CLAIMS

1. A device (1) for emitting light, the device (1) comprising:

a substrate (2);

a base layer (4) arranged on the substrate (2), the base layer (4) comprising Al(x)Ga(1-x)N wherein $0 < x \leq 1$;

a diode layer structure (10) arranged on the base layer (4), the diode layer structure (10) comprising a quantum well layer structure (30) sandwiched between an n-doped semiconductor layer (12) and a p-doped semiconductor layer (14);

the quantum well layer structure (30) comprising a first (41) and second (42) quantum well, a first (51) and a second (52) proximal barrier layer, and a first (61) and a second (62) distal barrier layer,

wherein the first (41) and second (42) quantum well each has a thickness below 5 nm and a bandgap smaller than bandgaps of the first (51) and second (52) proximal barrier layers;

wherein the first (51) and second (52) proximal barrier layer each comprises intrinsically doped GaN, wherein the first (41) and second (42) quantum wells are sandwiched between the first (51) and second (52) proximal barrier layers,

wherein the first (61) and second (62) distal barrier layer each comprises Al(a)Ga(1-a)N wherein $0 \leq a \leq 0.3$, wherein both the first (61) and the second (62) distal barrier layer have larger bandgaps than the first (51) and second (52) proximal barrier layers, wherein the first (41) and second (42) quantum wells and the first (51) and second (52) proximal barrier layers are sandwiched between the first (61) and second (62) distal barrier layers;

wherein the n-doped semiconductor layer (12) is configured to inject electrons into the quantum well layer structure (30);

wherein the p-doped semiconductor layer (14) is configured to inject holes into the quantum well layer structure (30), preferably wherein said base layer (4) is AlN having a thickness 100-500 nm.

2. The device (1) according to claim 1, wherein the quantum well layer structure (30) is configured to be substantially doped by a distal n-doped semiconductor layer and a distal p-doped semiconductor layer for recombination of electrons and holes.

3. The device (1) according to claim 1 or 2, wherein the quantum well layer structure (30) of the diode layer structure (10) comprises a plurality of quantum wells, wherein adjacent quantum wells of the plurality of quantum wells are separated by a barrier layer having a thickness less than 10 nm.

4. The device (1) according to any one of the preceding claims, wherein the p-doped semiconductor layer (14) comprises a superlattice (20) of GaN layers (22) and Al(z)Ga(1-z)N layers (24), wherein $0 < z \leq 1$, wherein the Al(z)Ga(1-z)N layers (24) of the superlattice (20) are p-doped.

5. The device (1) according to any one of the preceding claims, wherein the n-doped semiconductor layer (12) comprises a superlattice (20) of GaN layers (22) and Al(z)Ga(1-z)N layers (24), wherein $0 < z \leq 1$, wherein the Al(z)Ga(1-z)N layers (24) of the superlattice (20) are n-doped.

6. The device (1) according to any one of the preceding claims, further comprising a via (3), the via (3) being a metal contact going through the substrate (2) and electrically connecting to the n-doped semiconductor layer (12) or to the p-doped semiconductor layer (14) of the diode layer structure (10).

7. The device (1) according to any one of the preceding claims, wherein the n-doped semiconductor layer (12) comprises a pillar layer (15), the pillar layer (15) of the n-doped semiconductor layer (12) comprising at least one n-doped semiconductor pillar (16) embedded in supporting material (18), wherein the at least one n-doped semiconductor pillar (16) is configured to form an electron transport channel through the pillar layer (15) of the n-doped semiconductor layer (12) to the quantum well layer structure (30); and/or

the p-doped semiconductor layer (14) comprises a pillar layer (15), the pillar layer (15) of the p-doped semiconductor layer (14) comprising at least one p-doped semiconductor pillar (16) embedded in supporting material (18), wherein the at least one p-doped semiconductor pillar (16) is configured to form a hole transport channel through the pillar layer (15) of the p-doped semiconductor layer (14) to the quantum well layer structure (30).

8. The device (1) according to claim 7, wherein, for one or more pillar layers (15) of the device (1), the supporting material (18) is a semiconductor material with a doping opposite to the doping of the semiconductor pillars (16) embedded in said supporting material (18).

9. The device (1) according to claim 7 or 8, wherein, for one or more pillar layers (15) of the device (1), the supporting material (18) is a gallium oxide.

10. The device (1) according to any one of claims 7-9, wherein, for one or more pillar layers (15) of the device (1), a diameter (D) of the semiconductor pillars (16) is 10-500 nm and a pitch (B) of the semiconductor pillars (16) is 200-500 nm.

11. The device (1) according to any one of the preceding claims, wherein a charge carrier concentration for light holes is provided in the p-doped semiconductor layer (14) by strain.

12. The device (1) according to any one of the preceding claims, wherein the device (1) is a vertical-cavity surface emitting laser (70) comprising a bottom reflector (72) below the first (41) and second (42) quantum wells and a top reflector (74) above the first (41) and second (42) quantum wells, the top (74) and bottom (72) reflector forming an optical resonator for light emitted by the first (41) and second (42) quantum wells.

13. A method (100) for producing a light-emitting device (1), the method comprising:

providing (S101) a substrate (2);

depositing (S102), by physical vapor deposition, a base layer (4) on the substrate (2), the base layer (4) comprising Al(x)Ga(1-x)N wherein $0 < x \leq 1$;

forming (S103) a diode layer structure (10) on the base layer (4), the diode layer structure (10) comprising a quantum well layer structure (30) sandwiched between an n-doped semiconductor layer (12) and a p-doped semiconductor layer (14),

the quantum well layer structure (30) comprising a first (41) and second (42) quantum well, a first (51) and a second (52) proximal barrier layer, and a first (61) and a second (62) distal barrier layer,

wherein the first (41) and second (42) quantum well each has a thickness below 5 nm and a bandgap smaller than bandgaps of the first (51) and second (52) proximal barrier layers;

wherein the first (51) and second (52) proximal barrier layer each comprises intrinsically doped GaN, wherein the first (41) and second (42) quantum wells are sandwiched between the first (51) and second (52) proximal barrier layers,

wherein the first (61) and second (62) distal barrier layer each comprises Al(a)Ga(1-a)N wherein $0 \leq a \leq 0.3$, wherein both the first (61) and the second (62) distal barrier layer have larger bandgaps than the first (51) and second (52) proximal barrier layers, wherein the first (41) and second (42) quantum wells and the first (51) and second (52) proximal barrier layers are sandwiched between the first (61) and second (62) distal barrier layers;

wherein the n-doped semiconductor layer (12) is configured to inject electrons into the quantum well layer structure (30);

wherein the p-doped semiconductor layer (14) is configured to inject holes into the quantum well layer structure (30), preferably wherein said base layer (4) is AlN having a thickness 100-500 nm.

14. The method according to claim 13, further comprising:

etching a hole through the substrate (2) by reactive ion etching; and

depositing metal in the hole through the substrate (2) such that a metal contact is formed, the metal contact going through the substrate (2) and

electrically connecting to the n-doped semiconductor layer (12) or to the p-doped semiconductor layer (14) of the diode layer structure (10).

15. The method according to claim 14, wherein the etching of the hole through the substrate (2) by reactive ion etching is ended based on spectroscopically detecting molecular species of aluminum chloride or aluminum fluoride.