CLAIMS

1. A temperature control device for controlling temperatures at a plurality of sites of a medium, comprising:

a plurality of active thermal sites disposed at respective locations on a substrate, each active thermal site comprising a heating element configured to apply a variable amount of heat to a corresponding site of said medium and a thermal insulation layer disposed between the heating element and the substrate; and

one or more passive thermal regions disposed between the plurality of active thermal sites on the substrate, each passive thermal region comprising a thermal conduction layer configured to conduct heat from a corresponding portion of the medium to the substrate;

wherein the thermal conduction layer of said one or more passive thermal regions has a lower thermal resistance in a direction perpendicular to a plane of the substrate than the thermal insulation layer of said plurality of active thermal sites;

wherein the thermal insulation layer comprises one or more voids;

the thermal insulation layer comprises one or more pillars of a first thermal insulation material extending substantially perpendicular to the plane of the substrate in the area of the active thermal site between the heating element and the substrate; and

said one or more voids are disposed between or around the pillars.

2. The temperature control device according to claim 1, comprising control circuitry configured to control whether a selected active thermal site provides heating of the corresponding site of the medium using the heating element or cooling of the corresponding site by heat flow through said thermal insulation layer to said substrate, in dependence on whether an amount of heat generated by the heating element of said selected active thermal site is greater or smaller than a threshold amount.

3. The temperature control device according to claim 2, wherein the threshold amount is dependent on the thermal resistance of the thermal insulation layer in the direction perpendicular to the plane of the substrate.

4. The temperature control device according to any preceding claim, wherein each active thermal site comprises a temperature sensor configured to sense a temperature at the corresponding active thermal site.

5. The temperature control device according to claim 4, comprising a plurality of feedback loops each corresponding to a respective active thermal site;

each feedback loop configured to implement a transfer function for determining a target amount of heat to be applied to the corresponding site of the medium in dependence on the temperature sensed by the temperature sensor of the corresponding active thermal site and a target temperature specified for the corresponding site of the medium.

6. The temperature control device according to claim 5, wherein each feedback loop is configured to implement a lineariser function to map said target amount of heat determined by the transfer function to an input signal for controlling the heating element of the corresponding active thermal site.

7. The temperature control device according to claim 6, wherein the lineariser function is a function of the temperature sensed by the temperature sensor of the corresponding active thermal site.

8. The temperature control device according to any of claims 6 and 7, wherein the lineariser function determines the input signal in dependence on a sum of the target amount of heat and an amount of heat lost from the heating element of the active thermal site to the substrate and surrounding passive thermal regions.

9. The temperature control device according to any preceding claim, wherein the heating element comprises a resistive heating element.

10. The temperature control device according to any preceding claim, wherein the thermal insulation layer of said plurality of active thermal sites has a greater thermal resistance in a direction parallel to the plane of the substrate than in a direction perpendicular to the plane of the substrate.

11. The temperature control device according to any preceding claim, wherein the thermal insulation layer of a given active thermal site comprises a thin film material having a thickness z in the direction perpendicular to the plane of the substrate which is substantially smaller than a smallest dimension L of the thermal insulation layer of the active thermal site in a direction parallel to the plane of the substrate.

12. The temperature control device according to any preceding claim, comprising a cooling mechanism to cool the substrate to act as a heat sink.

13. The temperature control device according to any preceding claim, wherein the medium comprises a fluid, and the temperature control device comprises a fluid flow control element configured to control flow of the fluid over the plurality of active thermal sites and the one or more passive thermal regions.

14. The temperature control device according to claim 13, wherein the active thermal sites are disposed in one or more rows oriented substantially parallel to the direction of fluid flow controlled by the fluid flow control element;

each row comprising two or more active thermal sites with a passive cooling region disposed between each pair of adjacent active thermal sites of the row.

15. The temperature control device according to claim 14, wherein each active thermal site has a length along the row direction that is greater than a length along the row direction of each passive cooling region disposed between adjacent active thermal sites of the row.

16. A method for controlling temperatures at a plurality of sites of a medium, comprising:

providing the medium on a temperature control device comprising a plurality of active thermal sites disposed at respective locations on a substrate and one or more passive thermal regions disposed between the plurality of active thermal sites on the substrate;

each active thermal site comprising a heating element configured to apply a variable amount of heat to a corresponding site of said medium and a thermal insulation layer disposed between the heating element and the substrate;

each passive thermal region comprising a thermal conduction layer configured to conduct heat from a corresponding portion of the medium to the substrate; and

the thermal conduction layer of said one or more passive thermal regions having a lower thermal resistance in a direction perpendicular to a plane of the substrate than the thermal insulation layer of said plurality of active thermal sites; and

controlling the amount of heat applied by the heating elements of the plurality of active thermal sites to control the temperatures at said plurality of sites of the medium;

wherein the thermal insulation layer comprises one or more voids;

the thermal insulation layer comprises one or more pillars of a first thermal insulation material extending substantially perpendicular to the plane of the substrate in the area of the active thermal site between the heating element and the substrate; and

said one or more voids are disposed between or around the pillars.

17. A method of manufacturing a temperature control device, comprising:

forming a plurality of active thermal sites at respective locations on the substrate and one or more passive thermal regions disposed between the plurality of active thermal sites on the substrate; wherein:

each active thermal site comprises a heating element configured to apply a variable amount of heat to a corresponding site of said medium and a thermal insulation layer disposed between the heating element and the substrate;

each passive thermal region comprises a thermal conduction layer configured to conduct heat from a corresponding portion of the medium to the substrate; and

the thermal conduction layer of said one or more passive thermal regions has a lower thermal resistance in a direction perpendicular to a plane of the substrate than the thermal insulation layer of said plurality of active thermal sites;

wherein the thermal insulation layer comprises one or more voids;

the thermal insulation layer comprises one or more pillars of a first thermal insulation material extending substantially perpendicular to the plane of the substrate in the area of the active thermal site between the heating element and the substrate; and

said one or more voids are disposed between or around the pillars.