

removing portions of the nanowire layer to create the desired patterned (subtractive patterning). Selective removal is often accomplished either by wet chemical etching or laser ablation. In both cases, one can be limited both by the width of the substrate that can be processed, which is typically less than 30" wide, and by the throughput, which is typically on the order of 1-10 ft/min or less. Also, both etching and laser ablation patterning can present certain process control challenges, related to management of chemical kinetic or photolytic phenomena. As such, a method of subtractive patterning a nanowire layer that does not require etching or laser ablation is needed.

FIRST EMBODIMENT:

The inventors have determined that a patterning process can be performed by the following sequence of steps: Coating a substrate with a conductive layer such as a nanowire layer. Optionally hardening or curing the nanowire layer. Applying a pattern on the nanowire layer with a resist matrix material to generate on the substrate one or more first regions of exposed nanowire layer and one or more second regions of the resist matrix material (typically a circuit pattern for a touch screen). Hardening or curing the resist matrix material. Over coating the pattern with a strippable polymer layer. Hardening or curing the strippable polymer layer. Peeling the strippable polymer layer from the substrate, removing the nanowire material in one or more first regions of the substrate and thereby forming a patterned nanowire layer. In another approach, the nanowire material can be replaced with a conductive polymer such as PEDOT and the same process used to pattern the conductive PEDOT layer.

The strippable polymer layer not only provides for efficient production of the necessary conductive patterns over a relatively wide and continuous, indefinite length of substrate thereby allowing the formation of multiple touch screens at a time, it can also be left in place after over coating to provide protection for the nanowire layer. The strippable polymer layer keeps the underlying conductive layer such as a nanowire layer clean, dust free, and protected from scratches (important attributes for a touch screen) during storage and transport. The strippable polymer layer can then be removed just before the next processing step(s) and wound into a roll and recycled.

In the first embodiment, the disclosure provide a method of forming a patterned conductive layer on a substrate including the steps of: coating a substrate with a conductive layer; applying a pattern on the conductive layer with a liquid resist matrix material to generate on the substrate one or more first regions of exposed conductive layer and one or more second regions of resist matrix material; hardening or curing the liquid resist matrix material; over coating the pattern with a strippable polymer layer-forming liquid; hardening or curing the strippable polymer layer-forming liquid to form a strippable polymer layer; peeling the strippable polymer layer from the substrate, removing the exposed conductive layer from the substrate in the one or more first regions of the substrate, and thereby forming a patterned conductive layer on the substrate.

LISTING OF EXEMPLARY EMBODIMENTS:

- A. A method of patterning a conductive layer on a substrate, comprising:
- coating a substrate with a conductive layer;
 - applying a pattern on the conductive layer with a liquid resist matrix material to generate on the substrate one or more first regions of exposed conductive layer and one or more second regions of resist matrix material;
 - hardening or curing the liquid resist matrix material;
 - over coating the pattern with a strippable polymer layer-forming liquid;
 - hardening or curing the strippable polymer layer-forming liquid to form a strippable polymer layer;
 - peeling the strippable polymer layer from the substrate, removing the exposed conductive layer from the substrate in the one or more first regions of the substrate, and thereby forming a patterned conductive layer on the substrate.
- B. The method according to embodiment A, wherein the conductive layer comprises nanowires.
- C. The method according to embodiment A or B, wherein over coating the pattern with the strippable polymer layer comprises over coating the one or more first regions and the one or more second regions with a strippable polymer layer-forming liquid.
- D. The method according to embodiment C, wherein the strippable polymer layer-forming liquid contacts between 50% to 99% of the exposed conductive layer in the one or more first regions.
- E. The method according to embodiment C or D, wherein the strippable polymer layer-forming liquid is selected from the group consisting of polymer solution, monomer, monomer solution, and polymer melt.
- F. The method according to embodiment E, wherein the strippable polymer layer-forming liquid comprises a polymer solution and over coating includes slot coating, roll coating, flood coating, notch bar coating, or spraying.
- G. The method according to any one of embodiments C, D, E or F, wherein the strippable polymer layer-forming liquid exhibits a viscosity between 10 and 2,500 cps (0.01-2.5 Pa-s).
- H. The method according to any one of embodiments C, D, E, F, or G, wherein the strippable polymer layer-forming liquid comprises PVA, an aliphatic polyester-polyurethane copolymer, an ethylene-acrylic acid copolymer, or a combination thereof.
- I. The method according to embodiment E, wherein the strippable polymer layer-forming liquid comprises a polymer melt and over coating includes thermal compression lamination.
- J. The method according to embodiment I, wherein the strippable polymer layer-forming liquid exhibits a viscosity of between 10,000 and 100,000,000 cps (10 and 100 Pa-s).
- K. The method according to any one of embodiments C-J, wherein the strippable polymer layer-forming liquid exhibits a yield stress.
- L. The method according to any one of embodiments C-K, wherein the strippable polymer layer-forming liquid exhibits a yield stress less than 100 Pa.

Claims

1. A method of patterning a conductive layer on a substrate, comprising:
coating a substrate with a conductive layer;
5 applying a pattern on the conductive layer with a liquid resist matrix material to generate on the substrate one or more first regions of exposed conductive layer and one or more second regions of resist matrix material;
hardening or curing the liquid resist matrix material;
over coating the pattern with a strippable polymer layer-forming liquid;
10 hardening or curing the strippable polymer layer-forming liquid to form a strippable polymer layer;
peeling the strippable polymer layer from the substrate, removing the exposed conductive layer from the substrate in the one or more first regions of the substrate, and thereby forming a patterned conductive layer on the substrate.
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2. The method according to claim 1 wherein the conductive layer comprises nanowires.
3. The method according to claim 1 or 2 wherein over coating the pattern with the strippable polymer layer comprises over coating the one or more first regions and the one or more second
20 regions with a strippable polymer layer-forming liquid.
4. The method according to claim 3 wherein the strippable polymer layer-forming liquid contacts between 50% to 99% of the exposed conductive layer in the one or more first regions.
- 25 5. The method according to claim 3 or 4, wherein the strippable polymer layer-forming liquid is selected from the group consisting of polymer solution, monomer, monomer solution, and polymer melt.
- 30 6. The method according to claim 5, wherein the strippable polymer layer-forming liquid comprises a polymer solution and over coating includes slot coating, roll coating, flood coating, notch bar coating, or spraying.
7. The method according to any one of claims 3, 4, 5 or 6 wherein the strippable polymer layer-forming liquid comprises a viscosity between 10 and 2,500 cps (0.01 and 2.5 Pa-s).
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8. The method according to any one of claims 3, 4, 5, 6, or 7 wherein the strippable polymer layer-forming liquid comprises PVA.

21. The method of any preceding claim, further comprising coating a lead-forming conductive layer over at least one portion of the patterned conductive layer.
22. The method of claim 21, wherein the step of coating the lead-forming conductive layer occurs after the peeling the strippable polymer layer from the substrate.
23. The method according to claim 21 wherein the pattern of the liquid resist matrix material includes interconnect pads, and wherein the lead forming conductive layer is coated above the interconnect pads with the lead-forming conductive layer contacting the patterned conductive layer along its exposed perimeter.
24. The method according to claim 23 wherein the interconnect pads are patterned so as increase the length of the exposed perimeter.
25. The method according to claim 24 wherein at least one of a void space or a corrugated outer margin is used to increase the length of the exposed perimeter.
26. The method according to claim 21 wherein the lead-forming conductive layer is an ink comprising silver particles.