Title: AN IMPROVED ELECTRICAL WIRE AND METHOD OF STRIPPING THE INSULATION THEREOF

Abstract: An electrical wire has a central electrically conductive member such as copper, aluminum, gold or silver or admixtures or alloys thereof, coated by a photoresistive insulator, preferably of a negative photoresistive material such as polyimide. A non-mechanical method of stripping a desired portion of the length of the insulator from the electrical wire comprises exposing the desired length of the electrical wire to a source of UV light. The UV light then hardens a portion of the insulator. The non-exposed portion of the insulator can be dissolved by immersing it in a solvent.
AN IMPROVED ELECTRICAL WIRE AND A METHOD OF STRIPPING THE INSULATION THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Continuation-in-Part of U.S. Patent Application Serial No. 10/369,903 filed on February 18, 2003, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present invention relates to an electrical wire and more particularly to an electrical wire which is used in an improved method for stripping a desired length of insulation therefrom to expose the conductive member.

BACKGROUND OF THE INVENTION

An electrical wire comprising an electrically conductive member with an insulator surrounding the member is well known in the art. Typically, in the prior art, electrical wires are used to electrically connect different electrical or electronic components. In so doing, the insulator surrounding the electrically conductive member must be removed so that the electrically conductive member, typically a metal such as gold, silver, or more commonly copper or aluminum, can then be electrically connected to the electrical or electronic components by solder or the like. In order to remove the insulator which surrounds the electrically conductive member, wire strippers or other mechanical devices have been used. In a wire stripper, a plier like device having a hole with a sharp edge is used. The hole is approximately the size of the electrically conductive member. As the stripper is squeezed or engages the outer insulator, it cuts the outer insulator. However, since there is a hole that is approximately the size of the electrically conductive member, the stripper stops and does not cut into the electrically conductive member. The user then exerts a force by pulling the insulator away. Sometimes, in the process of so doing, the stripper could hit or nick the electrically conductive member. In other cases, the pulling may cause tear in the insulator coating, thereby stripping more or
less than the desired amount. Other mechanical methods for stripping the insulation include the use of a knife to cut the insulation and then pull the cut insulation. However, the problems of potential nicking the electrically conductive member and the inaccuracy of the amount of insulation stripped remains. Still other methods have included the use of sand paper or other abrasive technique to remove the insulation.

The aforementioned problems of stripping an electrical wire is exacerbated as the size of the wire decreases. As the wires become smaller and smaller to connect smaller components or used in confined spaces, the electrically conductive member becomes extremely small and the insulator surrounding it is also very small. Thus the tolerance between the outer diameter of the electrical wire and the outer diameter of the electrically conductive member is very small. This increases the risk that using a stripper or other mechanical means can nick or cut the electrically conductive member and/or the mechanical device can remove more or less of the insulator than is desired.

In addition, it is especially difficult to strip an electrical wire when the insulator coating the wire has a tensile strength greater than the wire itself. Such a situation may occur especially when the wire diameter is small.

20 SUMMARY OF THE INVENTION

An electrical wire comprises an electrically conductive member with a photoresistive insulator coating the member.

The present invention also relates to a method of stripping a desired length of insulator from an electrical wire. The wire has an electrically conductive member and an insulator coating the member. The insulator is typically a negative photoresistive material which is sensitive to UV light. Where the insulator is a negative photoresistive material, the method of the stripping comprises exposing a length of the wire to a source of UV light to expose that portion, and then immersing the non-exposed portion in a solvent to dissolve the non-exposed portion. Where the insulator is a positive photoresistive material, the method of stripping comprises
exposing a length of the wire to a source of UV light, and then immersing the exposed portion in a solvent to dissolve that portion.

**BRIEF DESCRIPTION OF THE DRAWINGS**

5 Figure 1 is a perspective view of an improved electrical wire of the present invention.

Figure 2 is a perspective view of the method of the present invention to strip desired length of insulator from an electrical wire.

**DETAILED DESCRIPTION OF THE INVENTION**

10 Referring to Figure 1 there is shown an electrical wire 10 of the present invention. The electrical wire 10 comprises an electrically conductive member 12. Typically, the electrically conductive member 12 is a metal and is selected from a group consisting of gold, silver, copper, aluminum, or admixtures thereof or allows thereof. The electrically conductive member 12 can also comprise a strand which is a plurality of small wires made from any of the foregoing described metals. Surrounding the electrically conductive member 12 is a photoresistive insulator 14 coating the member 12.

The photoresistive insulator 14 is of any suitable structure, including both positive photoresistive materials and negative photoresistive materials. Examples of positive and negative photoresistive materials include, without limitation, photosensitive polyimides such as Pyralin® (e.g., Pyralin® PI2771, PI2720, PI2555, and PI2700), Nano™ SU-8 (e.g., SU-8 100), and the Microposit® S1800® series. Pyralin® photosensitive polyimides are formed from soluble, aromatic polyimide precursors containing pendant photoreactive side groups and are used as negative photoresists. Nano™ SU-8 100, for example, is an epoxy-based photoresist with a very high optical transparency above 360 nm that is optimized for near UV (350-400 nm) exposure. It is also a negative photoresist material. Microposit® S1800® materials are positive photoresist systems that can be exposed with light sources having wavelengths from 350 nm to 450 nm. The exposure properties have been
optimized for use at 436 nm. For a tabular description of various photoresists, see Table 1 below.

**Table 1. Summary of some photoresist properties, brand names and types.**

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Chemical base</th>
<th>Polarity</th>
<th>Developer</th>
<th>Typical thicknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipley 1818</td>
<td>Novalac resin</td>
<td>positive</td>
<td>Aqueous (TMAH)</td>
<td>2-3 microns</td>
</tr>
<tr>
<td>SU-8</td>
<td>Gamma Butyrolactone/epoxy resin</td>
<td>Negative</td>
<td>propylene glycol monomethyl ether acetate</td>
<td>Hundreds of microns up to mm</td>
</tr>
<tr>
<td>Pi 2721</td>
<td>Polyimide</td>
<td>Negative</td>
<td>Aqueous (TMAH)</td>
<td>Tens of microns</td>
</tr>
<tr>
<td>Pyralux PC 1025 dry resist</td>
<td>Polyimide dry film</td>
<td>Negative</td>
<td>Aqueous (Sodium carbonate)</td>
<td>Around 64 um</td>
</tr>
</tbody>
</table>

The photoresistive insulator 14 is light sensitive. As pointed out above, each particular photoresistive material may have been optimized to interact with a particular wavelength, or wavelengths of light. Typically, the materials will interact with UV light (e.g., wavelength of 10 nm to 400 nm), but certain materials may also be sensitive to visible light (e.g., wavelength of 400 nm to 780 nm), infrared light (e.g., wavelength of 780 nm to 1 mm), x-rays (e.g., wavelength of 4 Å to 50 Å) and laser-generated light (e.g., wavelength of 400 nm to 700 nm).

The photoresistive insulator 14 in the preferred embodiment is a negative photoresistive material which is sensitive to UV light. The negative photoresistive material of the present invention, upon exposure to an appropriate light source, hardens. The remaining portion of the photoresistive material, i.e., those portions which have not been exposed to the appropriate light source, will dissolve in the solvent.

In preferred embodiments, the negative photoresistive material is a material made from polyimide (e.g., Pyralin®), is epoxy-based (e.g., Nano™ SU-8 100), or is a photoresist solder mask. Further, the light source to which the photoresistive insulator 14 is sensitive is preferably in the UV light range.
Where the negative photoresistive material is Nano™ SU-8 100, for example, the wire is exposed to 600 mJ/cm² to 700 mJ/cm² light, preferably 610 mJ/cm². After the wire 10 is exposed, it is immersed in an SU-8 developer, such as PM acetate, ethyl lactate and diacetone alcohol, and stirred for a period of time (e.g., about 25 minutes). The non-exposed portion of the insulator is removed by the development process. (A post-exposure baking step may be inserted before solvent removal if desired.)

The wire 10 is then rinsed using an appropriate liquid (e.g., isopropyl alcohol) and dried (e.g., with air or nitrogen). Although described above in terms of a negative photoresist, it has been found that the method of the present invention can be used with both positive or negative photoresist material as the insulator 14.

Referring to Figure 2, there is shown a step in the method of the present invention. In the method of the present invention, a desired length 16 of the wire 10 of the present invention is to be stripped of the insulator 14. The desired length 16 of the wire length 10 is exposed to a UV light 20. In a preferred embodiment, a blocking panel 18 serves to block the rest of the wire 10 from the exposure of the UV light 20. Thus, for example, the panel 18 can be a box and the UV light 20 can be contained within the box 18 and the wire 10 inserted through an aperture into the box 18 such that a desired length 16 is placed inside the box 18. When the UV light 20 is activated, the desired portion of the wire 10 is then exposed inside the box 18.

As previously described, the insulator 14 is preferably made of a negative photoresistive material, such as a polyimide photoresist. Upon exposure to the UV light 20, the desired portion 16 will harden. After the desired portion 16 is exposed to the UV light 20, the wire 10 is immersed in a solvent. The solvent would dissolve that portion of the insulator 14 which has not been exposed to UV light. The solvent would not dissolve the portion of the insulator 16 exposed to UV light, even if it were immersed in the solvent.

From the foregoing it can be seen that a "clean" and non-mechanical method of removal of a desired length of an insulator about an electrical wire is disclosed.

Further, an improved electrical wire is also disclosed. The improved electrical wire can be easily manufactured since the electrically conductive member 12 is well known and is of conventional design. The electrically conductive member 12 is
simply "dipped" into a liquid solution of the insulator 14 which is of the requisite photoresistive properties.

Example Process Protocol Using PI 2771

Coating: A small section (30 cm) of a bare-tin-copper wire (30 awg) was dipped in a polyimide based photoresist (PI 2771, Dupont®). The wire was then passed between two pieces of absorbing tissue (kimwipes) saturated with the PI 2771 solution. The excess coating was thereby eliminated leaving a very thin (several microns) rather uniform coating on the surface on the bare-tin-copper wire. This was followed by a rather fast soft bake in a 90 °C oven for 90 seconds that allowed for the solvents to evaporate and for the photoresist coating to harden. By this stage the wire was coated and the outer layer of photosensitive polyimide provided a solid protective shield.

Exposing: In this stage, the coated wire was selectively exposed to a mercury lamp (G line) for 60 seconds with a 5 mw/cm² intensity. This step activated the photoinitiator and allowed for the exposed portion of the wire coating to crosslink. (The shielding can be done by simply covering the wire with aluminium foil where light is not intended to hit it.) This was followed by a post exposure bake (1 minute in a 120 °C) that enhanced further crosslinking as well as surface to coating adhesion.

Development: The wire was dipped in a TMAH developer solution (MF 319) for 30 seconds therefore eliminating the unexposed coating leaving behind a neat cross section of a stripped wire.
WHAT IS CLAIMED IS:

1. An electrical wire comprising:
   an electrically conductive member; and
   a photoresistive insulator coating said member.

2. The wire of claim 1, wherein the photoresistive insulator has a higher tensile strength than the electrically conductive member.

3. The wire of claim 1 wherein said electrically conductive member is a metal selected from a group consisting of gold, silver, copper, aluminum, or admixtures or alloys thereof.

4. The wire of claim 1 wherein said photoresistive insulator is a negative photoresistive material.

5. The wire of claim 1 wherein said photoresistive insulator is a positive photoresistive material.

6. The wire of claim 4 wherein said photoresistive material is made from polyimide.

7. The wire of claim 4 wherein said photoresistive material is made from an epoxy-based material.

8. The wire of claim 5 wherein said photoresistive material is made from a material optimized for exposure at 436 nm.

9. The wire of claim 5 wherein said photoresistive material dissolves in a solvent after exposure to UV light.
10. A method of stripping a first length of insulator from an electrical wire, said wire having an electrically conductive member and an insulator coating, said insulator being a negative photoresistive material, sensitive to UV light, said method comprising:

exposing a second length of said wire to a source of UV light sufficient; and,

immersing said wire in a solvent to dissolve said first length of insulator.

11. The method of claim 10, wherein the wire is positioned to extend through an aperture in a wall such that the second length of the wire is exposed to the UV light and the first length of the wire is shielded from exposure to the UV light.

12. A method of stripping a first length of insulator from an electrical wire, said wire having an electrically conductive member and an insulator coating, said insulator being a positive photoresistive material, sensitive to UV light, said method comprising:

exposing said first length of said wire to a source of UV light; and

immersing said exposed wire in a solvent to dissolve said first length of said photoresistive material.
FIG. 1

FIG. 2

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