A lithographically patterned mechanical design can be included to absorb the deformation strain in the conductive thin film while retaining high conductivity. It can be stretched and contracted back to its original form, allowing its usage as a geometrically and spatially tunable thermal patch on various pain locations. Web and battery integration can be included to make it a completely autonomous-mobile low-cost (for example, $1-2) smart electronic system, with precise temperature control using smartphones or mobile gadgets.

[0004] In the disclosure, a thermal patch is provided, comprising: an array of heating pads; and a plurality of stretchable conductors interconnecting each of the array of heating pads with adjacent heating pads. In an aspect, a thermal patch is provided, comprising: an array of heating pads, wherein each heating pad including metal lines on a flexible surface; and a plurality of metal stretchable conductors interconnecting the metal lines of each of the heating pads with metal lines of adjacent heating pads, wherein the plurality of metal stretchable conductors has a figure "8" configuration to undergo lateral elongation between the heating pads and the adjacent heating pads. In any one or more aspects or embodiments the array of heating pads can be interconnected between a plurality of contact pads. The plurality of contact pads can be connected to adjacent heating pads by stretchable conductors. The thermal patch can include or be connected to a battery. The thermal patch can include or be connected to a flexible microcontroller. The thermal patch can include or be connected to a wireless transceiver configured to communicate with a mobile computing device. The wireless transceiver can be a Bluetooth transceiver. The mobile computing device can be a smart phone.

[0005] In the disclosure, a method is provided, comprising: a) forming a mask on a polymer layer, the mask defining a thermal patch; b) etching the polymer layer; c) depositing a conductive material to form stretchable conductors of the thermal patch; and d) vapor phase etching to release the thermal patch. In another aspect, a method is provided, comprising: forming a mask on a polymer layer, the mask defining a thermal patch;

etching the polymer layer; depositing a conductive material to form metal lines on heating pads of an array of heating pads on the polymer layer and metal stretchable conductors interconnecting the metal lines of each of the heating pads with metal lines of adjacent heating pads, wherein the metal lines and metal stretchable conductors form the thermal patch, and wherein the metal stretchable conductors have a figure "8" configuration to undergo lateral elongation between the heating pads and the adjacent heating pads; and vapor phase etching to release the thermal patch including the array of heating pads having metal lines, the metal stretchable conductors, and flexible surface formed from the polymer layer and on which the heating pads are formed. In any one or more aspects or embodiments, the mask can be an aluminum mask. The polymer layer can be a polyimide (PI) layer. The conductive material can be a metal, preferably copper, nickel, chromium, tin, silver, platinum or a metal alloy. The method can include wet etching to remove the mask prior to depositing the conductive material. The method can include depositing a seed layer for depositing the conductive material. The vapor phase etching can be XeF_2 vapor phase etching. In any one or more of the various embodiments the stretchable conductor(s) can have a lateral spring design. The design of the conductors can make

CLAIMS

Therefore, at least the following is claimed:

1. A thermal patch, comprising:

an array of heating pads, wherein each heating pad including metal lines on a flexible surface; and

a plurality of metal stretchable conductors interconnecting the metal lines of each of the heating pads with metal lines of adjacent heating pads, wherein the plurality of metal stretchable conductors has a figure "8" configuration to undergo lateral elongation between the heating pads and the adjacent heating pads.

2. The thermal patch of claim 1, wherein the array of heating pads is interconnected between a plurality of contact pads.

3. The thermal patch of claim 2, wherein the plurality of contact pads are connected to adjacent heating pads by stretchable conductors.

4. The thermal patch of any of claims 1-3, further comprising a battery.

5. The thermal patch of any of claims 1-4, further comprising a flexible microcontroller.

6. The thermal patch of any of claims 1-5, further comprising a wireless transceiver configured to communicate with a mobile computing device.

7. The thermal patch of claim 6, wherein the wireless transceiver is a Bluetooth transceiver.

8. The thermal patch of claim 6, wherein the mobile computing device is a smart phone.

9. A method, comprising:

forming a mask on a polymer layer, the mask defining a thermal patch;

etching the polymer layer;

depositing a conductive material to form metal lines on heating pads of an array of heating pads on the polymer layer and metal stretchable conductors interconnecting the metal lines of each of the heating pads with metal lines of adjacent heating pads, wherein the metal lines and metal stretchable conductors form the thermal patch, and wherein the metal stretchable conductors have a figure "8" configuration to undergo lateral elongation between the heating pads and the adjacent heating pads; and

vapor phase etching to release the thermal patch including the array of heating

pads having metal lines, the metal stretchable conductors, and flexible surface formed from the polymer layer and on which the heating pads are formed.

10. The method of claim 9, wherein the mask is an aluminum mask.

11. The method of claim 9 or 10, wherein the polymer layer is a polyimide (PI) layer.

12. The method of any of claims 9-11, wherein the conductive material is one of copper, nickel, chromium, tin, silver, platinum, and a metal alloy.

13. The method of any of claims 9-12, further comprising wet etching to remove the mask prior to depositing the conductive material.

14. The method of claim 10, further comprising depositing a seed layer for depositing the conductive material.

15. The method of any of claims 9-14, wherein the vapor phase etching is XeF_2 vapor phase etching.