Claims

1. A tunable element (300, 320, 400, 420, 501) for an optical waveguide device, the tunable element comprising:

a first waveguide section (301) formed from a first material;

a second waveguide section (302, 402) formed from a second material and arranged to receive light coupled from the first waveguide section;

a third waveguide section (303) formed from the first material and arranged to receive light coupled from the second waveguide section; and

one or more resistive heating pads (304, 404A, 404B, 424A, 424B) proximate to the second waveguide section,

wherein the second material is more thermo-optically sensitive than the first material, and

wherein the first and third waveguide sections (301, 303) are formed in a first layer and are co-planar, and the second waveguide section (302, 402) is formed in a second layer; and

wherein the first, second and third waveguide sections are surrounded by cladding material (203); and wherein the one or more resistive heating pads is covered by a layer of cladding material (203); and

wherein each resistive heating pad (304) has a length that is identical to a length of the second waveguide section (302), such that each resistive heating pad is proximate to the second waveguide section and not to the first or third waveguide sections (301, 303).

2. The tunable element according to claim 1, wherein in use light is coupled vertically between an end of the first waveguide section and a proximate end of the second waveguide section and is further coupled vertically between an opposite end of the second waveguide section and a proximate end of the third waveguide section.

3. The tunable element according to claim 1 or 2, wherein a layer of cladding material is between the first layer and the second layer.

4. The tunable element according to any of claims 1-3, wherein the one or more resistive heating pads (304) are formed in a third layer.

5. The tunable element according to claim 4, wherein a layer of cladding material is between the second layer and the third layer.

6. The tunable element according to claim 4, wherein a layer of cladding is formed between the first layer and the third layer, such that the second layer is further from the third layer than the first layer.

7. The tunable element according to any of claims 1-3, wherein the one or more resistive heating pads (304A, 304B, 404A, 404B) are formed in the second layer.

8. The tunable element according to claim 7, wherein the one or more resistive heating pads (404A, 404B) are formed from a resistive region of the second material.

9. The tunable element according to claim 7 or 8, wherein the second waveguide section comprises a centre portion (402A) and two outer portions (402B, 402C), wherein the centre portion is thicker than the outer portions.

10. The tunable element according to claim 1, wherein the first, second and third waveguide sections (301-303) are formed in a single layer.

11. The tunable element according to claim 10, wherein in use light is butt-coupled between an end of the first waveguide section and a proximate end of the second waveguide section and is further butt-coupled between an opposite end of the second waveguide section and a proximate end of the third waveguide section.

12. The tunable element according to claim 10 or 11, wherein the resistive heating pad is formed in the second layer.

13. The tunable element according to claim 12, wherein a layer of cladding material surrounds the single layer.

14. The tunable element according to any of claims 1-4, 10 and 11, wherein the second waveguide section comprises a centre portion (402A) and two outer portions (402B, 402C),

wherein the centre portion is thicker than the outer portions and wherein the a resistive heating pad is formed on top of each of two outer portions of the second waveguide section.

15. The tunable element according to any of the preceding claims, wherein the first material is silicon nitride and the second material is silicon, amorphous silicon or polycrystalline silicon.

~~16. The tunable element according to any of the preceding claims, wherein each resistive heating pad (304) has a length that is identical to a length of the second waveguide section (302), such that each resistive heating pad is proximate to the second waveguide section and not to the first or third waveguide sections (301, 303); and~~

~~the first waveguide section and the second waveguide section overlap with each other, and the second waveguide section and the third waveguide section overlap with each other.~~

~~17~~16. A tunable optical waveguide device comprising one or more tunable elements according to any of the preceding claims.

~~18~~17. An optical phased array comprising one or more tunable elements according to any of claims 1-~~16~~15.

~~19~~18. A method of fabricating a tunable element for an optical waveguide device, the method comprising:

forming a first waveguide section (301) and a third waveguide section (303) from a first material (608);

forming a second waveguide section (302, 402) from a second material (604, 704);

forming at least one layer of cladding material on the second waveguide section (606, 610); and

forming one or more resistive heating pads on top of a layer of cladding material and proximate to the second waveguide section (612, 704-705),

wherein the second material is more thermo-optically sensitive than the first material and

wherein the first and third waveguide sections (301, 303) are formed in a first layer

and are co-planar, and the second waveguide section (302, 402) is formed in a second layer; and

wherein the first, second and third waveguide sections are surrounded by cladding material (203); and wherein the one or more resistive heating pads is covered by a layer of cladding material (203); and

wherein each resistive heating pad (304) has a length that is identical to a length of the second waveguide section (302), such that each resistive heating pad is proximate to the second waveguide section and not to the first or third waveguide sections (301, 303).