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(54) Titre : METHODE DE FABRICATION D'AFFICHAGES ET DE CIRCUITS A GRANDE SURFACE, AYANT DE LA FLEXIBILITE MECANIQUE

(54) Title: FABRICATION METHOD FOR LARGE AREA MECHANICALLY FLEXIBLE CIRCUITS AND DISPLAYS

(57) **Abrégé/Abstract:**

A method of fabricating large area electronics is disclosed. The method comprises steps of: using a plotter to patterning a first conductive polymer such as PEDOT on a thin layer of anode such as PEDOT/PSS, spin-coating a second polymer such as MEH-PPV on top of the pattern; and evaporating a cathode such as Aluminium.

## Abstract

A method of fabricating large area electronics is disclosed. The method comprises steps of: using a plotter to patterning a first conductive polymer such as PEDOT on a thin layer of anode such as PEDOT/PSS, spin-coating a  
5 second polymer such as MEH-PPV on top of the pattern; and evaporating a cathode such as Aluminium.

## Fabrication Method for Large Area Mechanically Flexible Circuits and Displays

### 5 Field of the Invention

The present invention relates to a method of fabricating large area electronics using standard plotters. By replacing the inks in different plotter pens with appropriate polymer solutions, electronics circuits (based on resistors, capacitors, inductors, light-emitting and non-light emitting diodes, transistors, etc.) can be plotted on a variety of substrates including plastic and glass.

### Background and Summary of the Invention

Nowadays, many research groups at both universities and companies are working on full colour organic light emitting devices. However, important is the way of patterning the organic layers in order to fabricate these displays. When using small molecule materials it is achieved by using precise shadow masks with the desired pattern and evaporation of the single materials on top of each other.

Producing polymer devices is more complicated, spin coating of the polymer solution is possible to get a thin and homogeneous layer, but the single material will cover the whole area of the substrate. To get single colour devices evaporation of the cathode material through a shadow mask is possible. But, the fabrication of multi-color devices needs patterning of each individual organic layer. Photolithography using photo resist and wet etching steps are difficult, because of their solubility in aqueous solutions and many solvents. Wet etching of one material could dissolve all the other layers as well. Therefore, some research groups developed inkjet printing of the polymer solution to pattern the devices. Other groups are using screen-printing to get full-color displays.

Inkjet technology is a very precise and convenient technology. The resolution is high, the set-up is easy, the images can be drawn in Corel, and in spite of spin-coating there is very little waste of polymer material.

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But, there are also problems such as clogging of the nozzles and the compatibility of the printer hardware to many solvents. The polymer has to be modified in order to lower the surface tension of the material and to connect the dots to each other to get a continuous layer.

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In summary, the issue of lithographic patterning has, to some extent, addressed by the new ink-jet printing technique. Ink jet printing offers good resolution and as such it looks very promising for organic light emitting diode (OLED) display applications. Despite progress made with ink-jet printers, there are still issues such as connectivity of dots, which require modification of one or all of the following parameters: the polymer solution, printing surfaces, and the hardware.

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The present invention overcomes the need for lithographic patterning or shadow masking of polymeric/organic layers, which is required when blanket deposition is made such as with spin coating or evaporation. Patterns of the different layers needed in the electronic device can directly written/plotted on the substrate.

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Other features and advantages associated with the present invention are as follows:

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(1) Simple and convenient technology – hardware is not complex and is able to handle a broad range of solvents for polymers, and there are no issues with clogging of nozzles or other parts of the hardware.

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(2) The plotted patterns are continuous and homogeneous.

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(3) Plotters handle any substrates including glass and plastic and the desktop plotters, unlike desktop printers, do not impose substrate bending.

5 (4) The technique is simple and lends itself to a variety of application areas including the plotting of electronics on grocery packaging and other household items, personal effects (e.g. clothing, etc.), electronic labeling, electronic signage in roads and buildings, etc.

10 (5) The same principle can be extended to create a new generation of hobby electronics based on polymeric markers/fountain pens, where circuits (including their synthesis) can be simply plotted or drawn.

(6) The technique provides the capacity to plot/draw patterns of biological material thus addressing a new and promising technique for bioMEMS.

15 A further understanding of other aspects, features, and advantages of the invention will be realized by reference to the following description, attached additional description of the invention, and appended claims.

#### Detailed Description of the Preferred Embodiment(s)

20 According to the present invention, a plotter such as Hewlett-Packard 7475A can be used as a patterning device, which have a serial connection to PC's. The plotter can handle all kinds of substrates like glass or plastic, because the substrates are just moved in horizontal direction and therefore are not bended like most printers do. The syringes that are used to replace  
25 the pen of the plotter are compatible to all solvents.

A PET substrate covered with a thin layer of PEDOT/PSS is used as the anode. The plotter is then used to pattern the conductive polymer PEDOT to get the desired image. The pattern drawn by the plotter has an easier  
30 shape compared to the images that can be drawn by the inkjet printer. On top

of the pattern, MEH-PPV is spin-<sup>4</sup> coated, followed by the evaporation of the cathode, such as aluminium.

5 Before using the plotter, the fibre and the syringe tip are cleaned ultrasonically in DI-water to remove all PEDOT/PSS particles.

After cleaning, the fibre is put back into the plotter pen and the syringe tip is put over the fibre.

Both are connected to a EFD-syringe, which is filled with ca. 2ml (0.45 micron filtered) PEDOT solution.

10 The whole set-up is connected to the EFD-dispenser.

Press the 'pen-down' button and apply as much pressure as needed to push the polymer on the substrate, then turn it back to zero.

Press the 'pen-up' button and adjust the vacuum knob to the maximum level that still keeps the polymer inside the syringe.

15 Put transparency on the plotter table.

Connect the serial cable to the HP plotter and plot the image on the transparency.\

Then, tape a ca. 2"x2" substrate on the already drawn image and plot again.

20 Remove the substrate from the transparency and put it in a oven at 60 °C to dry out the water for ca. 24hurs.

After drying the PEDOT/PSS layer, MEH-PPV is spin-coated on top of the polymer layer.

25 The samples are left to dry in a vacuum oven before the evaporation process.

The aluminium cathode is evaporated in a Varian e-beam evaporator at ca.  $5 \times 10^{-5}$  torr, 100 nm e-beam current and 2 min. evaporation time.

30 The present invention will be more clearly understood by the attached "Additional Description of the Invention" section.

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While this invention has been described with reference to several specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. Various modifications and variations may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of fabricating large area electronics, the method comprising steps of:
  - 5 (a) using a plotter to patterning a first conductive polymer on a thin layer of anode;
  - (b) on top of the pattern, spin-coating a second polymer; and
  - (c) evaporating a cathode.
- 10 2. A method according to claim 1, wherein the anode is PEDOT/PSS.
3. A method according to claim 1, wherein the first conductive polymer is PEDOT.
- 15 4. A method according to claim 1, wherein the second conductive polymer is MEH-PPV.
5. A method according to claim 1, wherein the cathode is aluminium.