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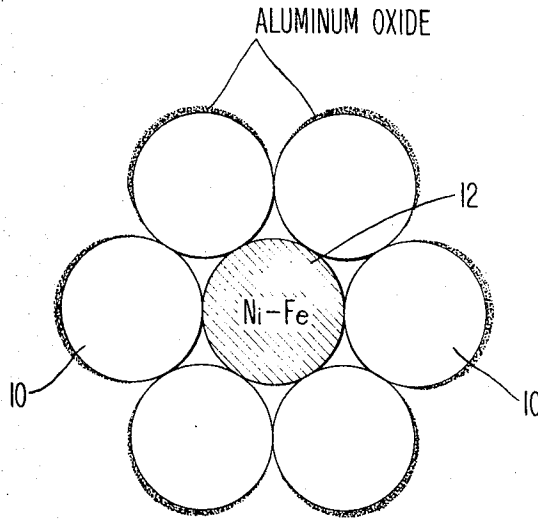


Fig. 1

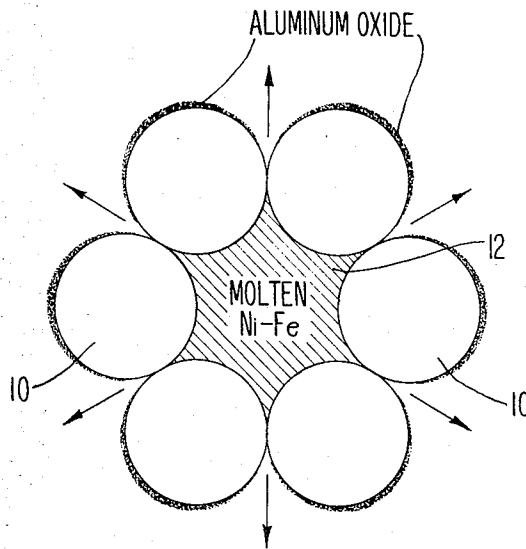


Fig. 2

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COATED CONFIGURATION AND METHOD FOR PREVENTION OF VAPORIZATION SPLATTERING OF THIN FILM SURFACES

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6 Claims

ABSTRACT OF THE DISCLOSURE

In the art of thin film coating by the vaporization of metals, an improvement in evaporation techniques by resistive heating of tungsten wires spirally wrapped around a core of the metal evaporant wherein the splattering of globules of the metal on the substrate is eliminated by coating the outer surfaces of the assembly.

BACKGROUND OF THE INVENTION

The technology of thin film coating has been greatly advanced through research under pressure of the advantages of miniaturized components in the electronics field. These techniques require thin films of extremely high quality and closely controlled thickness.

One of the well-known techniques for applying such thin films to substrates is through evaporation of certain metals which are used for printed circuitry, for example. A technique for the evaporation of such metals involves conductive heating of the metal through resistance heating of tungsten wires. These tungsten wires or filaments may be helically wrapped around a central core of the metal or alloy to be evaporated.

One of the problems in this technique is the tendency of the metal evaporated by the tungsten wire to splatter globules of the metal onto the substrate. If the metal being evaporated is a nickel-iron alloy, for example, these globules may range in size and diameter from .2 to 5 mils.

Such globules may even cause a glass substrate to crack, but in any event they reduce the quality of the product both mechanically and electronically. Mechanically they often make it difficult to maintain the stringent spacing requirements between laminants of a printed circuit assembly. It is, of course, apparent that if the thin film surface is to be used for the application of magnetic information that such globules, or sputter balls, as they are called, interfere with the high packing density of magnetic information.

There has been a great deal of research into the causes of such splattering and it has now been determined that it is due to small impurities in the tungsten wires. These contaminants in the tungsten are for the most part carbon although silicon and potassium also appear. A study by manufacturers of such tungsten filaments has disclosed that manufacturing techniques and quality control required to remove these small amounts of residual impurities would result in such high costs for the tungsten wires as to make it impracticable.

It appears that the carbon contaminants are largely responsible for the splattering. In the evaporation of nickel-iron, for example, carbon absorbs great quantities of gases and is highly soluble in nickel. When the melting point of nickel-iron is exceeded, surface tension will cause the molten material to cover the entire tungsten wire surface and any carbon impurities in the tungsten will dissolve into the nickel-iron alloy. The absorbed gasses are then released and sufficient energy is imparted to the evaporant in this region that relatively large atomic clusters of the

material are thrown off from the tungsten wire filament. These clusters can eventually range to the collecting substrate and condense to form the undesired agglomerates.

As the heating of the tungsten wire continues, splattering appears to develop from a slightly different combination of physical properties of the tungsten and nickel-iron evaporant. The tungsten wire contains very small quantities of graphite entrapped in the grain boundaries or pockets immediately under the surface of the wire. Nickel in its liquid phase tends to attack the tungsten along its grain boundaries. As the nickel gets access to the pockets of graphite by grain-boundary penetration bubbles of gasses form which sometimes rupture to produce sputter balls.

In the past one method of controlling such splattering has been to wrap a plurality of tungsten filaments spirally and in tangential relationship about a wire core of metal to be evaporated. In such a configuration the globules from the inner surfaces of the tungsten filaments are thrown back into the molten core and the evaporant escapes between the resistively heated wires themselves. It has been found that this technique greatly reduced the amount of such splattering. However, under surface tension forces the molten metal tends to creep along at the surface of the tungsten wires through the interstices until the whole surfaces of the tungsten wires are covered with the molten metal. In such a development sputter balls are thrown off the outer surfaces of the filaments of the assembly and find their way to the surface of the substrate.

SUMMARY OF THE INVENTION

In a configuration of tungsten filaments spirally wrapped in tangential configuration around a metal or alloy core to be evaporated for thin film coating on a substrate, applicants have discovered that a coating of a non-wetting agent, specifically a refractory oxide, on the outer surfaces of the filaments of the assembly will prevent creeping of the evaporant by surface tension about the wires and undesirable splattering of the metal or alloy on the substrate is prevented.

DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic cross section of a core wire to be evaporated surrounded by six spirally wrapped tungsten filaments having on the outer surfaces thereof a refractory coating;

FIG. 2 shows a schematic cross section of the assembly of FIG. 1 wherein the core is molten through resistive heating of the tungsten filaments.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

It is known in the art to wrap a wire core to be vaporized for thin film application with a plurality of spirally applied tungsten wires. These wires serve as filaments for resistive heating and provide hot tensile strength to support the assembly. They are so wrapped about the core as to be in close contact with each other and with the evaporant core. Due to the geometry of this configuration, six tungsten filaments are ordinarily used as shown in FIG. 1. When current is applied to the filaments 10, the metal core 12 becomes molten and the vapors therefrom escape between the filaments, as shown in FIG. 2, and are eventually deposited as a thin film on a substrate (not shown).

In one such assembly of preferred configuration, six tungsten wires (.025" OD) are helically wrapped in tangential relationship around a central core wire (.025" OD) composed of 83% nickel and 17% iron, commonly referred to under the trade name of Permalloy.

In such a configuration the direct contact between the tungsten filaments 10 and the molten alloy is toward the inside of the assembly. Any potential sputter balls are

thrown back into the molten mass as long as the molten alloy is contained within the assembly by the baffling action of the helical configuration.

However, as heretofore noted under surface tension forces of the molten alloy and the tungsten filaments, a film of the molten alloy tends to creep outwardly along the surfaces of the tungsten filaments in the interstices of the configuration. Eventually the entire surfaces are covered and the interaction of the molten film and the hot tungsten wires again provides conditions for sputter ball action.

Applicants have discovered that a non-wetting agent can be applied to the external surfaces of the tungsten wire baffle and thereby prevent such creeping of the molten alloy around the surfaces of the tungsten filaments.

Such a non-wetting agent must be insoluble in the molten metal or alloy and remain stable in the temperatures to which the surfaces of the tungsten wires rise during such evaporation operations.

For the vaporization of a nickel-iron core the surfaces of the tungsten filaments reach temperatures of 2000° C. for relatively short periods, for instance, less than one minute. Where the evaporant is nickel-iron, aluminum oxide has been found to exhibit excellent non-wetting properties when in contact with molten nickel-iron.

The external surfaces of the tungsten filaments are lightly sprayed with high purity aluminum oxide utilizing methyl alcohol as a carrier. One such aluminum oxide is sold by the Linde Division of Union Carbide Corporation under the trade designation of Linde type .058.

Known techniques are used for spraying the aluminum oxide coating onto the surface of the tungsten without oxidizing the metal. One such excellent technique is called "plasma spray."

In spraying the surface of the assembly of the tungsten wires about the core to be evaporated care must be taken that the interstices between the filaments are not filled with the refractory oxide coating, which would, of course, defeat the whole purpose of the assembly. It has been found that by rotating the assembly during the spraying process the coating tends to cover most heavily the surfaces of the wires farthest from the center of the assembly and to thin out toward the areas where the filaments are tangent to each other. The interstices between the wires are thus left open for the escape of the metallic vapors. Minor experimentation will show appropriate speeds for rotating the wire so as to avoid throwing the oxide off the wire and yet leave the interstices between the wires uncoated.

Although aluminum oxide was found to give excellent results with a nickel-iron evaporant, other oxides such as

beryllium oxide and zirconium oxide may be used. Other metal evaporants such as aluminum and nickel also exhibit tendencies to splatter and their vaporization can be similarly controlled by applicants' discovery.

It is, of course, apparent that applicants' discovery is applicable to filamentary wires other than tungsten where such conditions of splattering may develop.

We claim:

1. In vapor disposition apparatus for vaporizing a central metallic core by the resistive heating of filaments helically wrapped therearound in mutually tangential relationship, the improvement comprising:

a coating applied to the outer surfaces of such filaments, said coating being insoluble and non-wetting with respect to the metallic core in its molten state and thermally stable within the range of temperature of the heated filaments.

2. The apparatus of claim 1 wherein said non-wetting coating is a refractory oxide.

3. The apparatus of claim 2 wherein said core is nickel-iron alloy and said refractory oxide is a high purity aluminum oxide.

4. In the process of forming a thin film on a substrate by the evaporation of a metallic wire, a method for preventing the splattering of globules of the metal of said wire on the substrate comprising the steps of spirally wrapping a plurality of resistively heatable filaments in tangential relationship about the surface of such metallic wire to be evaporated to form an assembly, and coating the outer surfaces of such assembly with an agent, said agent being insoluble and non-wetting with respect to the metal of the wire in its molten state and thermally stable in the range of temperature of the filament under heat.

5. The method of claim 4 wherein said coating step comprises spraying said outer surfaces with a refractory oxide.

6. The method of claim 5 additionally including the step of rotating said assembly during the coating thereof.

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