Claims

1. A method of forming a strain relaxation layer in an epitaxial crystalline structure, the method comprising:

providing a crystalline template layer comprising a material with a first natural relaxed in-plane lattice parameter;

forming a first epitaxial crystalline layer on the crystalline template layer, wherein the first epitaxial crystalline layer has an initial electrical conductivity that is higher than the electrical conductivity of the crystalline template layer;

forming a second epitaxial crystalline layer on the first epitaxial crystalline layer, wherein the second epitaxial crystalline layer has an electrical conductivity lower than the initial electrical conductivity of the first epitaxial crystalline layer and comprises a material with a second natural relaxed in-plane lattice parameter that is different to the first natural relaxed in-plane lattice parameter of the crystalline template layer;

forming pores in the first epitaxial crystalline layer by electrochemical etching of the first epitaxial crystalline layer to enable strain relaxation in the second epitaxial crystalline layer by plastic deformation of bonds in the first epitaxial crystalline layer and/or at the interface between the first epitaxial crystalline layer and the second epitaxial crystalline layer; and

forming one or more channels comprising a conductive material through at least the first epitaxial crystalline layer and the second epitaxial crystalline layer thereby to enable electrical connection to the crystalline template layer through the first epitaxial crystalline layer and the second epitaxial crystalline layer.

2. The method according to claim 1, wherein the pores are formed with a density of the volume of the first epitaxial layer between the crystalline template layer and the second epitaxial crystalline layer of greater than 50%, preferably greater than 60% and more preferably greater than 70%.

3. The method according to any preceding claim, wherein the second epitaxial crystalline layer comprises at least one V-pit, preferably wherein the depth of the at least one V-pit is substantially the thickness of the first epitaxial crystalline layer and the second epitaxial crystalline layer combined.

4. The method according to claim 3, comprising enlarging the at least one V-pit, preferably wherein enlarging the at least one V-pit comprises etching material from at least one sidewall of the at least one V-pit thereby to expose at least a portion of the crystalline template layer.

5. The method according to any preceding claim, comprising etching through at least the second epitaxial crystalline layer thereby to form one or more islands in the second epitaxial crystalline layer, preferably comprising patterning the second epitaxial crystalline layer, wherein patterning comprises at least one of a lithographic technique and a self-assembled Ni hard mask.

6. The method according to any preceding claim, comprising forming the crystalline template layer on a patterned template layer.

7. The method according to claim 6, wherein the patterned template layer is patterned to provide trenches, preferably wherein forming the crystalline template layer comprises forming overgrowth material in the trenches to provide V-grooves, thereby to enable the formation of two dimensional domains at least partially defined by valleys in the second epitaxial crystalline layer.

8. The method according to claim 6, wherein the crystalline template layer is patterned to provide one or more overgrowth structures, preferably wherein forming the patterned template layer comprises at least partially masking the crystalline template layer to provide one or more apertures and forming overgrowth material in the one or more apertures thereby to provide the one or more overgrowth structures, preferably wherein forming the one or more channels comprising the conductive material through at least the first epitaxial crystalline layer and the second epitaxial crystalline layer comprises removing material from one or more sidewalls of the one or more overgrowth structures.

9. The method according to any preceding claim, comprising planarizing at least a portion of the second epitaxial crystalline layer thereby to form a third epitaxial crystalline layer that is pseudomorphic with the second epitaxial crystalline layer, preferably wherein the conductive material forms part of the third epitaxial crystalline layer.

10. The method according to claim 9, wherein the third epitaxial crystalline layer is an electrically conductive layer, preferably wherein the third epitaxial crystalline layer is in electrical communication with the crystalline template layer and/or wherein the third epitaxial crystalline layer forms at least part of an active region configured to emit light in response to carrier recombination.

11. The method of any preceding claim comprising a third epitaxial crystalline layer, wherein at least one of the crystalline template layer, the first epitaxial crystalline layer,

the second epitaxial crystalline layer and the third epitaxial crystalline layer comprises a semiconductor material, preferably wherein the semiconductor material is a III-V based material, more preferably wherein the III-V based material is a nitride based material.

12. An epitaxial crystalline structure comprising:

a crystalline template layer comprising a material with a first natural relaxed in-plane lattice parameter;

a first epitaxial crystalline layer formed on the crystalline template layer;

a second epitaxial crystalline layer formed on the first epitaxial crystalline layer, wherein the second epitaxial crystalline layer comprises a material with a second natural relaxed in-plane lattice parameter that is different to the first natural relaxed in-plane lattice parameter of the crystalline template layer;

one or more pores formed in the first epitaxial crystalline layer such that any strain in the second epitaxial crystalline layer is relaxed by plastic deformation of bonds in the first epitaxial crystalline layer and/or at the interface between the first epitaxial crystalline layer and the second epitaxial crystalline layer; and

one or more channels comprising a conductive material formed through at least the first epitaxial crystalline layer and the second epitaxial crystalline layer thereby to enable electrical connection to the crystalline template layer through the first epitaxial crystalline layer and the second epitaxial crystalline layer.

13. The epitaxial crystalline structure according to claim 12, comprising a third epitaxial crystalline layer that is pseudomorphic with the second epitaxial crystalline layer.

14. The epitaxial crystalline structure according to any of claims 12 and 13, wherein the one or more pores are formed with a density of the volume of the first epitaxial layer between the crystalline template layer and the second epitaxial crystalline layer of greater than 50%, preferably greater than 60% and more preferably greater than 70%.

15. The epitaxial crystalline structure according to any of claims 12 to 14, wherein the second epitaxial crystalline layer comprises at least one V-pit, preferably wherein the depth of the at least one V-pit is substantially the thickness of the first epitaxial crystalline layer and the second epitaxial crystalline layer combined.

16. The epitaxial crystalline structure according to claim 15, wherein the at least one V-pit exposes at least a portion of the crystalline template layer.

17. The epitaxial crystalline structure according to any of claims 12 to 16, comprising one or more islands formed in the second epitaxial crystalline layer.

18. The epitaxial crystalline structure according to claim 17, comprising one or more valleys at least partially surrounding the one or more islands in the second epitaxial crystalline layer thereby to enable the formation of one or more two dimensional domains.

19. The epitaxial crystalline structure according to claim 13, wherein the conductive material forms part of the third epitaxial crystalline layer.

20. The epitaxial crystalline structure according to any of claims 12 to 19, wherein the third epitaxial crystalline layer is an electrically conductive layer, preferably wherein the third epitaxial crystalline layer is in electrical communication with the crystalline template layer and/or wherein the third epitaxial crystalline layer forms part of an active region configured to emit light in response to carrier recombination.

21. The epitaxial crystalline structure of any of claims 12 to 20 comprising a third epitaxial crystalline layer, wherein at least one of the crystalline template layer, the first epitaxial crystalline layer, the second epitaxial crystalline layer and the third epitaxial crystalline layer comprises a semiconductor material, preferably wherein the semiconductor material is a III-V based material, more preferably wherein the III-V material is a nitride based material.

22. A light emitting device comprising the epitaxial crystalline structure according to any of claims 12 to 21.

23. An array of light emitting pixels comprising at least one light emitting device according to claim 22.

24. A method of forming a light emitting device comprising the method according to any of claims 1 to 11.

25. A method of forming an array of light emitting pixels comprising the method according to claim 24.