

A Method of Applying Polysilazane Coating onto the surface of Copper Wire or Strips for Electrical Insulation

BACKGROUND

Field of the Invention:

The present invention is pertaining to the application of Polysilazane Coating onto the surfaces of copper wires or strips to provide electrical insulation on the surface of copper wires or strips.

Description of the Related Art:

Copper is a good electrical conductor. Copper wires and strips are commonly used as electrical contacts in many electrical applications such as power generation, power transmission, power distribution, telecommunications, electronics circuitry, and countless types of electrical equipment. On the surface of these copper wires or strips, insulation is achieved typically by a layer of PVC (polyvinyl chloride) or rubber.

For electromagnetic applications such as transformers, inductors, motors, speakers, hard disk head actuators, electromagnets, etc, copper wires are insulated (also known as enameled) using a thin layer of polyvinyl formal (Formvar), (Formvar), polyurethane, polyamide, polyester, polyester-polyimide, polyamide-polyimide (or amide-imide), and polyimide.

For these enameled wires, the thin insulation layer is typically of the thickness of 150-200 μm , and the operating temperature is typically limited to 200⁰C. This is because the polymer insulation layer will melt at temperature higher than 200⁰C. This temperature limitation essentially restricts the electrical load carrying capacity of the copper wire and thus limits the performance of the electromagnetic device.

Polysilazane coating offers a thin film coating that could serve as protective film on polymer or metal surface. The Polysilazane film coating is constituted of silica, the thickness is typically only 1-2 μm . It is hard and flexible, and has been used for many applications, such as automobile, train, building etc as a protective coating.

The polysilazane coating with 1-2 μm thickness is hard and flexible. It is well suited for surface protection for both metal and non-metal surface. It does not, however, provide electrical insulation. Increasing coating thickness beyond 1-2 μm might be able to achieve some level of electrical insulation, but is not desirable as the coating will be more brittle and prone to crack.

SUMMARY

The present invention pertains to method of applying polysilazane coating onto copper wires or strips for electric insulation.

This invention also pertains to application of thin polysilazane coatings on copper wire in the order of several micrometer for electrical insulation that could significantly reduce the size of the devices that use such copper wire windings. These devices include: transformers, inductors, motors, speakers, hard disk head actuators, electromagnets, etc.

This invention also further pertains to application of thin polysilazane coatings on copper wire for electrical insulation that could increase the operating temperature, and hence increase the electrical load carrying capacity of the devices that use copper wire windings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG 1 showing 1st layer of polysilazane coating formed according to embodiments of the present disclosure

FIG 2 showing addition of Al_2O_3 layer on top of the 1st polysilazane coating formed according to embodiments of the present disclosure

FIG3 Showing 2nd layer of polysilazane coating on top of the Al_2O_3 layer, formed according to embodiments of the present disclosure

DETAILED DESCRIPTION

The primary object of the present invention is to provide a method for forming a silica film onto the surface of copper wires or strips, using the precursor of a mixture of Polysilazane and Perhydropolysilazanes, that is able to provide electrical insulation of the coated surface.

The present invention provides a first method for forming the electrical insulated silica film, comprising the steps of:

- i) Forming a coated film, which is consisted of a polysilazane and perhydropolysilazanes with a thickness of 1-2 μm
- ii) Deposition of a Al_2O_3 layer with a thickness of 100-200 nm via Atomic Deposition Method, and
- iii) Forming of a 2nd coated film of polysilazane and perhydropolysilazanes with a thickness of 1-2 μm

In this present invention, precursor solution of with the following composition is used:

Compound	Weight Percentage
Polysilazane	X%
Perhydropolysilazane	Y%
Solvent	(100-X-Y)%

The 1st silica film is formed onto the copper substrate using either dip coating method or wiping method. The coat is left to cure at room temperature over approximately 6 hours period. The surface of the coating, however, is cured within 1 hour. A layer of silica film is formed as shown in FIG 1.

After the 1st Polysilazane coating is formed, a thin layer of Al_2O_3 is deposited onto the polysilazane coating using the atomic depository method. The thickness of the Al_2O_3 layer is about 100-200 nm. The formation of the Al_2O_3 layer on top of the 1st layer silica film is shown in FIG 2.

A second layer of silica film is form on top of the Al_2O_3 layer using the same precursor solution, via dip coating or wiping method. Again the coat is left to cure at room temperature over approximately 6 hours period. The thickness of the 2nd silica film is also approximately 1-2 μm . The final coating of polysilazane films with a Al_2O_3 layer sandwich in between is shown in FIG 3.

Electrical conductivity test was conducted on the surface of the coating shown in FIG 1, and it was shown that the surface is conductive and has zero electrical resistance.

Electrical conductivity test was conducted on the surface of the coating shown in FIG 2, and it was shown that the surface is also conductive and has zero electrical resistance.

Electrical conductivity test was conducted on the surface of the coating shown in FIG 3, and it was shown that the surface is perfectly insulated electrically.

The present invention described herewith thus provide a method of forming a silica film using polysilazane and perhydropolysilazanes mixture as precursor to provide electrical insulation on copper strip or wire surface.

The coated specimens were heated in an oven, where the oven temperature is set at 200⁰C and 500⁰C, for 30 mins respectively. The specimen shown in FIG 3 is still perfectly insulated after the heating upto 500⁰C. This present invention has provided the method of applying polysilazane coating onto surface of copper wires or trips that is able to provide electrical insulation for temperature upto 500⁰C.

CLAIMS

1. A method of forming a coating on a copper wire or strip for electric insulation, the coating comprising:

applying the coating onto the copper wire or strip, wherein the coating consists of a layer of Al_2O_3 sandwiched between a first silica film and a second silica film, each of the first silica film and the second silica film produced by curing a mixture comprising polysilazane and perhydropolysilazanes and has a thickness of 1-2 μm .

2. The method of claim 1, wherein applying the coating comprises forming the first silica film onto the copper wire or strip, depositing the layer of Al_2O_3 onto the first silica film and forming the second silica film onto the layer of Al_2O_3 .

3. The method of claim 2, wherein the first silica film is cured before applying the layer of Al_2O_3 .

4. The method of claim 3, wherein the first silica film is cured for at least 6 hours.

5. The method of any one of claims 2 to 4, wherein the second silica film is cured for at least 6 hours.

6. The method of any one of claims 2 to 5, wherein the first silica film and the second silica film are cured at normal room temperature or at elevated temperature.

7. The method of any one of claims 2 to 6, wherein forming the first silica film and the second silica film comprises dipping the copper wire or strip into or wiping the copper wire or strip with the mixture of polysilazane, perhydropolysilazanes and solvent.

8. The method of any one of claims 2 to 7, wherein the layer of Al_2O_3 is deposited using atomic layer deposition method.

9. An electrically insulated copper wire or strip comprising a coating on the copper wire or strip, wherein the coating consists of a layer of Al_2O_3 sandwiched between a first silica film and a second silica film, each of the first silica film and the second silica film produced by curing a mixture comprising polysilazane and perhydropolysilazanes and has a thickness of 1-2 μm .