Claims

1. A method for manufacturing a plurality of synthetic single crystal diamonds, the method comprising:

forming a plurality of seed pads, each seed pad comprising a plurality of single crystal diamond seeds anchored to, or embedded in, an inert holder;

loading a carbon source, a metal catalyst, and the plurality of seed pads into a capsule, wherein at least a portion of the carbon source is located less than 0.1 mm from the single crystal diamond seeds;

loading the capsule into a high pressure high temperature (HPHT) press; and

subjecting the capsule to a HPHT growth cycle to grow single crystal diamond material on the plurality of single crystal diamond seeds, the HPHT growth cycle comprising:

initiating HPHT growth of single crystal diamond material on the plurality of single crystal diamond seeds by increasing pressure and temperature;

maintaining HPHT growth of single crystal diamond material on the plurality of single crystal diamond seeds via a pressure driven growth process by controlling and maintaining pressure and temperature; and

terminating HPHT growth of single crystal diamond material on the plurality of single crystal diamond seeds by reducing pressure and temperature,

wherein the plurality of single crystal diamond seeds remain anchored to, or embedded in, the inert holders during the HPHT growth cycle.

2. A method according to claim 1, wherein each seed pad comprises a number of single crystal diamond seeds in a range 8 to 3000, 30 to 1500, 50 to 800, or 80 to 650, and/or wherein each seed pad comprises a density of single crystal diamond seeds in a range 0.3 to 45, 0.5 to 30, 0.8 to 20, or 1.0 to 10 seeds cm^{-2}.

3. A method according to any preceding claim, wherein the capsule comprises a number of seed pads in a range 4 to 30, 4 to 20, 6 to 15, or 8 to 10.

4. A method according to any preceding claim, wherein the seeds pads are spaced apart within the capsule such that a distance between the seeds pads is selected to be in a range 1 to 10, 1.2 to 5.0, 1.2 to 3.0, or 1.2 to 2.0 times a height of the single crystal diamond material after

terminating HPHT growth, and /or wherein the seeds pads are spaced apart within the capsule such that a distance between the seeds pads is selected to be in a range 1.0 to 12 mm, 1.5 to 10 mm, 2.0 to 8 mm, 2.5 to 7.0 mm, or 3.0 to 6.0 mm.

5. A method according to any preceding claim, further comprising:

mixing the carbon source with the metal catalyst to form a reaction mixture prior to loading the reaction mixture and the plurality of seed pads into the capsule to form alternating layers of reaction mixture and seed pads.

6. A method according to claim 5, wherein the carbon source material has a total impurity level no more than 0.1%, 0.05%, 0.02%, 0.015%, 0.01%, or 0.005% by weight.

7. A method according to any one of claims 5 or 6, wherein the carbon source material has a surface area per gram in a range 0.001 m^2/g to 10 m^2/g, 0.01 m^2/g to 4 m^2/g or 0.05 m^2/g to 1.9 m^2/g

8. A method according to any one of claims 5 to 7, wherein the reaction mixture comprises graphite in an amount in a range 5% to 60%, 9% to 50%, 14% to 40%, 16% to 35%, 18% to 30%, or 20% to 30% by weight prior to the HPHT growth cycle.

9. A method according to any one of claims 5 to 8, wherein the reaction mixture comprises powdered metal catalyst in an amount in the range 40% to 95%, 60% to 90%, 65% to 85%, or 70% to 80% by weight prior to the HPHT growth cycle.

10. A method according to any preceding claim, wherein the initiating step comprises raising the pressure to a target starting value P_s which is below the Berman-Simon graphite/diamond thermodynamic phase stability line, raising the temperature to a value T_g which exceeds a eutectic temperature for the carbon source and the metal catalyst, holding the temperature and pressure for a time t, and then raising the pressure to a target starting value P_g for the maintaining step to initiate HPHT growth.

11. A method according to claim 10, wherein the time t is in a range 1 to 36000 seconds, 20 to 24000 seconds, 40 to 15000 seconds, or 60 to 11000 seconds.

12. A method according to claim 10 or 11, wherein the temperature T_g is in a range 1070 Kelvin to 2470 Kelvin, 1370 Kelvin to 1970 Kelvin, 1520 Kelvin to 1770 Kelvin, or 1570 Kelvin to 1670 Kelvin.

13. A method according to any one of claims 10 to 12, wherein the pressure P_s is within 0.01 to 2.0 GPa, 0.05 to 1.5 GPa, 0.1 to 1 GPa, or 0.2 to 0.5 GPa of pressure P_g.

14. A method according to any one of claims 10 to 13, wherein the pressure P_g is in a range 4.0 to 8.0 GPa, 4.5 to 7.0 GPa, 5.0 to 6.0 GPa, or 5.2 to 5.7 GPa.

15. A method according to any one of claims 10 to 14, wherein the pressure is raised from P_s to P_g at a rate in a range 0.001 to 1.0 GPa per minute, 0.01 to 0.8 GPa per minute, 0.01 to 0.5 GPa per minute, or 0.05 to 0.3 GPa per minute.

16. A method according to any preceding claim, wherein, during the maintain step, a temperature difference between a top side and a bottom side of the capsule is maintained to be no more than 100 Kelvin, 75 Kelvin, 50 Kelvin, 30 Kelvin, 20 Kelvin, 10 Kelvin, 5 Kelvin, or 1 Kelvin.

17. A method according to any preceding claim, wherein, during the maintain step, a temperature gradient between a top side and a bottom side of the capsule is maintained to be no more than 0.66 Kelvin mm^{-1}, 0.50 Kelvin mm^{-1}, 0.33 Kelvin mm^{-1}, 0.20 Kelvin mm^{-1}, 0.13 Kelvin mm^{-1}, 0.07 Kelvin mm^{-1}, 0.03 Kelvin mm^{-1}, or 0.01 Kelvin mm^{-1}.

18. A method according to any preceding claim, wherein during the maintaining step the press moves anvils inwards whereby a volume of the capsule reduces by an amount in a range 0.5% to 50%, 0.5% to 30%, 1.0% to 25%, 2.0% to 20%, or 5% to 15%, and/or wherein during the maintaining step the press moves anvils inwards by a combined distance in the range 1 mm to 100 mm, 5 mm to 75 mm, 10 mm to 60 mm, 20 mm to 50 mm, or 20 mm to 40 mm.

19. A method according to any preceding claim, wherein during the maintaining step the temperature is decreased in a continuous or stepwise manner while maintaining growth of single crystal diamond material on the plurality of single crystal diamond seeds.

20. A method according to claim 19, wherein the temperature is decreased at a rate in a range 0.1 Kelvin/hour to 2 Kelvin/hour, 0.3 Kelvin/hour to 1.5 Kelvin/hour or 0.5 Kelvin/hour to 0.75 Kelvin/hour.

21. An apparatus configured to perform the method according to any preceding claim, the apparatus comprising:

a capsule comprising a plurality of seed pads and reactants including a carbon source and a metal catalyst, wherein the reactants and seed pads are provided in alternating layers, ~~and~~ wherein each seed pad comprises a plurality of single crystal diamond seeds anchored to, or embedded in, an inert holder, and wherein at least a portion of the carbon source is located less than 0.1 mm from the single crystal diamond seeds; and

a HPHT press comprising a heating circuit configured to maintain a substantially uniform temperature throughout the capsule ~~whereby diamond growth on the single crystal seeds is achieved via a pressure driven growth process~~.