and the obtained nanoporous GaN template (as shown in Figure 3(a)) was cleaned and then loaded into the MOCVD reactor.

Secondary Portion and Quantum Well Preparation

A ~200nm GaN layer was deposited on the nanoporous GaN template at 1010 °C using H_2 as carrier gas. The growth time was precisely controlled in order to produce a plurality of nanostructures ~~12~~ 9′ of Figure 2 (without the optically active layer 19). a . Four periods of InGaN/GaN multiquantum-wells (MQW) were then grown on the nanoepitaxial GaN at a temperature of 755 °C and chamber pressure of 100 Torr, to form an optically active layer 19 as shown in Figure 2. Trimethylgallium (TMGa), trimethylindium (TMIn), and NH_3 were used as the source for Ga, In, and N, respectively. During the growth of the GaN layer, TMGa flow rate of about 80sccm, NH_3 flow rate of about 12000sccm, H_2 flow rate of about 6000sccm, a pressure of about 200torr and a growth time of about 9.5mins were applied. Nitrogen was used as the carrier gas for the InGaN/GaN quantum well growth. For InGaN/GaN MQWs growth, TMGa flow rate of about 320sccm, NH_3 flow rate of about 18000sccm, N_2 flow rate of about 6000sccm and a pressureof about 100torr were used. To grow InGan/GaN MQWs, a lyer o fInGaN with growth time of 0.4mins was grown followed by a layer of GaN with growth time of 1.2mins. Four pairs of InGaN/GaN layers were sequentially deposited.A nonpatterned GaN epilayer was also loaded into the MOCVD chamber to be grown simultaneously as a reference sample.

Results (1): Fig. 3a shows the top view SEM image of the GaN template. The GaN template was fabricated by ICP etching. The darker hexagon 20 represents etched holes. The average diameter of the hexagon 20 was ~200nm with an

Claims

1. A photonic device comprising:

a plurality of nanostructures that extend from a substrate, each nanostructure comprising:

a generally longitudinal nanostructure body formed of a semiconductor material and having a proximal end portion of a first crystal lattice structure and a distal end portion, opposite said proximal end portion, of a second crystal lattice structure that is expanded ~~relative to~~outwardly from the proximal end portion;

an optically active material optically associated with the distal end portion to form a heterojunction therebetween.

2. The photonic device as claimed in claim 1, wherein the width of the distal end portion has larger dimension relative to the proximal end portion of the nanostructure body.

3. The photonic device as claimed in claim 2, wherein a lower section of the distal end portion tapers outwardly from the end of the proximal end portion along a longitudinal axis of the nanostructure body.

4. The photonic device as claimed in claim 2, wherein an upper section of the distal end portion tapers inwardly from the lower section towards the end of the distal end potion of the nanostructure body.

5. The photonic device as claimed in any one of the preceding claims, wherein a layer of the optically active material is disposed on one or more surfaces of the distal end portion.

6. The photonic device as claimed in claim 5, wherein ~~a~~ the layer of the optically active material is disposed on ~~a~~ the one or more surfaces of the distal end portion with a selected orientation.

7. The photonic device as claimed in claim 5 or 6, wherein said each nanostructure further comprises a layer of a semiconductor material in contact with and sandwiching the~~, or an,~~ optically active layer of the distal end portion or a further layer of the optically active material, formed of a different composition, disposed on another one or more surfaces of the distal end portion.

8. The photonic device as claimed in any one of the preceding claims, wherein a plurality of nanopores are disposed between the proximal end portions of the adjacently disposed nanostructures.

9. The photonic device as claimed in any one of the preceding claims, wherein the semiconductor material forming the proximal and distal end portions of the nanostructures is a metalloid.

10. The photonic device as claimed in any one of the preceding claims, wherein the optically active material is a semiconductor metalloid being doped with a metal selected from Group III of the periodic table.

11. The photonic device as claimed in ~~claims 5 and 9-10~~claim 7, wherein the layer of the semiconductor material in contact with and sandwiching the optically

active layer is a metalloid having an opposite polarity to the metalloid of claim 9.

12. A method of forming a photonic device comprising a plurality of nanostructures that extend from a substrate, the method comprising the steps of:

(a) providing a template formed of a semiconductor material on the substrate, the template comprising a plurality of primary generally longitudinally shaped nanostructures projecting from the substrate and being formed of a semiconductor material having a first crystal lattice structure;

(b) forming a secondary portion on each of the primary nanostructures, said secondary portions being composed of semiconductor material having a second crystal lattice structure that is expanded outwardly from~~relative to~~ the first crystal structure; and

(c) forming an optically active layer of optically active material on the secondary portions of the nanostructures.

13. The method according to claim 12, wherein step b) comprises a first stage of growing a portion of the semiconductor material having the first crystal lattice structure by nanoepitaxial growth under selected conditions to form lower sections of the secondary portions of the nanostructures.

14. The method according to claim 13, wherein step b) comprises a second stage of further growth of the semiconductor material to form upper sections of the secondary portions of the nanostructures.

15. The method according to claim 13 and 14, wherein the lower and upper sections are formed under a temperature selected from the range of from about 900°C to about 1100°C, and a pressure selected from the range of from about 50torr to about 200torr.

16. The method according to any one of claims 12-15, wherein step a) includes a step of configuring the template to form a plurality of nanopores disposed between the primary nanostructures.

17. The method according to claim 16, wherein configuring the layer of the semiconductor material to form a template is achieved using a nanofabrication method and subsequent etching.

18. The method according to claim 17, wherein the nanofabrication method is selected from the group consisting of: nano-imprinting, anodized aluminium oxide mask, E-beam lithography and interference lithography.

19. The method according to any one of claims 13-16 further comprising a step of providing a layer of a semiconductor material above the optically active layer.

20. A light emitting diode device having a semiconductor element comprising:

a plurality of nanostructures that extend from a substrate, each nanostructure comprising:

a generally longitudinal nanostructure body formed of a semiconductor material and having a proximal end portion of a first crystal lattice structure and a distal end portion, opposite the proximal end portion, of a second crystal lattice structure that is expanded ~~relative to~~ outwardly from the proximal end portion;

an optically active material optically associated with the distal end portion to form a heterojunction therebetween;

a layer of a semiconductor material disposed over the distal end portions of the nanostructures to form a continuous nanostructured contact surface on the semiconductor element; and

a pair of electrodes, one of the electrodes being electrically coupled to the continuous nanostructured contact surface and the other electrode being electrically coupled to the seminconductor material of the nanostructure body.