Patterning of electronic devices on a flexible substrate

A versatile, low-cost and customizable method for patterning graphene oxide onto a myriad of substrates

This patented technology uses wax-printed membranes for fast patterning and water activation transfer using pressure-based mechanisms. It requires neither a clean room nor organic solvents. The wax-printed membranes have 50μm resolution, long-term stability and infinite shaping capability over a variety of substrates, including textile, paper, adhesive film or PET. The ICN2 printing technology will enable in situ transfer of multiple electronic devices such as supercapacitors, solar cells, biosensors or LEDs. In addition to graphene oxide, this approach might be suitable for other electronic materials.

Related publication:
A cost-effective method for mass production

Some methods for patterning electronic devices involve long fabrication periods, high cost, great expertise and clean room facilities. Moreover, these methods are not versatile or effective for designing simple devices such as transistors or capacitors. The patterning method by ICN2 allows the transfer of graphene oxide onto almost any substrate in an easy, cost-effective and customizable way. This technique might also be appropriate for other electronic materials.

Wax printing technology is a green, low-cost and versatile technology that can be easily performed using the desired shape or image chosen by the user with micrometer resolution. The printed membranes have 50μm resolution, long-term stability and infinite shaping capability. The technology can also be implemented in a roll-to-roll hardware, speeding up the printing.

Devices can be made with graphene oxide, gold nanoparticles, carbon nanotubes, quantum dots, etc. Depending on the materials and their concentration, the device may be transparent. The ability to print transparent devices offers new possibilities to flexible and wearable electronics.

Graphene oxide has been transferred over a wide variety of substrates as textile, paper, adhesive film or PET among others. This long-term transfer of electronic materials is promising for implementation in areas that are not suitable for laboratories such as under-developed countries, opening the way for in-field transfer.

A three-step method:

1 Printing
A nitrocellulose membrane is patterned onto the desired shape using a wax printer. The inverse pattern is printed onto the membrane surface.

2 Filtering
The wax-printed membrane is set onto the filtering glass and the suspension of graphene oxide is filtered. The wax clogs the membrane pores wherever it is printed.

3 Pressing
The pattern obtained is transferred by pressure to the desired target substrate.

### FORMING A PATTERNED ELECTRONIC DEVICE ON A FLEXIBLE SUBSTRATE

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Printing</td>
<td>Process of printing wax masks with the aid of a computer and a printer. The masks can be computer-designed and such designs can be wax-printed on nitrocellulose sheets. Openings define the desired electrode pattern (the openings are the complement or “negative” of the mask).</td>
</tr>
<tr>
<td>2 Filtering</td>
<td>The wax-printed membrane is set onto the filtering glass and the suspension of graphene oxide is filtered. The wax clogs the membrane pores wherever it is printed.</td>
</tr>
<tr>
<td>3 Pressing</td>
<td>The pattern obtained is transferred by pressure to the desired target substrate.</td>
</tr>
</tbody>
</table>

### PRINTING STEP

- **Assembly of the porous membrane**: The printed mask and the electronic material are turned down and being pressed by a press stamp (e.g. a PDMS stamp) against a flexible substrate.
- **Process of printing wax masks**: The process involves using a computer and a printer to create the desired pattern on the membrane.