Solid solution: A homogeneous crystalline phase that contains two or more chemical species. Both substitutional and interstitial solid solutions are possible.

Substitutional solid solution: A solid solution wherein the solute atoms replace or substitute for the host atoms.

Interstitial solid solution: A solid solution wherein relatively small solute atoms occupy interstitial positions between the solvent or host atoms.

Solute: One component or element of a solution present in a minor concentration. It is dissolved in the solvent.

Solvent: The component of a solution present in the greatest amount.
It is the component that dissolves a solute.

Solidus line: On a phase diagram, the locus of points at which solidification is complete upon equilibrium cooling, or at which melting begins upon equilibrium heating.

Solvus line: The locus of points on a phase diagram representing the limit of solid solubility as a function of temperature.

Solubility limit: The maximum concentration of solute that may be added without forming a new phase.

Component: A chemical constituent (element or compound) of an alloy, which may be used to specify its composition

System:. Two meanings are possible: (1) a specific body of material that is being considered, and (2) a series of possible alloys consisting of the same components.

Phase: A homogeneous portion of a system that has uniform physical and chemical characteristics.

Phase diagram: A graphical representation of the relationships between environmental constraints (e.g., temperature and sometimes pressure), composition, and regions of phase stability, ordinarily under conditions of equilibrium.

Introduction

A pure metal consisting of only one type of atom just isn't possible; impurity or foreign atoms will always be present, and some will exist as crystalline point defects.

In fact, even with relatively sophisticated techniques, it is difficult to refine metals to purity in excess of 99.9999%. At this level, on the order of 10^{22} to10^{23} impurity atoms will be present in one cubic meter of material. Most familiar metals are not highly pure; rather, they are ***alloys,*** in which impurity atoms have been added intentionally to impart specific characteristics to the material. Ordinarily, alloying is used in metals to improve mechanical strength and corrosion resistance.

For example, sterling silver is a 92.5% silver-7.5 % copper alloy. In normal ambient environments, pure silver is highly corrosion resistant, but also very soft. Alloying with copper significantly enhances the mechanical strength without depreciating the corrosion resistance appreciably.

The addition of impurity atoms to a metal will result in the formation of a ***solid solution*** and/or a new ***second phase***, depending on the kinds of impurity, their concentrations, and the temperature of the alloy.

Several terms relating to impurities and solid solutions deserve mention. With regard to alloys, ***solute*** and ***solvent*** are terms that are commonly employed. "Solvent" represents the element or compound that is present in the greatest amount; on occasion, solvent atoms are also called ***host atoms***. "Solute" is used to denote an element or compound present in a minor concentration.

Solid Solutions

A solid solution forms when, as the solute atoms are added to the host material, the crystal structure is maintained, and no new structures are formed. Perhaps it is useful to draw an analogy with a liquid solution. If two liquids, soluble in each other (such as water and alcohol) are combined, a liquid solution is produced as the molecules intermix, and its composition is homogeneous throughout. A solid solution is also compositionally homogeneous; the impurity atoms are randomly and uniformly dispersed within the solid.

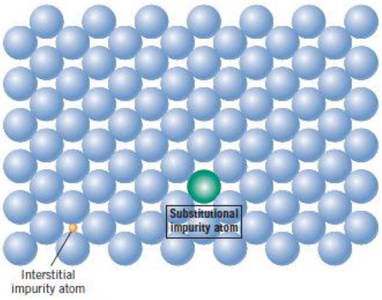

Figure (1): Two-dimensional schematic representations of substitutional and interstitial impurity atoms.

Impurity point defects are found in solid solutions, of which there are two types: ***substitutional*** and ***interstitial.*** For the substitutional type, solute or impurity atoms replace or substitute for the host atoms (Figure 1). There are several features of the solute and solvent atoms that determine the degree to which the former dissolves in the latter, as follows:

1. ***Atomic size factor***. Appreciable quantities of a solute may be accommodated in this type of solid solution only when the difference in atomic radii between the two atom types is less than about ±15%. Otherwise the solute atoms will create substantial lattice distortions and a new phase will form.
2. ***Crystal structure***. For appreciable solid solubility the crystal structures for metals of both atom types must be the same.
3. ***Electronegativity.*** The more electropositive one element and the more electronegative the other, the greater is the likelihood that they will form an intermetallic compound instead of a substitutional solid solution.
4. ***Valences.*** Other factors being equal, a metal will have more of a tendency to dissolve another metal of higher valency than one of a lower valency.

An example of a substitutional solid solution is found for copper and nickel. These two elements are completely soluble in one another at all proportions. With regard to the aforementioned rules that govern degree of solubility, the atomic radii for copper and nickel are 0.128 and 0.125 nm, respectively, both have the FCC crystal structure, and their electronegativities are 1.9 and 1.8; finally, the most common valences are +1for copper (although it sometimes can be +2) and +2 for nickel.

For interstitial solid solutions, impurity atoms fill the voids or interstices among the host atoms (see Figure 1). For metallic materials that have relatively high atomic packing factors, these interstitial positions are relatively small. Consequently, the atomic diameter of an interstitial impurity must be substantially smaller than that of the host atoms. Normally, the maximum allowable concentration of interstitial impurity atoms is low (less than 10%). Even very small impurity atoms are ordinarily larger than the interstitial sites, and as a consequence they introduce some lattice strains on the adjacent host atoms.

Carbon forms an interstitial solid solution when added to iron; the maximum concentration of carbon is about 2%.The atomic radius of the carbon atom is much less than that for iron: 0.071 nm versus 0.124 nm.