A METHOD FOR RAPID DEPOSITION OF A COATING ON A SUBSTRATE

Technical Field

The present invention generally relates t to a method of rapidly depositing a coating on a substrate.

Background

Vapor deposition technology is typically used to form thin film deposition layers in various types of applications, including microelectronic applications and plastic coating applications. In one application, vapor deposition of metallic compounds on the surfaces of glass, ceramic, metal or plastic substrates is a commonly employed technology in the field of microelectronic systems, for example in Micro-Electro-Mechanical Systems (MEMS). The common forms of metallic compounds deposited include soft metals such as aluminum (Al), zinc (Zn), tin (Sn) and alloys thereof. In another application, vapor deposition is used to form uniform, thin metal coatings on the covers of devices such as mobile phones, PDAs and hand-held gaming consoles.

Such deposition technology can be classified in two main categories. A first category of such deposition technology is known as Chemical Vapor Deposition (CVD). CVD generally refers to deposition processes occurring due to a chemical reaction. Common examples of CVD processes include electro-deposition, epitaxy and thermal oxidation. The underlying concept behind CVD lies in the creation of solid materials as a result of direct chemical reactions occurring in the CVD environment. The reactions are typically between gaseous reactants and the

solid products thus formed are slowly deposited and built up on the surface of a substrate for a pre-determined amount of time to control the thickness of said deposition.

A second category of deposition is commonly known as Physical Vapor Deposition (PVD). PVD generally refers to the deposition of solid substances occurring as a result of a physical process. The main concept underlying the PVD processes is that the deposited material is physically transferred onto the substrate surface via direct mass transfer. No chemical reaction takes place during the process, and the thickness of the deposited layer is independent of chemical reaction kinetics as opposed to CVD processes.

(1) Sputtering is a known technique for depositing metallic compounds on a substrate, wherein atoms, ions or molecules are ejected from a target material (also called the sputter target) by particle bombardment so that the ejected atoms or molecules accumulate on a substrate surface as a thin film. Sputtering has become one of the most widely used techniques for depositing various metallic films on wafers. Sputtering, however, is a relatively low energy deposition process and results in non-uniform deposition of the ejected particles, thereby causing void formation within the deposited layers. Consequently, the deposited material suffers from inferior adhesion to substrate surfaces, low density and reduced strength. While this problem can be slightly ameliorated by operating the sputtering process at an elevated temperature (e.g. operating

temperatures of 300°C to 700°C),, this results in high energy costs and renders the deposition process unsuitable for heat sensitive substrates such as plastic substrates;

(2) Poor adhesion between the deposited layer and the substrate surface, leading to "chipping" problems in the finished product; and

(3) Sputtering has a greater tendency to introduce impurities in the substrate.

A particular problem with sputtering is that, to avoid the formation of voids, relatively high temperatures are employed which precludes, or at least makes undesirable, the use of plastic substrates in sputtering as plastic deformation occurs. Consequently, while PVD by sputtering may be relatively faster as compared to other PVD processes, is not suitable for use in the deposition of metals and metal compounds onto plastic substrates for generating an image, for the reasons disclosed above.

Another problem associated with forming metal layers on plastic substrates is that the metals deposited on the substrate need to be deposited at a relatively low temperature, otherwise the plastic substrate will melt or deform in shape. Accordingly, in PVD methods, most of the metals and alloys employed have relatively low temperatures and are relatively "soft metals". Examples of relatively soft metals include such metals as aluminum (Al), Zinc(Zn), Tin (Sn) and copper (Cu). A particular problem with soft metals is that they tend to be readily subject to scratching and deformation when impacted with hard surfaces. Such surface scratching and deformation

degrades the overall aesthetics of the metal layer deposited on the plastic substrate. This imparts significant limitations on the deposition of harder metals on plastic substrates, which may be less readily subject to scratching.

There is a need to provide a process for rapidly depositing a coating on a substrate that does not suffer from the disadvantages listed above.

There is a need to provide a method which allows hard material layers, such as hard metals, to be rapidly deposited on a plastic substrate without degradation of the plastic.

Summary

According to one aspect, there is provided a process of depositing a coating on a substrate, the method comprising the steps of:

a) depositing material on a substrate by performing a cathodic vacuum arc (CVA) deposition step; and

b) depositing material on a substrate by performing at least one of a chemical vapor deposition (CVD) step and a physical deposition (PVD) step that excludes CVA deposition, wherein the thickness of the material deposited in step (b) is greater than the thickness of material deposited in step (a).

The CVA process in step (a) of the above process may be a filtered cathodic vacuum arc (FCVA) deposition step. The PVD process in step (b) of the above process may be a sputtering step. The PVD process in step (b) may deposit

material at a faster rate than the FCVA process in step (a).

The process may further comprise the step of alternating steps (a) and (b) to form subsequent layers of material. The material may be a hard metal, a hard metal compound and carbon and carbon derivatives. The hard metal compounds may be selected from a list comprising of hard metal oxides, hard metal carbides, hard metal carbonitrides, hard metal silicides and hard metal borides.

The process may comprise depositing a first layer of material directly on the substrate by performing a FCVA deposition step. Advantageously, the first FCVA layer has good adhesion to the substrate and can be applied at low temperatures (ie less than 200 degrees centigrade, typically about 50 to 150 degrees centigrade) which is particular advantageous for substrates which may be of a heat sensitive material, such as plastic. Furthermore, the sputtered layer is applied very quickly and hence, the combination of depositing FCVA and sputtered layers results in a rapidly applied coating which overcomes the problems associated with coatings applied by sputtering only or any other PVD or CVD process in which the coating is not hard or which is not dense. Hence, the method provides a hard and dense coating which can be rapidly applied to a substrate surface.

In one embodiment, there is provided a process of depositing a coating on a substrate, the process comprising the steps of:

c) depositing a first layer of hard material on a substrate by performing a filtered vacuum cathodic arc deposition step; and

d) depositing a second layer of hard material on a substrate by performing a sputtering step.

In another embodiment, there is provided a process of depositing a coating of hard metal on a substrate, the process comprising the steps of:

e) depositing a first layer of hard metal on a substrate by performing a filtered vacuum cathodic arc deposition step;

f) depositing a second layer of hard metal on the first hard metal layer by performing a sputtering step; and

g) optionally repeating alternating steps (e) and (f) to form subsequent hard metal layers. Advantageously, the resulting metallic coating therefore comprises of hard metal layers that are wear resistant and do not deform or chip off easily under external impact.

The FCVA deposition step may also include applying a negative voltage pulse to a conductive substrate, e.g. metallic substrates. The negative voltage pulse may be from about -1800 V to about -4500V, having a frequency of about 1 kHz to about 50 kHz for a pulse duration ranging from about 1 μs to about 50 μs.

The layer of material deposited by each FCVA cycle may have a thickness ranging from about 0.01 microns to about 0.2 microns.

The layer of material deposited by each sputtering cycle may have a thickness ranging from about 0.1 microns to about 0.5 microns.

According to another aspect, there is provided a coating having at least one layer deposited by filtered vacuum cathodic arc deposition and another layer deposited by sputtering.

According to another aspect, there is provided a substrate having a coating having at least one layer deposited by filtered vacuum cathodic arc deposition and another layer deposited by sputtering.

The coating may be comprised of one or more nanofilm material layers.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term "hard material" as used herein refers to a material such as a pure hard metal, hard metal compound or diamond-like carbon, which has as a characteristic of great hardness and a high resistance to wear. The term encompasses materials having a Vickers hardness of more than 500 kg/mm^2, typically more than 800 kg/mm^2 or more than 900 kg/mm^2 or more than 1,000 kg/mm^2, for a given Vickers load of 50 mg.

The term "hard metal" as used herein refers to a metal, generally a metal such as Cr, Ti or W, which has a relatively high hardness and resistance to wear compared to a soft metal such as Al or Zn, and characterized in having a Vickers hardness of at least 500 kg/mm^2 for a given Vickers load of 50 milligrams. It should be realized that the more than one type of metal may be encompassed by the term, that is, the term also encompasses hard metal alloys.

The term "hard metal compound" means oxides, carbides, nitrides, carbonitrides, silicides and borides of a hard metal as defined above, and mixtures thereof which have a Vickers hardness of 1,000 kg/mm^2, for a given Vickers load of 50 milligrams.

The term "soft material" as used herein refers to a material such as a pure soft metal, metal compound or amorphous carbon such as graphite, which has as a characteristic of low hardness. The term encompasses materials having a Vickers hardness of less than 500 kg/mm^2 for a given Vickers load of 50 mg.

The term "soft metal" as used herein refers to a metal, generally a metal such as Al or Zn, which has a relatively low hardness and resistance to wear compared to a hard metal such as Cr, Ti or W, and characterized in having a Vickers hardness of less than 500 kg/mm^2 for a given Vickers load of 50 milligrams. It should be realized that the more than one type of metal may be encompassed by the term, that is, the term also encompasses soft metal alloys.

The term "soft metal compound" means oxides, carbides, nitrides, carbonitrides, silicides and borides of a hard metal as defined above, and mixtures thereof which have a Vickers hardness of less than 500 kg/mm^2, for a given Vickers load of 50 milligrams.

The term "diamond-like carbon" and abbreviation thereof, "DLC", as used herein relates to hard carbon that is chemically similar to diamond, but with the absence of a well-defined crystal structure. Diamond-like carbon are mostly metastable amorphous material but can include a microcrystalline phase. Examples of diamond

like carbon include amorphous diamond (a-D), amorphous carbon (a-C), tetrahedral amorphous carbon (ta-C) and diamond-like hydrocarbon and the like. Ta-C is the most preferred diamond like carbon.

The term "nanofilm" refers to a film having a thickness dimension in the nano-sized range of about 1 nm to less than about 1 micron.

The term "microfilm" refers to a film having a thickness dimension in the micro-sized range of about 1 micron to about 10 micron. It should be realized that a microfilm may be comprised of multiple nanofilm layers.

The term "Filtered Cathodic Vacuum Arc" and abbreviation thereof "FCVA" are to be used interchangeably. A method for performing FCVA deposition is disclosed in International patent publication number WO 96/26531, which is incorporated herein in its entirety for reference. The plasma generated in a cathodic arc beam are "filtered" in that they are substantially free of macroparticles.

The term "macroparticles" refers to, in the context of this specification, contaminant particles in a cathodic arc beam. The macroparticles typically have a neutral charge and are large relative to the ions and/or atoms of the plasma. More typically, they are particles that are multi-atom clusters and are visible under an optical microscope in a deposited film using cathodic arc methods.

The term "sputtering" or "sputter deposition" describes a mechanism in which atoms are ejected from a surface of a target material upon being hit by sufficiently energetic particles. Exemplary sputtering

deposition is taught by, for example, U.S. Pat. No. 4,361,472 (Morrison, Jr.) and U.S. Pat. No. 4,963,524 (Yamazaki).

The word "substantially" does not exclude "completely" e.g. a composition which is "substantially free" from Y may be completely free from Y. Where necessary, the word "substantially" may be omitted from the definition of the invention.

Unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, unrecited elements.

As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have

specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Disclosure of Optional Embodiments

Exemplary, non-limiting embodiments of a process for rapidly depositing a coating on a substrate will now be disclosed.

The substrate may be a plastic substrate, a glass substrate, a ceramic substrate or a metallic substrate.

The PVD process may comprise of ion plating, thermal evaporation, sputtering, cathodic arc vapor (CAV) deposition and filtered vacuum cathodic arc (FCVA) deposition.

The PVD process may further comprise employing said sputtering and said FCVA deposition processes in alternation, in succession or a combination of both to form a coating comprised of multiple layers formed by sputtering and PVD. The PVD process may also include other suitable forms of chemical or physical vapor deposition methods, to be used in combination with the FCVA and sputtering processes.

The deposited patterned layer may comprise of alternating layers of metal or metal compounds such as metal carbides, metal nitrides, metal silicides, metal borides or combinations thereof, deposited via either sputtering or FCVA respectively.

The deposited patterned layer may be comprised of a repeating layer, wherein the repeating layer may be comprised of a first layer of material deposited via sputtering and a second layer of material deposited via FCVA. The repeating layer may also comprise of more than 2 layers. The repeating layer may be duplicated as desired to achieve a target thickness required, resulting in a multi-layered arrangement.

The ions/atoms may be positively charged ions(cations)/atoms of elements chosen from the group consisting of: Scandium (Sc), Titanium (Ti), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni), Yttrium (Y), Zirconium (Zr), Niobium (Nb), Molybdenum (Mo), Technetium (Tc), Rubidium (Ru), Rhodium (Rh), Palladium (Pd), Silver (Ag), Cadmium (Cd), Hafnium (Hf), Tantalum (Ta), Tungsten (W), Rhenium (Re), Osmium (Os), Iridium (Ir), Platinum (Pt), Gold (Au), Mercury (Hg), Rutherfordium (Rf), Dubnium (Db), Seaborgium (Sg), Bohrium (Bh), Hassium (Hs) and Meitnerium (Mt). The ions/atoms may also be positively charged ions(cations)/atoms of elements chosen from the group consisting of: Aluminium (Al), Zinc (Al), Copper (Cu), Lead (Pb), Tin (Sb), Gold (Au), Silver (Ag), Magnesium (Mg), Antimony (Sb), Cadmium (Cd), Thallium (Tl), Bismuth (Bi), Indium (In), Gallium (Ga), Mercury (Hg), Manganese (Mn)and alloys thereof.

The deposited material may have a Vickers hardness ranging from about 500 kg/mm^2 to about 2000 kg/mm^2, from about 500 to about 1800 kg/mm^2, from about 500 to about 1,500 kg/mm^2, from about 500 to about 1300 kg/mm^2, from about 500 to 1100 kg/mm^2, from about 500 to about 1000

kg/mm^2, from about 500 to about 900 kg/mm^2, from about 500 to about 800 kg/mm^2, for a Vickers load of 50 milligrams. Advantageously, the disclosed deposited material may have a Vickers hardness of at least about 1000 kg/mm^2, conferring the deposited material with wear resistance and durability.

The deposited material may be a hard metal compound. The hard metal compound may be comprised of oxides, carbides, nitrides, carbonitrides, silicides and borides of hard metals, and/or composite mixtures thereof which have a Vickers hardness of between 500 kg/mm^2 to more than 1,000 kg/mm^2.

The hard metals used to form the hard metal compounds may be chosen from the group consisting of: Scandium (Sc), Titanium (Ti), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni), Yttrium (Y), Zirconium (Zr), Niobium (Nb), Molybdenum (Mo), Technetium (Tc), Rubidium (Ru), Rhodium (Rh), Palladium (Pd), Silver (Ag), Cadmium (Cd), Hafnium (Hf), Tantalum (Ta), Tungsten (W), Rhenium (Re), Osmium (Os), Iridium (Ir), Platinum (Pt), Gold (Au), Mercury (Hg), Rutherfordium (Rf), Dubnium (Db), Seaborgium (Sg), Bohrium (Bh), Hassium (Hs) and Meitnerium (Mt).

The deposited material may be also be at least one of a soft metal, soft metal compound and carbon. In one embodiment, the soft metal compound is at least one of a soft metal oxide, a soft metal carbide, a soft metal nitride, a soft metal carbon nitride, a soft metal silicide and a soft metal boride. The soft metal compound may be comprised of oxides, carbides, nitrides, carbonitrides, silicides and borides of metals, and/or

composite mixtures thereof which have a Vickers hardness of less than 500 kg/mm^2, preferably less than 100 kg/mm^2 for a given Vickers load of 50 mg.

The soft metals may be chosen from the group consisting of: Aluminium (Al), Zinc (Al), Copper (Cu), Lead (Pb), Tin (Sb), Gold (Au), Silver (Ag), Magnesium (Mg), Antimony (Sb), Cadmium (Cd), Thallium (Tl), Bismuth (Bi), Indium (In), Gallium (Ga), Mercury (Hg), Manganese (Mn) and alloys thereof.

The filtered vacuum cathodic deposition step may be comprised of applying a negative voltage pulse to a substrate that is electrically conductive, such as metal. The negative voltage pulse may be ranging from about -1800V to about -4500V, from about -2500V to about -4500V, from about -3500V to about -4500V.

The negative voltage pulse may have a frequency ranging from about 1 kHz to about 50 kHz, from about 10 kHz to about 50 kHz, from about 20 kHz to about 50 kHz from about 30 kHz to about 50 kHz, from about 40 kHz to about 50 kHz.

The negative voltage pulse has pulse durations of about 1 μs to about 50 μs, from about 5 μs to about 45 μs, from about 10 μs to about 40 μs and from about 15 μs to about 35 μs.

The sputtering step may deposit a thicker layer of material than the FCVA step. The layer of material deposited using the sputtering step may be about 2 to 15 times thicker than the layer of material deposited using the FCVA step.

The material layer deposited by the sputtering step may be ranging from about 0.1 microns to about 1 micron,

0.1 microns to about 0.5 microns, from about 0.1 microns to about 0.2 microns, from about 0.1 micron to about 0.3 microns, from about 0.1 microns to about 0.4 microns, from about 0.2 microns to about 0.3 microns and from about 0.2 microns to about 0.4 microns, in thickness.

The material layer deposited by the FCVA step ranging from about 0.01 microns to about 0.2 microns, from about 0.01 micron to about 0.12 micron, from about 0.02 micron to about 0.12 micron, from about 0.04 micron to about 0.12 micron, in thickness.

Brief Description Of Drawings

The accompanying drawings illustrate a disclosed embodiment and serves to explain the principles of the disclosed embodiment. It is to be understood, however, that the drawings are designed for purposes of illustration only, and not as a definition of the limits of the invention.

Fig. 1 shows a metal coating layer of a multi-layered film formed by both FCVA and sputtering on a plastic substrate; and

Fig. 2 shows a metal coating layer of a multi-layer film formed by both FCVA and sputtering on a metal substrate.

Detailed Description Of Drawings

Referring now to Fig. 1, there is shown a schematic diagram of a deposited patterned layer 33. The schematic diagram shows alternating layers of chromium (Cr) and chromium nitride (CrN) deposited in succession of one

another. An innermost Cr layer 42 is deposited via FCVA deposition directly onto the surface of the plastic substrate 12. The thickness of the Cr layer 42 is typically about 0.02 microns. Advantageously, in doing so, the heat sensitive plastic substrate will be partially insulated from the high temperatures arising as a result of the subsequent sputtering deposition of succeeding layers. More advantageously, the FCVA layer 42 has strong adhesion to the substrate surface 12a. Even more advantageously, the compact and uniform particle arrangement of the innermost Cr layer 42 provides an ideal seeding layer for subsequent deposition of Cr or CrN. A penultimate CrN layer 44 is then deposited on top of the innermost Cr layer 42, also via FCVA deposition.

Repeating layers 45 are then deposited on top of said CrN layer 44. While only one repeating layer 45 is shown in the Figure, it should be realized that it is merely for the convenience of illustration and in practice, a plurality of "n" repeating layers 45 can be deposited, wherein *n* range from about 2 to 4.

Each repeating layer 45 is comprised of a sputtered-CrN layer 46 (deposited through a sputtering process) and a FCVA-CrN layer 48 (deposited through a FCVA process). The sputtered-CrN layer 46 is of a much greater thickness relative to the Cr/CrN layers that were deposited using the FCVA process. The thickness of the sputtered-CrN layer 46 is typically from about 0.3 micron while the coupling FCVA-CrN layer is about 0.04 micron. Advantageously, by alternating between layers deposited via sputtering and layers deposited via the FCVA process,

the resulting coating 33 enjoys both the benefits of high quality FCVA deposition, the relatively short deposition time as a result of the sputtering of thicker layers, and at the same time minimizing the defects associated with conventional sputtering processes. Also advantageously, the deposited patterned layer 33 is comprised of a hard metal composite CrN which confers a high degree of wear resistance to the resulting image deposited.

The outermost layer 50 is a shiny, attractive Cr layer deposited using FCVA deposition. Advantageously, this gives the finished coating 33 a polished and shiny appearance and is aesthetically pleasing. This is an exceptionally important aspect for all commercial applications.

Now referring to fig. 2, there is shown another embodiment of the patterned layer 33a deposited on a metallic substrate surface 12b. The patterned layer 33a has a multi-layered arrangement, wherein sputtered-CrN layers (46a, 46b, 46c) are alternated with FCVA-deposited CrN layers (48a, 48b, 48c). The innermost Cr layer 42a is similarly deposited on the metal substrate using the FCVA process. The alternating design advantageously ensures that the resulting patterned layer possesses desirable qualities such as good adhesion, low voidage, high strength, and relatively short deposition time. An optional CrN layer 44a can be deposited adjacent and on top of said innermost layer 42a. The outermost layer 50a is a FCVA-deposited Cr layer to give it a lustrous and aesthetically pleasing finish. Furthermore, as the outermost layer 50a is deposited via the FCVA process, it does not chip readily upon external impact.

Non-limiting examples of the invention, including the best mode, and a comparative example will be further described in greater detail by reference to specific Examples, which should not be construed as in any way limiting the scope of the invention.

Applications

The disclosed process may be used to rapidly deposit hard metals and hard metallic compounds onto various substrate surfaces, such as plastic substrates, metal substrates, glass substrates, ceramic substrates and plastic substrates.

Advantageously, multiple nanofilm layer coatings of hard materials can be applied to surfaces. In one aspect, these nanofilm coatings can be applied to plastic substrates to without damaging the plastic through heat degradation. Advantageously, multiple nanofilm layers can be applied to a substrate to form a microfilm.

More advantageously, the nanofilm or microfilm layers on the substrate appear, to the naked eye, to be integrally formed with the surface to which they are attached. This provides a good overall aesthetic appeal to the coated article. Advantageously, in one aspect, the disclosed process allows for the deposition of hard metals, DLC and hard compounds onto plastic substrates, without causing any deformation or damage to the plastic substrates.

In one aspect, the disclosed process employs both sputtering and FCVA processes for the physical vapor deposition step. Advantageously, the disclosed process

is able to deposit hard metals onto the plastic substrate without the need for high operating temperatures which would otherwise damage or deform the substrate. The FCVA deposited layer is also substantially free of voids within the metallic layers, thus allowing the formation of a denser and higher quality coat. Furthermore, the hard metal coating is also resistant to surface scratching and deformation arising from external impact, which would otherwise compromise the overall aesthetics of the deposited coating.

Also advantageously, in one aspect, the disclosed process enjoys the benefit of a relatively short overall deposition time as a result of employing the sputtering method to deposit some of the layers of the metallic coating in combination with FCVA. As a result, the coatings can be rapidly deposited on the substrates.

FCVA deposition when used with sputtering boasts of considerable advantages over the use of sputtering alone. Specifically, thin metal films deposited via the FCVA process enjoy better adhesion with the substrate surface. The deposited film is also considerably more closely packed and compact, containing little or no voids therein, as compared to films that were deposited via sputtering processes only.

It should be noted that certain low energy PVD processes, such as sputtering, causes a degree of tensile stress in the coating, while FCVA causes a degree of compressive stress in the coating. Accordingly, when a layer of coating formed by a PVD such as sputtering is alternated with a layer formed by FCVA, the tensile and compressive stresses of the respective layers tends to

cancel each other out, or at least reduce the stress effects of the layers in the overall coatings. This results in a reduced stress coating which is not as prone to chipping or flaking of the coating when applied to a substrate.

It will be apparent that various other modifications and adaptations of the invention will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the invention and it is intended that all such modifications and adaptations come within the scope of the appended claims.

Claims

1. A process of depositing a coating on a substrate, the method comprising the steps of:

(a) depositing material on a substrate by performing a cathodic vacuum arc (CVA) deposition step; and

(b) depositing material on a substrate by performing at least one of a chemical vapor deposition (CVD) step and a physical vapor deposition (PVD) step that excludes CVA deposition,

wherein the thickness of the material deposited in step (b) is greater than the thickness of material deposited in step (a).

2. The process as claimed in claim 1, wherein said step (a) comprises the step of depositing material on a substrate by performing a filtered vacuum cathodic arc deposition (FVCA) step.

3. The process as claimed in claim 2, wherein said step (b) comprises a PVD step that deposits material faster than the (FVCA) step.

4. The process as claimed in claim 3, wherein said step (b) comprises a sputtering step.

5. A process as claimed in claim 1, further comprising the step of repeating alternating steps of at least one of (a) and (b) to form subsequent layers.

6. The process according to claim 1, wherein said material comprises at least one of a hard metal, hard metal compound and carbon.

7. The process according to claim 6, wherein said hard metal compound is at least one of a hard metal oxide, a hard metal carbide, a hard metal nitride, a hard metal carbonitride, a hard metal silicide and a hard metal boride.

8. The process according to claim 1, wherein said material comprises at least one of a soft metal, soft metal compound and carbon.

9. The process according to claim 8, wherein said soft metal compound is at least one of a soft metal oxide, a soft metal carbide, a soft metal nitride, a soft metal carbonitride, a soft metal silicide and a soft metal boride.

10. The process according to claim 4, wherein said sputtering step deposits a layer of material that has a thickness dimension greater than said FCVA step.

11. The process according to claim 10, wherein said sputtering step deposits layer of material that has a thickness dimension between 2 to 10 times that of the layer deposited by said FCVA step.

12. The process according to claim 2, wherein said FCVA deposition layer is deposited directly on said substrate.

13. The process according to claim 4, wherein said sputtering step deposits a material layer ranging from about 0.1 microns to about 1 micron in thickness.

14. The process according to claim 4, wherein said FCVA step deposits a material layer ranging from about 0.01 microns to about 0.2 microns in thickness.