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METAFUSION
A BREAKTHROUGH IN METALLURGY

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ABSTRACT

The Metafuse Process is a patented development in the field of thin film coatings utilizing cold fusion which results in a true inter-dispersion of dissimilar materials along a gradual transition gradient through a boundary of several hundred atomic layers. The process is performed at ambient temperatures and pressures requiring relatively little energy and creating little or no heat. The process permits a remarkable range of material combinations and joining of materials which are normally incompatible. Initial applications include titanium carbide into and onto the copper resistance welding electrodes and tungsten carbide onto the cutting edges of tool steel blades. The process is achieved through application of an R.F. signal of low power and is based on the theory of vacancy fusion.

MAJOR METALLURGICAL BREAKTHROUGH

After years of extensive research, the scientists of the Metafuse Corporation have achieved a major breakthrough in modifying or organizing matter at the surface of substrates. The process "fuses" materials to achieve new surface properties. With an absence of noticeable heat, the relatively simple process joins materials at the sub-atomic level. The process offers engineers a remarkable range of material combinations and alloys which can be formed to significantly alter the physical, electrical, optical, or thermal properties of a given substrate. There are no specific "clean room" requirements and results are achieved with almost no effluent waste.

The Metafuse Process is a patented development in the field of thin film coating by way of cold fusion. The process is achieved by the application of an R.F. signal of a low power to correspond with the matching resonance of the material applied and the substrate.

The process results in the fusion of several hundreds of atomic layers at the boundary, causing a true inter-dispersion of the materials and a gradual transition from one material to another.

Performed at ambient temperatures and pressures, the process requires relatively little energy and creates little or no heat.

The Metafuse Process produces results similar to those achieved by ion implantation. However, there are significant differences which clearly set it apart from both conventional high technology ion implantation processes and older more primitive processes such as electroplating, welding and heat treating. The most significant differences are attributable to the relatively simple technique of application, the absence of heat and the remarkable range of material combinations and alloys which can be formed in-situ to significantly alter the properties of a given substrate. The company has demonstrated the uniqueness of its process by joining materials which are normally incompatible, such as tungsten, titanium or molybdenum on the surface of copper, gold on zirconium; aluminum on steel.

The fusion achieved using the Metafuse Process is an excellent non-peeling non-chipping bond. The ability to impart a desired new property such as reflectivity, corrosion resistance, color, or hardness depends on a high degree of peel resistance. The process achieves a bond that will not peel without damaging the substrate material itself. The system requires low energy consumption, is portable and can be operated by relatively unskilled labor. Being a cold process, it allows the use of a wide range of materials previously incompatible and permits changing surface characteristics of substrates that may otherwise be adversely affected by heat.

THEORY

The underlying theory for the Metafuse Process is based upon the theory of vacancy fusion as found in contemporary physics.

A more detailed analysis of the Metafuse Process enters the realm of atomic physics and dictates a brief review of our present knowledge of binding energies and entropies which exist between single vacancies and single substitutional solute atoms in metals. We define the Gibbs free energy of binding, G^{b}_{vs}, as the decrease in total free energy of the crystal G, which occurs when a vacancy and a solute atom are brought together from an essentially infinite separation to become nearest neighbors as in Figure 1.

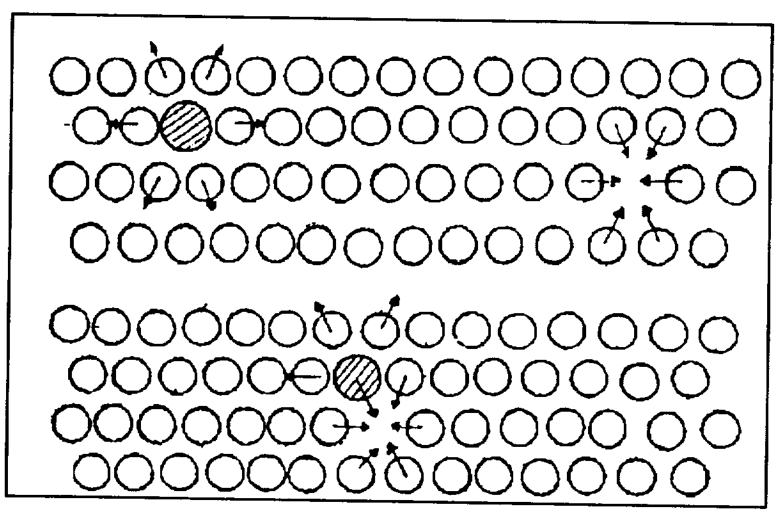

FIGURE 1: The association of a well-separated solute atom and vacancy (above to form a nearest-neighbor vacancy-solute atom pair (below) in the plane of an fcc crystal. The arrows represent possible directions of the atomic relaxations near the defects.

With the following definition, and a positive binding energy, an attractive interaction occurs.

$$G^b_{vs} = G\ [\infty \text{ separation - } G \text{ (nearest neighbors)}]$$

The binding energy, $E^b_{vs'}$ and entropy, $S^b_{vs'}$ are defined in a similar manner, i.e.,

$$E^b_{vs'} = E\ (\infty \text{ separation}) - E \text{ (nearest neighbors)}$$
$$S^b_{vs'} = E\ (\infty \text{ separation}) - S \text{ (nearest neighbors)}$$

so that

$$G^b_{vs} = E^b_{vs} = TS^b_{vs}$$

No attempt will be made to consider the binding of higher order vacancy-solute atom clusters. Even though such clusters are of great importance in many kinetic situations, essentially nothing is known at present about their properties. Even in the relatively simple case of the binding between single vacancies and single solute atoms, the accumulation of reliable information has turned out to be a slow and difficult process. Experimentally, it has been necessary to employ indirect techniques in order to gain information, and such experiments have often led to ambiguous or conflicting results. Theoretically, it has proven difficult to obtain exact solutions of the binding problem, and various approximate methods have therefore been employed. Nevertheless, a substantial body of knowledge has been accumulated, and progress has been made recently with the application of new experimental and theoretical techniques.

The cold diffusion process of Dr. Adrian Joseph is based on an electron movement created by an application of a pulsing current between the applied material i.e. solute atoms and the matrix movement of the electrons which are in a frequency equal to the atoms movements and the relaxation of the host matrix ions. The determination of the pulse current will of course vary depending on the lattice and grain boundary of the host metal.

The calculation of the formation entropy thus becomes a problem of determining the normal vibration (frequencies) of all the atoms in the defect lattice. The problem is complicated because a suitable interatomic potential between the defect and atoms has to be obtained. Secondly, the specific frequencies of the "jumping electrons" coupled to one another have to be determined. In addition, the frequencies have to be calculated for the defect crystal in which the atoms are in their relaxed positions. Therefore, the atomic relaxations around the defect have to be determined prior to the frequency calculation. In this case it will be equivalent to a capacity value. In order to simplify the calculations, the Einstein model, in which the atoms are treated as harmonic oscillators, is generally adopted.

Therefore, the F_0 will depend on the capacity of the total vacancies in the said circuit, and the resistivity of the host, multiplied by the resistivity of the material being applied, will determine the amount of solute electrons that will be delivered per time unit on a set host vacancy.

$$Fo = \frac{1}{2\pi\sqrt{L*c}}$$

Working with the above formula, assuming constant capacity, the Metafuse Process will occur.

Values of the binding entropies have not been calculated on a fundamental basis. However, methods for calculating the formation entropies of defects have been developed, and it is concluded that it should be feasible to apply these methods to the calculations of binding entropies.

SUMMARY

The frequency calculation of the Metafuse Process is related to the lattice structure and the atomic weight of the material. Although a precise calculation is possible, it would be accurate for only a 100% pure material, which is not found in practical applications. Therefore, approximations are incorporated into the calculations for ease of measurement and process, thus providing a frequency range of several percent. This has been proven effective in the testing of hundreds of different materials combinations.

To determine the proper frequency, a measurement of the resistance and capacitance of the materials is necessary. The remaining measurements of resistance are accomplished with standard meters. The figures are then inserted into the applicable formula and the frequency determined.

The Metafuse machine has been specifically developed to apply the precisely controlled R.F. electrical circuit to permit the process to occur. The ability of the machine to maintain both power and frequency when the electrode or solution is in contact with the substrate, is the key to the practical operation of this system.

The first commercial application of the Metafuse Process has occurred in the automotive industry for resistance spot welding. In this case, the industry standard copper welding tips have been surface treated with a fusion coating of titanium carbide. The titanium, being a reflector metal, lowers the energy requirement of the welding equipment to produce a weld and results in a tip life that is three times that of the unprocessed tip while reducing electrical consumption of the equipment by 15%. The product is now being introduced onto the production lines of the major automotive manufacturers, both in the United States and in Europe.

Other commercial applications are in the final stages of testing, including the deposition of tungsten carbide onto cutting blades for improved wear resistance and the replacement of traditional plating equipment owing to environmental concerns.

The company is available to assist manufacturers and developers of products that will benefit from material surface treatments. The patented process is available through licenses and joint ventures.