Claims

1. A coated substrate with a multi-layer coating, the coated substrate comprising in order:

(a) the substrate;

(a-i) a seed layer comprising SiC;

(b) a thermally insulating layer comprising Si_3N_4;

(c) an interfacial layer comprising SiC; and

(d) 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.

~~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, optionally wherein the seed layer comprises SiN, SiC, WC, TiSi, CrSi, AlN or a carbide (e.g. SiC).~~

2~~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 insulating layer comprises Si, Si_3N_4, SiO_2, Al_2O_3, AlN, $TiSi_2$, CrSi or TiAlN.~~

~~5. A coated substrate according to any one of claims 1 to 3 wherein the thermally insulating layer comprises silicon or a silicon-containing material (e.g. Si_3N_4).~~

3~~6~~. A coated substrate according to any preceding claim, wherein the thermally insulating layer has a thickness of from 0.2µm to 1µm.

4. A coated substrate according to any preceding claim, wherein the seed layer has a thickness of from 0.05µm to 1µm.

5. A coated substrate according to any preceding claim, wherein the interfacial layer has a thickness of from 0.05µm to 0.3µm.

~~7. A coated substrate according to any preceding claim, wherein the interfacial layer comprises a chemical element which is present in the thermally insulating layer.~~

~~8. A coated substrate according to any preceding claim, wherein the thermally insulating layer comprises silicon (for example, Si_3N_4) and the interfacial layer comprises SiC.~~

~~9. A substrate coated with a multi-layer coating, comprising in order:~~
~~(a) the substrate;~~
~~(b) an interfacial layer;~~
~~(c) 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.~~

~~10. A coated substrate according to any preceding claim wherein the interfacial layer comprises a carbide (e.g. SiC, WC, TiC or mixtures thereof).~~

~~11. A coated substrate according to any preceding claim, wherein the substrate is graphite and the seed layer is SiC.~~

6~~12~~. 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.

7~~13~~. A coated substrate according to any preceding claim, wherein the total thickness of the coating is from 1µm to 5µm.

8~~14~~. A coated substrate according to any preceding claim, wherein the substrate comprises graphite.

9. A coated substrate according to any of claims 1-7, wherein the substrate is a SiO_2-coated ceramic material.

10~~15~~. A coated substrate according to any preceding claim, wherein the coating has a hardness of at least 2000HV.

11~~16~~. A coated substrate according to any preceding claim, wherein there are two or more layers comprising ta-C, optionally 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.

12~~7~~. A substrate coated with a multi-layer coating according to any ~~preceding~~ of claims 1 to 8 and 10 to 11, wherein:

(a) the substrate is graphite sealed with an organic sealant;

(ai) the seed layer comprising~~es~~ SiC ~~and~~ has a thickness of from 0.1µm to 0.2µm;

(b) the thermally insulating layer comprising~~es~~ Si_3N_4 ~~and~~ has a thickness of from 0.4µm to 0.6µm;

(c) the interfacial layer comprising~~es~~ 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.

13~~8~~. A substrate coated with a multi-layer coating according to any of claims 1 to 7 and 9 to 11~~16~~, wherein:

(a) the substrate is SiO_2 coated ceramic (optionally further coated with SiC);

(a(i)) ~~optionally, there is a~~ the seed layer that consists of SiC and has a thickness of from 0.4µm to 0.8µm;

(b) the thermally insulating layer consists of Si_3N_4 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.

14~~9~~. A substrate coated with a multi-layer coating according to any of claims 1 to 8 and 10 to 11~~16~~, 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;

(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.

15~~20~~. A method of making a coated substrate according to any preceding claim, comprising depositing onto the substrate a coating comprising in order:

(a-i) a seed layer comprising SiC;

(a) a thermally insulating layer comprising Si_3N_4;

(b) an interfacial layer comprising SiC; and

(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.