mode to a pulsed growth mode. By continuing the pulsed growth mode of the semiconductor material, a plurality of semiconductor nanowires can be formed.

**[0008]** According to various embodiments, the present teachings also include a group III-N nanowire array, which can include a selective growth mask disposed over a substrate. The selective growth mask can include a plurality of patterned apertures that expose a plurality of portions of the substrate. A group III-N nanowire can be connected to and extend from the exposed plurality of portions of the substrate and extend over a top of the selective growth mask. The group III-N nanowire can be oriented along a single direction and can maintain a cross-sectional feature of one of the plurality of selected surface regions.

**[0009]** According to various embodiments, the present teachings further include a GaN substrate structure. The GaN substrate structure can be a GaN film coalesced from a plurality of GaN nanowires, which is defect free. The GaN film can have a defect density of about $10^7$ $cm^{-2}$ or lower.

**[0009a]** According to a first aspect of the invention, there is provided a method of forming a thin-walled structure comprising: forming a selective growth mask over a substrate, wherein the selective growth mask comprises a plurality of patterned apertures; forming a thin-walled structure on the substrate by disposing a semiconductor material in each patterned aperture using a non-pulsed growth mode; and growing the thin-walled structure using a pulsed growth mode of the semiconductor material, wherein the thin-walled structure comprises a hollow shape having a wall thickness.

**[0009b]** According to a second aspect of the invention, there is provided a thin-walled structure comprising: a selective growth mask disposed over a substrate, wherein the selective growth mask comprises a plurality of patterned apertures with each patterned aperture exposing a surface portion of the substrate; and a thin-walled structure connected to and extending from the surface portion of the substrate and through each patterned aperture, wherein the thin-walled structure comprises a hollow shape having a wall thickness of 1000 nm or less.

**[0010]** Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

**[0011]** It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

**WHAT IS CLAIMED IS**:

1. A group III-N nanowire array comprising:

a substrate;

a selective growth mask over the substrate, wherein the selective growth mask comprises a plurality of patterned apertures that expose a plurality of portions of the substrate; and

a group III-N nanowire connected to and extending from each of the plurality of portions of the substrate, wherein the group III-N nanowire is oriented along a single direction and maintains a cross-sectional feature of one of the plurality of selected surface regions, and wherein the group III-N nanowire extends over a top of the selective growth mask.

2. The nanowire array of claim 1, wherein the group III-N nanowire comprises GaN oriented along a (0001) crystallographic direction.

3. The nanowire array of claim 1 or 2, wherein the group III-N nanowire comprises one or more materials selected from the group consisting of GaN, AlN, InN, InGaN, AlGaN, and AlInGaN.

4. The nanowire array of any of the preceding claims, wherein each of the plurality of patterned apertures comprises a shape chosen from a polygon, a rectangle, a square, an oval, or a circle.

5. The nanowire array of any of the preceding claims, wherein the group III-N nanowire further comprises an aspect ratio of about 100 or higher and a cross-sectional dimension of about 10 micrometers or less.

6. The nanowire array of any of the preceding claims, further comprising a buffer layer disposed between the substrate and the selective growth mask, wherein the buffer layer comprises one or more of GaN, AlN, InN, InGaN, AlInGaN or AlGaN.

**WHAT IS CLAIMED IS:**

1. A method of forming a thin-walled structure comprising:

forming a selective growth mask over a substrate, wherein the selective growth mask comprises a plurality of patterned apertures;

forming a thin-walled structure on the substrate by disposing a semiconductor material in each patterned aperture using a non-pulsed growth mode; and

growing the thin-walled structure using a pulsed growth mode of the semiconductor material, wherein the thin-walled structure comprises a hollow shape having a wall thickness.

2. The method of claim 1, wherein at least one lateral dimension of each patterned aperture is about 1 micron or less.

3. The method of claim 1, wherein at least one lateral dimension of each patterned aperture is about 500 nm or less to form a thin-walled nanowire structure.

4. The method of claim 1, wherein the thin-walled structure has a length of about 1 micron to about 10 mm.

5. The method of claim 1, wherein the wall thickness is about 1000 nm or less.

6. The method of claim 1, wherein the thin-walled structure comprises a thin-walled hollow structure having a lateral cross section selected from the group consisting of a thin-walled polygon, a thin-walled rectangle, a thin-walled square, a thin-walled oval, and a thin-walled circle.

7. The method of claim 1, wherein the substrate comprises one or more materials selected from the group consisting of Si, SiC, sapphire, GaN and GaAs.

8. The method of claim 1, wherein the pulsed growth mode is applied before or after growth of the semiconductor material protrudes over a top of the selective growth mask.

9. The method of claim 1, wherein the semiconductor material for forming the thin-walled structure comprises one or more materials selected from the group consisting of GaN, AlN, InN, InGaN, AlInGaN and AlGaN.

10. A group III-N thin-walled structure formed according to the method of claim 1.

11. The method of claim 1, further comprising forming a group III-N substrate structure by terminating and coalescing one or more formed thin-walled structures.

12. The method of claim 1, further comprising forming a multiple quantum well (MOW) active structure on one or more sidewalls of the formed thin-walled structure, the thin-walled structure being used as a core structure.

13. A group III-N substrate structure formed by the method of claim 11.

14. The method of claim 12, wherein the MOW active structure comprises one or more materials chosen from AlGaN, InGaN, AlInGaN, GaN, AlN, and InN.

15. A thin-walled structure comprising:

a selective growth mask disposed over a substrate, wherein the selective growth mask comprises a plurality of patterned apertures with each patterned aperture exposing a surface portion of the substrate; and

a thin-walled structure connected to and extending from the surface portion of the substrate and through each patterned aperture, wherein the thin-walled structure comprises a hollow shape having a wall thickness of 1000 nm or less.

16. The structure of claim 15, wherein the at least one lateral dimension of each patterned aperture is about 1 micron or less.

17. The structure of claim 15, wherein the at least one lateral dimension of each patterned aperture is about 500 nm or less for a thin-walled nanowire structure.

18. The structure of claim 15, wherein the thin-walled structure has a length of about 1 micron or longer extended from the substrate surface.

19. The structure of claim 15, wherein the thin-walled structure comprises a thin wall, a thin-walled polygon, a thin-walled rectangle, a thin-walled square, a thin-walled oval, or a thin-walled circle.

20. A multiple quantum well (MQW) active structure disposed on one or more sidewalls of the thin-walled structure of claim 15, to form a core-shell active structure for a device comprising a light emitting diode (LED), a laser, or a high electron mobility transistor (HEMT).