CLAIMS

1. A method of manufacturing lab grown diamond including single crystal diamond (SCD) material by plasma enhanced chemical vapour deposition (PECVD), which comprises:

providing a chamber,

providing within the chamber a substrate holder having a recessed pocket,

placing within the pocket a single crystal diamond substrate to act as a seed, and

establishing within the chamber a plasma containing carbon species, by introducing process gases into the chamber and heating the gases by electrically generated energy, to cause carbon to be deposited as a single crystal diamond (SCD) on the substrate to form a lab grown diamond and in polycrystalline diamond (PCD) form on the substrate holder,

characterised by

setting the relative rate of growth of the single crystal diamond on the substrate and the polycrystalline diamond on the surface of the holder, by control of at least one of (i) the applied energy, (ii) cooling of the substrate holder and (iii) the chemical composition of the process gases, such that the single crystal diamond grown on the substrate protrudes out of the recessed pocket in the holder, and the polycrystalline diamond layer is grown on the surrounding surface of the holder at such a rate as to lie, at all times, at a height above the surface of the recessed pocket in the holder that is higher than the surface of the single crystal diamond, whereby lateral growth of the single crystal diamond is constrained by a polycrystalline diamond layer that entirely surrounds lateral faces of the growing diamond to cause a reduction in a cross sectional area of a part of the single crystal diamond protruding out of the recessed pocket with increasing distance from the holder.

2. A method as claimed in claim 1, wherein the constraining of the lateral growth of the single crystal diamond is such that the height of the synthesised single crystal diamond, as measured from the substrate, is between 40% and 80%, or preferably 60%, of the maximum width of the substrate.

3. A method as claimed in any one of claim 1 to claim 2, wherein the energy is applied in the form of electromagnetic (EM) energy at a frequency in the microwave range, *i.e.* having a wavelength between 1mm and 1m.

4. A PECVD apparatus for manufacturing a lab grown diamond including single crystal diamond (SCD) material via chemical vapour deposition, the apparatus comprising:

a. a microwave generator configured to generate microwaves at a frequency ***f***;

b. a plasma chamber comprising a base, a top plate, and a side wall extending from said base to said top plate defining a resonance cavity for supporting a microwave resonance mode between the base and the top plate;

c. a microwave coupling configuration for introducing microwaves from the microwave generator into the plasma chamber;

d. a gas flow system for feeding process gases into the plasma chamber and removing exhaust gases therefrom, the gas flow system including a gas flow controller for controlling a composition of the process gases;

e. a substrate holder disposed in the plasma chamber and comprising an outer surface and at least one supporting surface for supporting a substrate of single crystal diamond to serve as a seed, the surface supporting the seed being recessed with respect to the outer surface of the holder, forming a recessed pocket;

f. a pressure control system for regulating the pressure within the plasma chamber; and

g. a cooling system for regulating the temperature of the substrate holder;

characterised by a control system for setting a relative rate of growth of the single crystal diamond on the substrate and a polycrystalline diamond (PCD) layer on the surface of the holder, by control of at least one of (i) the applied energy, (ii) cooling of the substrate holder and (iii) the chemical composition of the process gases, such that the single crystal diamond grown on the substrate protrudes out of the recessed pocket in the holder, and the polycrystalline diamond layer is grown on the surrounding surface of the holder at such a rate as to lie, at all times, at a height above the surface of the recessed pocket in the holder that is at least as high as the surface of the single crystal diamond, whereby lateral growth of the single crystal diamond is constrained by a polycrystalline diamond layer that entirely surrounds lateral faces of the growing diamond to cause a reduction in a cross sectional area of a part of the single crystal diamond protruding out of the recessed pocket with increasing distance from the holder.

5. A CVD synthesized lab grown single crystal diamond (SCD) material manufactured according to a method as claimed in any one of claim 1 to claim 3, the SCD material upon completion of chemical vapour deposition having a first shape of which the cross sectional area decreases with increasing distance from a flat base formed by a surface of a seed from which the SCD material is grown and having a truncated surface substantially parallel to the base, or a second shape having the form of a two back-to-back truncated tapered shapes that share a

common base, the seed from which the SCD material is grown forming a flat truncated surface of one of the two truncated tapered shapes.

6. A CVD synthesized lab grown SCD material as claimed in claim 5, wherein the first shape is, or the back-to-back truncated tapered shapes are each, a truncated pyramid having a polygon base and truncated surface.

7. A CVD synthesized lab grown SCD material as claimed in claim 5 or claim 6, wherein the first shape, or at least one of the two truncated tapered shapes, has a height, measured between the base or common base and the truncated surface, the lab grown SCD material having any one, any two, or all three of the following structural features:

a) at least one height is of 1 mm or more, 2 mm or more, or 3 mm or more;

b) at least one height is of 15 mm or less, or 10 mm or less, or 5 mm or less; and

c) at least one height is within the range of 1 mm to 15 mm, 2 mm to 10 mm, or 3 mm to 10 mm.

8. A CVD synthesized lab grown SCD material as claimed in any one of claim 5 to claim 7, the lab grown SCD material having any one, any two, or all three of the following structural features:

a) the base of the first shape or the common base of the two truncated tapered shapes has a surface area of at least $16mm^2$, at least $25mm^2$, or at least $36mm^2$;

b) the base of the first shape or the common base of the two truncated tapered shapes has a surface area of at most $400mm^2$, at most $225mm^2$, or at most $144mm^2$; and

c) the base of the first shape or the common base of the two truncated tapered shapes has a surface area within a range of $16mm^2$ to $400mm^2$, $25mm^2$ to $225mm^2$, $36mm^2$ to $225mm^2$, or $36mm^2$ to $144mm^2$.

9. A CVD synthesized lab grown SCD material as claimed in any one of claim 5 to claim 8, the lab grown SCD material having any one, any two, or all three of the following structural features:

a) at least one truncated surface of the first shape or of the two truncated tapered shapes has a surface area of at least $1mm^2$, at least $4mm^2$, or at least $9mm^2$;

b) at least one truncated surface of the first shape or of the two truncated tapered shapes has a surface area of at most $196mm^2$, at most $64mm^2$, or at most $25mm^2$; and

c) at least one truncated surface of the first shape or of the two truncated tapered shapes has a surface area within a range of 1mm^2 to 196mm^2, 9mm^2 to 196mm^2, or 4mm^2 to 64mm^2.

10. A CVD synthesized lab grown SCD material as claimed in any one of claim 5 to claim 9, the lab grown SCD material having any one, any two, or all three of the following structural features:

a) at least one slope formed between an edge of the base or common base and an edge of the at least one truncated surface forms an acute angle with the base or common base, the acute angle being of 75° or less, 70° or less, or 65° or less, for a first shape or one of the two truncated tapered shapes having a height of 3 mm or more;

b) at least one slope formed between an edge of the base or common base and an edge of the at least one truncated surface forms an acute angle with the base or common base, the acute angle being of 35° or more, 40° or more, or 45° or more, for a first shape or one of the two truncated tapered shapes having a height of 3 mm or more; and

c) at least one slope formed between an edge of the base or common base and an edge of the at least one truncated surface forms an acute angle with the base or common base, the acute angle being in the range of 35° to 75°, or 40° to 75°, or 40° to 70°, for a first shape or one of the two truncated tapered shapes having a height of 3 mm or more.

11. A CVD synthesized lab grown SCD material as claimed in any one of claim 5 to claim 10, wherein the lab grown SCD material has the form of two back to back truncated tapered shapes sharing a common base, a first truncated tapered shape having a first height ***H1*** between the common base and a first proximal truncated surface, and a second truncated tapered shape having a second height ***H2*** between the common base and a second distal truncated surface, wherein ***H1*** << ***H2***, the truncated tapered shapes of the lab grown SCD material having any one, any two, or all three of the following structural features:

a) the height ratio of ***H2*** to ***H1*** is at least 2, at least 2.5, at least 3, at least 3.5, or at least 4;

b) the height ratio of ***H2*** to ***H1*** is at most 15, at least 10, at most 8, or at most 6; and

c) the height ratio of ***H2*** to ***H1*** is within the range of 2 to 15, 2 to 10, or 4 to 10.

12. A CVD synthesized lab grown SCD material as claimed in any one of claim 5 to claim 11, the lab grown SCD material having any one, any two, or any three or more of the following structural features:

a) a polishing efficiency for polishing any cut diamond shape out of the first shape or two truncated tapered shapes maximizing exploitation of a volume of the first shape or two truncated tapered shapes, of 30% or more, 35% or more, 40% or more, or 45% or more;

b) a polishing efficiency for polishing any cut diamond shape out of the first shape or two truncated tapered shapes maximizing exploitation of a volume of the first shape or two truncated tapered shapes of 80% or less, 70% or less, or 60% or less;

c) a polishing efficiency for cutting a round brilliant diamond shape maximizing exploitation of a volume of the first shape or two truncated tapered shapes within the range of 30% to 80%, 35% to 80%, 30% to 70%, 35% to 70%, 30% to 60%, 35% to 60%, or 40% to 60%;

d) the lab grown SCD material has a weight of at least 0.5 carat, at least 0.7 carat, or at least 1.0 carat; and

e) a diamond polished out of the first shape or two truncated tapered shapes meets gem quality standards and is optionally colorless, near colorless, or faintly tinted, the polished diamond having a color grade on a GIA scale of M or better, L or better, or K or better, a better color grade meaning a less tinted, near colorless or colorless polished diamond.

13. A diamond material comprising at least one CVD synthesized lab grown single crystal diamond (SCD) material manufactured by chemical vapour deposition according to a method as claimed in any one of claim 1 to claim 3 on a surface of at least one seed, the SCD material grown on each seed being surrounded by a polycrystalline diamond (PCD) material on all lateral faces, the SCD material grown on each seed having either a first shape of which the cross sectional area decreases with increasing distance from the respective surface of the seed and having a truncated surface substantially parallel to the base, or a second shape formed of two back to back truncated tapered shapes that share a common base, the seed from which the SCD material is grown forming a flat truncated surface of one of the two truncated tapered shapes.

14. A diamond material comprising at least one CVD synthesized lab grown SCD material surrounded by the PCD material as claimed in claim 13, wherein the first shape of the CVD synthesized lab grown SCD material on each seed is, or the back-to-back truncated tapered shapes are each, a truncated pyramid having a polygon base and truncated surface.

15. A diamond material comprising at least one CVD synthesized lab grown SCD material surrounded by the PCD material as claimed in claim 13 or claim 14, wherein the first

shape, or at least one of the two back-to-back truncated tapered shapes, of the CVD synthesized lab grown SCD material on each seed has a height, measured between the base or common base and the truncated surface, the respective lab grown SCD material having any one, any two, or any three or more of the following structural features:

a) at least one height is of 1 mm or more, 2 mm or more, or 3 mm or more;

b) at least one height is of 15 mm or less, or 10 mm or less, or 5 mm or less;

c) at least one height is within the range of 1 mm to 15 mm, 2 mm to 10 mm, or 3 mm to 10 mm;

d) the base of the first shape or the common base of the two truncated tapered shapes has a surface area of at least 16mm^2, at least 25mm^2, or at least 36mm^2;

e) the base of the first shape or the common base of the two truncated tapered shapes has a surface area of at most 400mm^2, at most 225mm^2, or at most 144mm^2;

f) the base of the first shape or the common base of the two truncated tapered shapes has a surface area within a range of 16mm^2 to 400mm^2, 25mm^2 to 225mm^2, 36mm^2 to 225mm^2, or 36mm^2 to 144mm^2;

g) at least one truncated surface of the first shape or of the two truncated tapered shapes has a surface area of at least 1mm^2, at least 4mm^2, or at least 9mm^2;

h) at least one truncated surface of the first shape or of the two truncated tapered shapes has a surface area of at most 196mm^2, at most 64mm^2, or at most 25mm^2;

i) at least one truncated surface of the first shape or of the two truncated tapered shapes has a surface area within a range of 1mm^2 to 196mm^2, 9mm^2 to 196mm^2, or 4mm^2 to 64mm^2;

j) at least one slope formed between an edge of the base or common base and an edge of the at least one truncated surface forms an acute angle with the base or common base, the acute angle being of 75° or less, 70° or less, or 65° or less, for a first shape or one of the two truncated tapered shapes having a height of 3 mm or more;

k) at least one slope formed between an edge of the base or common base and an edge of the at least one truncated surface forms an acute angle with the base or common base, the acute angle being of 35° or more, 40° or more, or 45° or more, for a first shape or one of the two truncated tapered shapes having a height of 3 mm or more; and

l) at least one slope formed between an edge of the base or common base and an edge of the at least one truncated surface forms an acute angle with the base or common base, the acute

angle being in the range of 35° to 75°, or 40° to 75°, or 40° to 70°, for a first shape or one of the two truncated tapered shapes having a height of 3 mm or more.

16. A diamond material comprising at least one CVD synthesized lab grown SCD material surrounded by the PCD material as claimed in any one of claim 13 to claim 15, wherein the lab grown SCD material of the at least one CVD synthesized lab grown SCD material has the form of two back-to-back truncated tapered shapes sharing a common base, a first truncated tapered shape having a first height ***H1*** between the common base and a first proximal truncated surface, and a second truncated tapered shape having a second height ***H2*** between the common base and a second distal truncated surface, wherein ***H1*** << ***H2***, the truncated tapered shapes of the lab grown SCD material having any one, any two, or all three of the following structural features:

a) the height ratio of ***H2*** to ***H1*** is at least 2, at least 2.5, at least 3, at least 3.5, or at least 4;

b) the height ratio of ***H2*** to ***H1*** is at most 15, at least 10, at most 8, or at most 6; and

c) the height ratio of ***H2*** to ***H1*** is within the range of 2 to 15, 2 to 10, or 4 to 10.