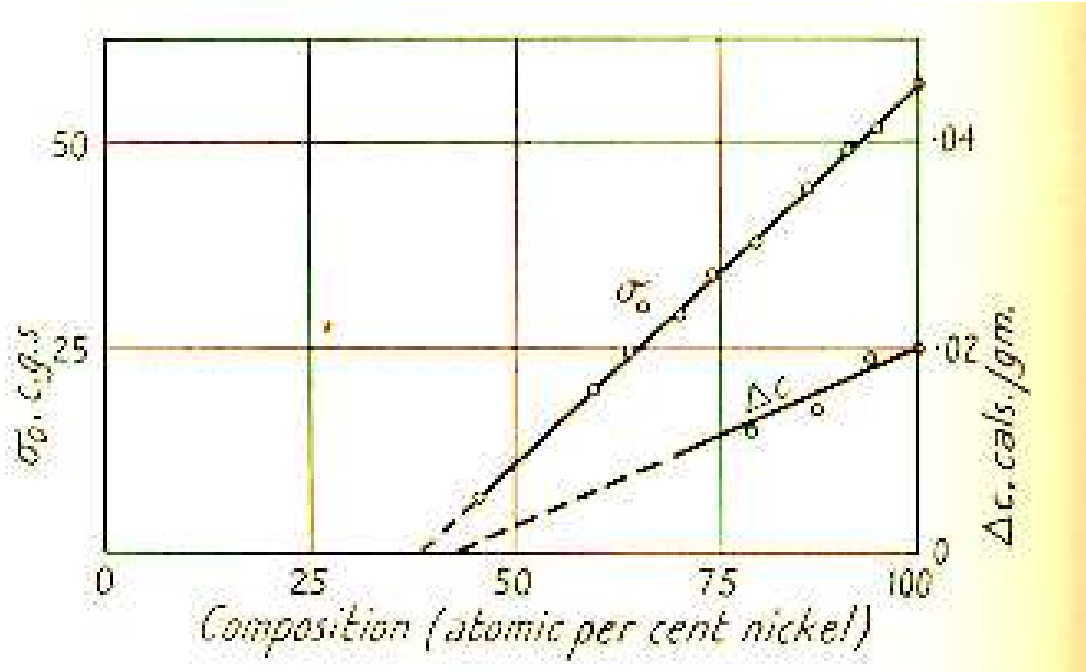

Figure 4: *Excess Specific Heat of Cu-Ni Alloys*

5 Current Research

A study has been carried out to investigate the solid state reaction between Cu-Ni bilayers on Si(100)[5]. Results indicates an unusual co-existance of pases(Ni, Ni_2Si and NiSi). Thin film interaction for ternary Cu-Ni-Si systems are of great in two context: they form shalow siliside contact due to the miniturization of very large scale integrated (VSLI) electronic devices and they allow a better understanding of metallurgical aspects such as phase seperation, ternary silicide formation and solid solutions of silisides.

Cu-Ni alloys have been used extensively in piping systems for off shore sea water plat-forms[6] and drilling structures due to thier non corrosive and non boiofouling effects. However recent studies indicates that sulfide ions found in some areas of the ocean causes both corrosion and erosion particularly 90 percent Cu-10 percent Ni alloy.

A study[7] by the Center for Materials Fabrication (CMF) shows that Copper Aluminium Nickel (CAN) alloys (a Cu-Ni alloy with trace amount of Al) can be processed to develop shape memory properties suitable for use in thermo-mechanical actuators, such as circuit brakers, electric connectors and calibration devices. Shape-memory materials require transformation temperatures above 100c. According to CMF, the CAN alloys are currently the only cost-effective materials capable of meeting this requirement.

References

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