

Claims

1. A coated substrate with a multi-layer coating, the coated substrate comprising in order:
- 5 (a) the substrate;
- (b) a thermally insulating layer;
- (c) an interfacial layer; and
- (d) one or more layers comprising ta-C;
- wherein the interfacial layer promotes adhesion of the one or more layers comprising
- 10 ta-C to the thermally insulating layer.
2. A coated substrate according to claim 1, further comprising between the substrate and the thermally insulating layer a seed layer for promoting adhesion of the thermally insulating layer to the substrate.
- 15 3. A coated substrate according to claim 1 or 2, wherein the one or more (d) layers consist of ta-C.
4. A coated substrate according to any preceding claim, wherein the thermally
- 20 insulating layer comprises a non-metallic material.
5. A coated substrate according to any preceding claim, wherein the thermally insulating layer comprises Si, Si₃N₄, SiO₂, Al₂O₃, AlN, TiSi₂, CrSi or TiAlN.
- 25 6. A coated substrate according to any preceding claim, wherein the thermally insulating layer comprises Si₃N₄, AlN or TiAlN.
7. A coated substrate according to any one of claims 1 to 3 wherein the thermally insulating layer comprises silicon or a silicon-containing material.
- 30 8. A coated substrate according to claim 7 wherein the thermally insulating layer comprises Si₃N₄.

9. A coated substrate according to any preceding claim, wherein the thermally insulating layer has a thickness of from 0.2 μ m to 1 μ m.
10. A coated substrate according to any preceding claim, wherein the interfacial layer comprises a chemical element which is present in the thermally insulating layer.
11. A coated substrate according to any preceding claim, wherein the thermally insulating layer comprises silicon (for example, Si₃N₄) and the interfacial layer comprises SiC.
12. A coated substrate according to any preceding claim, wherein the thermal conductivity of the thermally insulating layer is 10 W/(m,K) or less when measured at a temperature of 25°C.
13. A coated substrate according to any preceding claim, wherein the thermal conductivity of the thermally insulating layer is 1.0 W/(m,K) or less when measured at a temperature of 25°C.
14. A substrate coated with a multi-layer coating, comprising in order:
- the substrate;
 - an interfacial layer;
 - one or more layers comprising ta-C; and, optionally, a seed layer between the interfacial layer and the substrate,
- wherein the interfacial layer promotes adhesion of the one or more layers comprising ta-C to the substrate or if a seed layer is present promotes adhesion of the one or more layers comprising ta-C to the seed layer.
15. A coated substrate according to any preceding claim wherein the interfacial layer comprises a carbide (e.g. SiC).
16. A coated substrate according to any preceding claim, wherein the interfacial layer comprises SiC, WC, TiC or mixtures thereof.

17. A coated substrate according to any preceding claim, further comprising a seed layer, wherein the seed layer comprises SiN, SiC, WC, TiSi, CrSi or AlN.
18. A coated substrate according to any preceding claim, comprising a seed layer
5 that comprises a carbide (e.g. SiC).
19. A coated substrate according to any preceding claim, wherein the substrate is graphite and the seed layer is SiC.
- 10 20. A coated substrate according to any preceding claim, wherein the one or more layers comprising ta-C have a total thickness of from 0.1µm to 1µm.
21. A coated substrate according to any preceding claim, wherein the one or more layers comprising ta-C have a total thickness of from 0.1µm to 0.3µm.
- 15 22. A coated substrate according to any preceding claim, wherein the interfacial layer has a thickness of from 0.05µm to 0.3µm.
23. A coated substrate according to any preceding claim, wherein the interfacial
20 layer has a thickness of from 0.1µm to 0.3µm.
24. A coated substrate according to any preceding claim, wherein the total thickness of the coating is from 1µm to 5µm.
- 25 25. A coated substrate according to any preceding claim, wherein the total thickness of the coating is from 1µm to 2µm.
26. A coated substrate according to any preceding claim, wherein the substrate is comprises graphite.
- 30 27. A coated substrate according to claim 26, wherein the graphite substrate is graphitised with an organic sealant.

28. A coated substrate according to any preceding claim, wherein the coating has a hardness of at least 2000HV.
29. A coated substrate according to any preceding claim, wherein the coating has
5 a hardness of at least 2500HV.
30. A coated substrate according to any preceding claim, wherein there are two or more layers comprising ta-C.
- 10 31. A coated substrate according to claim 30, wherein the hardness of each layer comprising ta-C increases from the layer comprising ta-C adjacent the interfacial layer to the outermost layer of ta-C.
32. A coated substrate according to claim 30 or claim 31, wherein the layer
15 comprising ta-C adjacent the interfacial layer has a hardness of 1200HV or more.
33. A coated substrate according to any preceding claim, wherein the interfacial layer has a Young's modulus and/or hardness value which is intermediate between those of the thermally insulating layer and the first layer comprising ta-C.
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34. A coated substrate according to any preceding claim, wherein the Young's modulus and/or hardness remain the same or increase from the layer comprising ta-C adjacent the interfacial layer to the uppermost ta-C layer.
- 25 35. A coated substrate according to any preceding claim, wherein the Young's modulus and/or hardness increase from the layer comprising ta-C adjacent the interfacial layer to the uppermost ta-C layer.
36. A substrate coated with a multi-layer coating according to any preceding claim,
30 wherein:
(a) the substrate is graphite sealed with an organic sealant;
(ai) the seed layer comprises SiC and has a thickness of from 0.1µm to 0.2µm;
(b) the thermally insulating layer comprises Si₃N₄ and has a thickness of from 0.4µm to 0.6µm;

- (c) the interfacial layer comprises SiC and has a thickness of from 0.1µm to 0.2µm; and
- (d) the one or more layers comprising ta-C have a thickness of 0.1µm to 0.2µm.

5 37. A substrate coated with a multi-layer coating according to any of claims 1 to 35, wherein:

- (a) the substrate is SiO₂ coated ceramic (optionally further coated with SiC);
- (a(i)) optionally, there is a seed layer that consists of SiC and has a thickness of from 0.4µm to 0.8µm;
- 10 (b) the thermally insulating layer consists of Si₃N₄ and has a thickness of from 0.4µm to 0.8µm;
- (c) the interfacial layer consists of SiC and has a thickness of from 0.4µm to 0.8µm; and
- (d) the one or more layers consisting of ta-C have a thickness of 0.4µm to 0.8µm.

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38. A substrate coated with a multi-layer coating according to any of claims 1 to 35, wherein:

- (a) the substrate is graphite;
- (b) the seed / interfacial layer consists of SiC and has a thickness of from 0.3µm to 0.5µm;
- 20 (c) the first ta-C layer consists of ta-C and has a thickness of from 0.3µm to 0.5µm; and
- (d) the second ta-C layer consists of ta-C and has a thickness of from 0.2µm to 0.4µm.

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39. A method of making a coated substrate according to any preceding claim, comprising depositing onto the substrate a coating comprising in order:

- (a) a thermally insulating layer;
- (b) an interfacial layer; and
- 30 (c) one or more layers comprising ta-C;

wherein the interfacial layer promotes adhesion of the one or more layers comprising ta-C to the thermally insulating layer.

40. A method of making a coated substrate according to any of claims 1 to 38, comprising depositing onto the substrate a coating comprising in order
- (a) an interfacial layer; and
 - (b) one or more layers comprising ta-C; and, optionally, a seed layer between the
- 5 interfacial layer and the substrate,
- wherein the interfacial layer promotes adhesion of the one or more layers comprising ta-C to the substrate or if a seed layer is present promotes adhesion of the one or more layers comprising ta-C to the seed layer.