SOLAR CONTROL COATINGS AND METHODS OF FORMING SOLAR CONTROL COATINGS

FIELD OF THE INVENTION

[0001] The present invention relates to solar control coatings and methods of forming such coatings.

BACKGROUND OF THE INVENTION

[0002] Substrates used in a variety of applications including architectural applications, automotive applications, consumer appliances, etc. are typically coated with a functional and/or aesthetic coating. For example, solar control coatings are commonly applied to transparent architectural and automotive substrates to reflect and/or absorb light. For example, solar control coatings are typically used to block or filter certain ranges of electromagnetic radiation to reduce the amount of solar energy entering a vehicle or building. This reduction of solar energy transmittance helps reduce the energy load on the cooling units of the vehicle or building.

[0003] Solar control coatings can be applied to various substrates such as glass substrates using various techniques including chemical vapor deposition ("CVD"), spray pyrolysis, and magnetron sputtered vacuum deposition ("MSVD"). MSVD processes are especially suited for complex coatings containing one or more coating layers because they allow for a wider selection of coating materials to be deposited at thinner thicknesses on a broader variety of substrates. However, while MSVD is the desired technique for depositing complex coatings containing one or more coating layers, some materials are not properly deposited using MSVD. In particular, when deposited by MSVD in an 80% oxygen - 20% argon environment followed by heating, antimony-doped tin oxide forms a thin film that does not absorb visible light.

[0004] It is therefore desirable to provide new solar control coatings that block or filter certain ranges of electromagnetic radiation. It is also desirable to provide methods of applying solar control coatings formed from certain materials that provide improved solar control properties.

SUMMARY ~~OF THE INVENTION~~

[0005] The present ~~invention~~disclosure relates to a coated article comprising a substrate and a coating applied over at least a portion of the substrate. The coating includes at least one metallic layer comprising one or more silver compounds doped with at least one metal selected from Groups 3 to 15 of the periodic table of the elements. For example, the metallic layer can comprise one

or more silver compounds doped with at least one metal selected from Groups 4 to 14 of the periodic table of the elements. In some examples, the silver compound is doped with a metal selected from tin, iron, chromium, cobalt, nickel, manganese, copper, gold, zinc, or a combination thereof. The doped silver compound can further comprise at least 50% silver, based on the total solids weight of the doped silver compound.

[0006] The coating of the present ~~invention~~disclosure can further comprise at least two separate dielectric layers such that the metallic layer is positioned between the two separate dielectric layers. In some examples, at least one primer layer applied over the metallic layer. The primer layer can be formed from a material comprising titanium, alloys containing nickel and chromium, silicon, silicon dioxide, silicon nitride, silicon oxynitride, nickel-chromium, zirconium, aluminum, alloys of silicon and aluminum, alloys containing cobalt and chromium, or combinations thereof.

[0007] The metallic layer can also comprise a continuous metallic layer or a discontinuous layer. The coating can also comprise at least one additional metallic layer. The additional metallic layer can be formed from a material comprising gold, copper, silver, aluminum, or combinations thereof. Moreover, in some examples, the substrate is glass such as an insulated glass unit.

[0008] The coating of the present ~~invention~~disclosure can also include: a first dielectric layer formed over at least a portion of the substrate; a first metallic layer formed over at least a portion of the first dielectric layer; a second dielectric layer formed over at least a portion of the first metallic layer; a second metallic layer formed over at least a portion of the second dielectric layer; and a third dielectric layer formed over at least a portion of the second metallic layer. Further, at least one of the metallic layers is formed from a material comprising one or more silver compounds doped with at least one metal selected from Groups 3 to 15 of the periodic table of the elements. Also, at least one of the metallic layers can be a continuous metallic layer or a discontinuous metallic layer. In some examples, a third metallic layer is formed over the third dielectric layer and a fourth dielectric layer is formed over at least a portion of the third metallic layer. In addition, at least one primer layer can be formed over at least one of the metallic layers.

[0008a] Thus, in one aspect, the present disclosure relates to a coated article comprising: a substrate; and a coating applied over at least a portion of the substrate, the coating comprising a

first dielectric layer formed over at least a portion of the substrate; a first metallic layer formed over at least a portion of the first dielectric layer; a second dielectric layer formed over at least a portion of the first metallic layer; a second metallic layer formed over at least a portion of the second dielectric layer; and a third dielectric layer formed over at least a portion of the second metallic layer, wherein at least one of the metallic layers is formed from a material comprising one or more silver compounds doped with at least one metal selected from Groups 3 to 15 of the periodic table of elements, wherein at least one of the metallic layers is a discontinuous metallic layer.

[0009] The present ~~invention~~disclosure also includes a coated article comprising: a substrate and a coating applied over at least a portion of the substrate in which the coating comprises one or more metallic layers and one or more dielectric layers. Further, at least one of the dielectric layers comprises a capsule comprising a first silicon nitride film, a metal layer formed over at

least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer.

[0009a] Thus, in another aspect, the present disclosure relates to a coated article comprising: a substrate; and a coating applied over at least a portion of the substrate, the coating comprising one or more metallic layers and one or more dielectric layers, wherein at least one of the dielectric layers comprises a capsule comprising a first silicon nitride film, a metal layer formed over at least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer, wherein at least one of the metallic layers is a discontinuous metallic layer.

[0010] The metal layer formed over at least a portion of the first silicon nitride film can comprise a material that absorbs at least a portion of electromagnetic radiation passing through the coating. For example, the metal layer formed over at least a portion of the first silicon nitride film can comprise titanium, silicon, silicon dioxide, nickel-chromium alloys, zirconium, aluminum, alloys of silicon and aluminum, alloys containing cobalt and chromium, or combinations thereof. In some examples, the metal layer formed over at least a portion of the first silicon nitride film comprises nickel-chromium alloys, alloys containing cobalt and chromium, or combinations thereof. Moreover, at least one of the metallic layers can be a discontinuous metallic layer and/or a continuous metallic layer. The metal layer can also be a sub-oxide or a sub-nitride. For example, the metal layer can be a silicon sub-nitride, a nickel sub-nitride, or a silicon-nickel sub-nitride.

[0011] The coated article can also comprise an overcoat. The overcoat can include a capsule comprising a first silicon nitride film, a metal layer formed over at least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer.

[0012] The present ~~invention~~disclosure can further include a coated article comprising a substrate and a coating applied over at least a portion of the substrate in which the coating comprises: a first dielectric layer formed over at least a portion of the substrate; a first metallic layer formed over at least a portion of the first dielectric layer; a second dielectric layer formed over at least a portion of the first metallic layer; a second metallic layer formed over at least a

portion of the second dielectric layer; a third dielectric layer formed over at least a portion of the second metallic layer, and an overcoat formed over at least a portion of the third dielectric layer. Further, at least one of the dielectric layers and/or the overcoat comprises a capsule comprising a first silicon nitride film, a metal layer formed over at least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer.

[0013] The coating can further include a third metallic layer formed over the third dielectric layer and a fourth dielectric layer formed over at least a portion of the third metallic layer. In such examples, the overcoat is formed over at least a portion of the fourth dielectric layer.

[0014] The present ~~invention~~disclosure is also directed to a process of forming an antimony-doped tin oxide coating layer over a substrate. The process includes: (a) applying antimony-doped tin oxide to a substrate in a gaseous atmosphere comprising oxygen and a noble gas using a MSVD coater, wherein the gaseous atmosphere comprises at least 15% oxygen; and (b) heating the

THE INVENTION CLAIMED IS

1. A coated article comprising: a substrate; and a coating applied over at least a portion of the substrate, the coating comprising a first dielectric layer formed over at least a portion of the substrate; a first metallic layer formed over at least a portion of the first dielectric layer; a second dielectric layer formed over at least a portion of the first metallic layer; a second metallic layer formed over at least a portion of the second dielectric layer; and a third dielectric layer formed over at least a portion of the second metallic layer, wherein at least one of the metallic layers is formed from a material comprising one or more silver compounds doped with at least one metal selected from Groups 3 to 15 of the periodic table of elements, wherein at least one of the metallic layers is a discontinuous metallic layer.

~~2. The coated article according to claim 1, wherein at least one of the metallic layers is a continuous metallic layer.~~

~~3. The coated article according to claim 1, wherein at least one of the metallic layers is a discontinuous metallic layer.~~

~~4.~~2. The coated article according to claim~~s~~ 1 ~~to 3~~, further comprising a third metallic layer formed over at least a portion of the third dielectric layer and a fourth dielectric layer formed over at least a portion of the third metallic layer.

~~5.~~3. The coated article according to any of claims 1 ~~to 4~~or 2, further comprising at least one primer layer formed over at least one of the metallic layers.

~~6.~~4. The coated article according to any of claims 1 to ~~5~~3, wherein the substrate is glass.

~~7.~~5. A coated article comprising: a substrate; and a coating applied over at least a portion of the substrate, the coating comprising one or more metallic layers and one or more dielectric layers, wherein at least one of the dielectric layers comprises a capsule comprising a first silicon nitride film, a metal layer formed over at least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer, wherein at least one of the metallic layers is a discontinuous metallic layer.

~~8.~~6. The coated article of claim ~~7~~5, wherein the metal layer formed over at least a portion of the first silicon nitride film comprises a material that absorbs at least a portion of electromagnetic radiation passing through the coating.

~~9.~~7. The coated article of claim ~~7~~5 or ~~8~~6, wherein the metal layer formed over at least a portion of the first silicon nitride film comprises titanium, silicon, silicon dioxide, nickel-chromium alloys, zirconium, aluminum, alloys of silicon and aluminum, alloys containing cobalt and chromium, or mixtures thereof.

~~10.~~8. The coated article of claim ~~7~~5 or ~~8~~6, wherein the metal layer formed over at least a portion of the first silicon nitride film comprises nickel-chromium alloys, alloys containing cobalt and chromium, or mixtures thereof.

~~11. The coated article of any of claims 7 to 10, wherein at least one of the metallic layers is a discontinuous metallic layer.~~

~~12.~~9. The coated article of any of claims ~~7~~5 to ~~12~~8, further comprising an overcoat, wherein the overcoat is formed from a capsule comprising a first silicon nitride film, a metal layer formed over at least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer.

~~13.~~10. ~~A~~The coated article according to claim 5 comprising: a substrate; and a coating applied over at least a portion of the substrate, the coating comprising: a first dielectric layer formed over at least a portion of the substrate; a first metallic layer formed over at least a portion of the first dielectric layer; a second dielectric layer formed over at least a portion of the first metallic layer; a second metallic layer formed over at least a portion of the second dielectric layer; a third dielectric layer formed over at least a portion of the second metallic layer, and an overcoat formed over at least a portion of the third dielectric layer, wherein at least one of the dielectric layers and~~/or~~ optionally the overcoat comprises a capsule comprising a first silicon nitride film, a metal layer formed over at least a portion of the first silicon nitride film, and a second silicon nitride film formed over at least a portion of the metal layer.

~~14.~~11. The coated article of claim ~~13~~10, further comprising a third metallic layer formed over at least a portion of the third dielectric layer and a fourth dielectric layer formed over at least a portion of the third metallic layer, wherein the overcoat is formed over at least a portion of the fourth dielectric layer.

~~15.~~12. The coated article of claim ~~13~~10 or ~~14~~11, wherein the metal layer formed over at least a portion of the first silicon nitride film comprises titanium, silicon, silicon dioxide, nickel-chromium alloys, zirconium, aluminum, alloys of silicon and aluminum, alloys containing cobalt and chromium, or mixtures thereof.