Claims

1. A single crystal CVD synthetic diamond layer comprising a non-parallel dislocation array, wherein the non-parallel dislocation array comprises a plurality of dislocations forming an array of inter-crossing dislocations, as viewed in an X-ray topographic cross-sectional view or under luminescent conditions.

2. A single crystal CVD synthetic diamond layer according to claim 1, wherein the layer of single crystal CVD synthetic diamond has a thickness equal to or greater than 1 μm, 10 μm, 50 μm, 100 μm, 500 μm, 1 mm, 2 mm, or 3 mm.

3. A single crystal CVD synthetic diamond layer according to claim 1 or 2, comprising a density of dislocations in a range 10 cm^{-2} to $1x10^{3}$ cm^{-2}, $1x10^{2}$ cm^{-2} to $1x10^{8}$ cm^{-2}, or $1x10^{4}$ cm^{-2} to $1x10^{7}$ cm^{-2}.

4. A single crystal CVD synthetic diamond layer according to any preceding claim, comprising a birefringence equal to or less than $5x10^{-4}$, $5x10^{-5}$, $1x10^{-5}$, $5x10^{-6}$, or $1x10^{-6}$.

5. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the single crystal CVD synthetic diamond layer is a {110} or {113} oriented layer.

6. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the non-parallel dislocation array extends over a significant volume of the single crystal CVD synthetic diamond layer, the significant volume forming at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total volume of the single crystal CVD synthetic diamond layer.

7. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the non-parallel dislocation array comprises a first set of dislocations propagating in a first direction through the single crystal CVD synthetic diamond

layer and a second set of dislocations propagating in a second direction through the single crystal CVD synthetic diamond layer, and wherein an angle between the first and second directions lies in the range 40° to 100°, 50° to 100°, or 60° to 90° as viewed in an X-ray topographic cross-sectional view or under luminescent conditions.

8. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein a direction in which a dislocation propagates is measured in terms of an average direction over a significant length of the dislocation, where the significant length is at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total length of the dislocation and/or at least 50 μm, 100 μm, 250 μm, 500 μm, 1000 μm, 1500 μm, or 2000 μm.

9. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein at least 30%, 40%, 50%, 70%, 80%, or 90% of a total number of visible dislocations within a significant volume of the single crystal CVD synthetic diamond layer form the non-parallel dislocation array as viewed in an X-ray topographic cross-sectional view or under luminescent conditions, the significant volume forming at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total volume of the single crystal CVD synthetic diamond layer.

10. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the non-parallel dislocation array as viewable in an X-ray topographic cross-sectional view but not under luminescent conditions or alternatively the non-parallel dislocation array as viewable under luminescent conditions but not in an X-ray topographic cross-sectional view.

11. A single crystal CVD synthetic diamond material layer according to any preceding claim, comprising a hardness of at least 100 GPa or at least 120 GPa.

12. A single crystal CVD synthetic diamond object comprising a single crystal diamond layer according to any preceding claim, wherein the single crystal diamond layer forms at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total volume of the single crystal CVD synthetic diamond object.

13. Use of a single crystal CVD synthetic diamond object according to claim 13 in an optical, mechanical, luminescent, and/or electronic device or application.

14. A single crystal CVD synthetic diamond object according to claim 13, wherein the single crystal CVD synthetic diamond object is cut into a gemstone configuration.

15. A method of forming a single crystal CVD synthetic diamond layer, the method comprising:

providing a single crystal diamond substrate with a growth face having a density of defects equal to or less than 5×10^3 defects/mm^2 as revealed by a revealing plasma etch; and

growing a layer of single crystal CVD synthetic diamond according to any one of claims 1 to 12 on the growth face.

16. A method according to claim 15, wherein the growth face of the single crystal diamond substrate has a {110} or {113} crystallographic orientation.

17. A method according to claim 15 or 16, wherein a growth rate of the layer of single crystal CVD synthetic diamond is controlled to be sufficiently low such that the non-parallel dislocation array is formed.

18. A method according to any one of claims 15 to 17, wherein the non-parallel dislocation array comprises a significant number of dislocations propagating at an acute angle of at least 20° relative to a growth direction of the layer of single crystal CVD synthetic diamond, said significant number being at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total number of dislocations visible in an X-ray topographic cross-sectional view or under luminescent conditions.

19. A method according to claim 18, wherein said significant number of dislocations propagate at an acute angle in the range 20 to 60°, 20 to 50°, or 30 to 50° relative to the growth direction of the layer of single crystal CVD synthetic diamond.

Claims

1. A single crystal CVD synthetic diamond layer comprising a non-parallel dislocation array, wherein the non-parallel dislocation array comprises a plurality of dislocations forming an array of inter-crossing dislocations, as viewed in an X-ray topographic cross-sectional view or under luminescent conditions, wherein the layer of single crystal CVD synthetic diamond has a thickness equal to or greater than 1 μm, wherein the non-parallel dislocation array extends over a volume forming at least 30% of a total volume of the single crystal CVD synthetic diamond layer, and wherein a direction in which a dislocation propagates is measured in terms of an average direction over at least 30% of a total length of the dislocation.

2. A single crystal CVD synthetic diamond layer according to claim 1, wherein the layer of single crystal CVD synthetic diamond has a thickness equal to or greater than 10 μm, 50 μm, 100 μm, 500 μm, 1 mm, 2 mm, or 3 mm.

3. A single crystal CVD synthetic diamond layer according to claim 1 or 2, comprising a density of dislocations in a range 10 cm^{-2} to $1x10^{8}$ cm^{-2}, $1x10^{2}$ cm^{-2} to $1x10^{8}$ cm^{-2}, or $1x10^{4}$ cm^{-2} to $1x10^{7}$ cm^{-2}.

4. A single crystal CVD synthetic diamond layer according to any preceding claim, comprising a birefringence equal to or less than $5x10^{-4}$, $5x10^{-5}$, $1x10^{-5}$, $5x10^{-6}$, or $1x10^{-6}$.

5. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the single crystal CVD synthetic diamond layer is a {110} or {113} oriented layer.

6. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the non-parallel dislocation array extends over a volume forming at least 40%, 50%, 60%, 70%, 80%, or 90% of a total volume of the single crystal CVD synthetic diamond layer.

7. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the non-parallel dislocation array comprises a first set of dislocations propagating in a first direction through the single crystal CVD synthetic diamond layer and a second set of dislocations propagating in a second direction through the single crystal CVD synthetic diamond layer, and wherein an angle between the first and second directions lies in the range 40° to 100°, 50° to 100°, or 60° to 90° as viewed in an X-ray topographic cross-sectional view or under luminescent conditions.

8. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein a direction in which a dislocation propagates is measured in terms of an average direction over at least 40%, 50%, 60%, 70%, 80%, or 90% of a total length of the dislocation and/or at least 50 μm, 100 μm, 250 μm, 500 μm, 1000 μm, 1500 μm, or 2000 μm.

9. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein at least 30%, 40%, 50%, 70%, 80%, or 90% of a total number of visible dislocations within a volume of the single crystal CVD synthetic diamond layer form the non-parallel dislocation array as viewed in an X-ray topographic cross-sectional view or under luminescent conditions, said volume forming at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total volume of the single crystal CVD synthetic diamond layer.

10. A single crystal CVD synthetic diamond layer according to any preceding claim, wherein the non-parallel dislocation array as viewable in an X-ray topographic cross-sectional view but not under luminescent conditions or alternatively the non-parallel dislocation array as viewable under luminescent conditions but not in an X-ray topographic cross-sectional view.

11. A single crystal CVD synthetic diamond material layer according to any preceding claim, comprising a hardness of at least 100 GPa or at least 120 GPa.

12. A single crystal CVD synthetic diamond object comprising a single crystal diamond layer according to any preceding claim, wherein the single crystal diamond

layer forms at least 30%, 40%, 50%, 60%, 70%, 80%, or 90% of a total volume of the single crystal CVD synthetic diamond object.

13. Use of a single crystal CVD synthetic diamond object according to claim 12 in an optical, mechanical, luminescent, and/or electronic device or application.

14. A single crystal CVD synthetic diamond object according to claim 12, wherein the single crystal CVD synthetic diamond object is cut into a gemstone configuration.