transparent conductive oxide is applied over at least a portion of the second underlayer film at the transparent conductive oxide film thickness.

[0008] A coated article including a substrate. An underlayer is positioned over at least a portion of the substrate. The underlayer includes at least a first underlayer film over at least a portion of the substrate, and an optional second underlayer film over at least a portion of the first underlayer film. The first underlayer film contains a first high refractive index material. The optional second underlayer film contains a first low refractive index layer. A transparent conductive oxide layer is positioned over at least a portion of the first or optional second underlayer film. A second high refractive index material is embedded within the transparent conductive oxide layer. The coated article has a sheet resistances of at least 5 Ω/□ and at most 25 Ω/□. The sheet resistance is at least 35% higher than without the second high refractive index material embedded within the transparent conductive oxide layer.

[0008a] In one aspect, the present disclosure relates to a coated article comprising

a substrate,

an underlayer over at least a portion of the substrate, the underlayer comprising

a first underlayer film wherein the first underlayer film comprises a first refractive index material, wherein the first underlayer film is in direct contact with the substrate and wherein the first refractive index material comprises zinc, and

a second underlayer film over at least a portion of the first underlayer film wherein the second underlayer film comprises a second refractive index material, and wherein the first refractive index material has a refractive index greater than the second refractive index material,

a transparent conductive oxide layer over at least a portion of the underlayer and

an embedded film embedded within the transparent conductive oxide layer wherein the embedded film comprises a third refractive index material, and wherein the third refractive index material has a refractive index greater than the second refractive index material.

[0009] Optionally, the coated article can have a protective layer over at least a portion of the transparent conductive oxide layer. The protective layer includes a first protective film over at least a portion of the transparent conductive oxide layer, and a second protective film over at least a portion of the first protective film. The second protective film is the outer-most film in the coating stack, and includes a mixture of titania and alumina. Optionally, the protective layer can include a third protective film positioned between the first protective film and a second protective film.

[0010] A coated article including a substrate. An underlayer is positioned over at least a portion of the substrate. The underlayer includes at least a first underlayer film over at least a portion of the substrate, and an optional second underlayer film over at least a portion of the first underlayer film. The first underlayer film contains a first high refractive index material. The optional second underlayer film contains a first low refractive index layer. A first transparent conductive oxide layer is positioned over at least a portion of the first or optional second underlayer film. An embedded film is positioned over at least a portion of the first transparent conductive oxide layer. The embedded film has a second high refractive index material. A second transparent conductive oxide layer is positioned over at least a portion of the second transparent conductive oxide layer. The coated article has a sheet resistances of at least 5 Ω/□ and at most 25 Ω/□. The sheet resistance is at least 35% higher than without the embedded film.

[0010a] In another aspect, the present disclosure relates to a coated article comprising

a substrate;

an underlayer over at least a portion of the substrate, wherein the underlayer comprises a first underlayer film and a second underlayer film over at least a portion of the first underlayer film, wherein the first underlayer film comprises a first refractive index material that comprises zinc, wherein said second underlayer film comprises a second refractive index material, wherein the first refractive index material is in direct contact with the substrate and has a refractive index greater than the second refractive index material;

a first transparent conductive oxide layer over at least a portion of the underlayer,

an embedded film over at least a portion of the first transparent conductive oxide layer, wherein the embedded film comprises a third refractive index material, and wherein the third refractive index material has a refractive index greater than the second refractive index material; and

a second transparent conductive oxide layer over at least a portion of the embedded film.

[0011] Optionally, the coated article can have a protective layer over at least a portion of the transparent conductive oxide layer. The protective layer includes a first protective film over at least a portion of the transparent conductive oxide layer, and a

is applied over at least a portion of the substrate in an atmosphere that comprises between 0 % and 2.0 % oxygen.

[0018a] In another aspect, the present disclosure relates to a method of reducing the sheet resistance of a coated article comprising

(a) applying a first underlayer film over at least a portion of a substrate, wherein the first underlayer film comprises a first refractive index material, wherein the first underlayer film is in direct contact with the substrate and wherein the first refractive index material comprise zinc;

(b) applying a second underlayer film over at least a portion of the first underlayer film, wherein the second underlayer film comprises a second refractive index material;

(c) applying a first transparent conductive oxide layer over at least a portion of the second underlayer film;

(d) applying an embedded film over at least a portion of the first transparent conductive oxide layer, wherein the embedded film comprises a third refractive index material, and wherein the third refractive index material has a refractive index greater than the second refractive index material; and

applying a second transparent conductive oxide layer over at least a portion of the embedded film.

[0019] A coated article having reduced absorption, resistance or emissivity comprising a transparent conductive oxide layer made by the following steps. A substrate is provided. A transparent conductive oxide layer is applied over at least a portion of the substrate in an atmosphere that comprises between 0 % and 2.0 % oxygen.

BRIEF DESCRIPTION OF THE DRAWING(S)

[0020] The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with color drawing(s) will be provided by the Office upon request and payment of the necessary fee.

[0021] Figs. 1a, 1b, 1c and 1d are side views (not to scale) of coatings incorporating a feature of the invention;

[0022] Figs. 2a, 2b, 2c, 2d and 2e are side views of other coatings (not to scale) incorporating a feature of the invention;

[0023] Figs. 3a, 3b, 3c, 3d, 3e are side views of other coatings (not to scale) incorporating a feature of the invention;

[0024] Figs. 4a and 4b are side views of other coatings (not to scale) incorporating a feature of the invention;

THE INVENTION CLAIMED IS

1. A coated article comprising

a substrate,

an underlayer over at least a portion of the substrate, the underlayer comprising

a first underlayer film wherein the first underlayer film comprises a first refractive index material, wherein the first underlayer film is in direct contact with the substrate and wherein the first refractive index material comprises zinc, and

a second underlayer film over at least a portion of the first underlayer film wherein the second underlayer film comprises a second refractive index material, and wherein the first refractive index material has a refractive index greater than the second refractive index material,

a transparent conductive oxide layer over at least a portion of the underlayer and

an embedded film embedded within the transparent conductive oxide layer wherein the embedded film comprises a third refractive index material, and wherein the third refractive index material has a refractive index greater than the second refractive index material.

2. The coated article according to claim 1, wherein the third refractive index material comprises tin oxide and zinc oxide.

3. The coated article according to claim 1, wherein the embedded film has a thickness in the range of 15 nm to 30 nm.

4. The coated article according to claim 1, wherein the transparent conductive oxide layer comprises tin-doped indium oxide.

5. The coated article according to claim 1, wherein the embedded film is positioned closer to a bottom of the transparent conductive oxide layer.

6. The coated article according to claim 1, wherein the embedded film is positioned closer to a top of the transparent conductive oxide layer.

7. The coated article according to claim 1, wherein the embedded film is positioned at a middle of the transparent conductive oxide layer.

8. The coated article according to claim 1, further comprising a protective layer over at least a portion of the transparent conductive oxide layer, wherein the protective layer comprises a first protective film comprising titania, alumina, zinc oxide, tin oxide, zirconia, silica alloys thereof or mixtures thereof; and a second protective film over at least a portion of the first protective film, wherein the second protective film comprises a mixture of titania and alumina.

9. A coated article comprising

a substrate;

an underlayer over at least a portion of the substrate, wherein the underlayer comprises a first underlayer film and a second underlayer film over at least a portion of the first underlayer film, wherein the first underlayer film comprises a first refractive index material that comprises zinc, wherein said second underlayer film comprises a second refractive index material, wherein the first refractive index material is in direct contact with the substrate and has a refractive index greater than the second refractive index material;

a first transparent conductive oxide layer over at least a portion of the underlayer,

an embedded film over at least a portion of the first transparent conductive oxide layer, wherein the embedded film comprises a third refractive index material, and wherein the third refractive index material has a refractive index greater than the second refractive index material; and

a second transparent conductive oxide layer over at least a portion of the embedded film.

10. The coated article according to claim 9, wherein the embedded film comprises tin oxide and zinc oxide.

11. The coated article according to claim 9, wherein the first transparent conductive oxide layer and the second transparent conductive oxide layer comprise tin-doped indium oxide (“ITO”).

12. The coated article according to claim 9, wherein the embedded film has a thickness of at least 15 nm and at most 30 nm.

13. The coated article according to claim 9, wherein the first transparent conductive oxide layer is thicker than the second transparent conductive oxide layer.

14. The coated article according to claim 9, further comprising a protective layer over at least a portion of the second transparent conductive oxide layer, wherein the protective layer comprises a first protective film comprising titania, alumina, zinc oxide, tin oxide, zirconia, silica or mixtures thereof; and a second protective film over at least a portion of the first protective film, wherein the second protective film comprises a mixture of titania and alumina.

15. A method of reducing the sheet resistance of a coated article comprising

(a) applying a first underlayer film over at least a portion of a substrate, wherein the first underlayer film comprises a first refractive index material, wherein the first underlayer film is in direct contact with the substrate and wherein the first refractive index material comprise zinc;

(b) applying a second underlayer film over at least a portion of the first underlayer film, wherein the second underlayer film comprises a second refractive index material;

(c) applying a first transparent conductive oxide layer over at least a portion of the second underlayer film;

(d) applying an embedded film over at least a portion of the first transparent conductive oxide layer, wherein the embedded film comprises a third refractive index material, and wherein the third refractive index material has a refractive index greater than the second refractive index material; and

(e) applying a second transparent conductive oxide layer over at least a portion of the embedded film.

16. The method according to claim 15, wherein the third refractive index material comprises tin oxide and zinc oxide.

17. The method according to claim 15, wherein the first transparent conductive oxide layer comprises tin-doped indium oxide.

18. The method according to claim 15, wherein the embedded film is applied at a thickness of at least 15 nm, and at most 30 nm.

19. The method according to claim 15, wherein the first transparent conductive oxide layer is thicker than the second transparent conductive oxide layer.

20. The method according to claim 15 further comprising applying a first protective film over at least a portion of the second transparent conductive oxide layer, and applying a second protective film over at least a portion of the first protective film, wherein the second protective film comprises a mixture of titania and alumina, and wherein the first protective film comprises titania, alumina, zinc oxide, tin oxide, zirconia, silica or mixtures thereof.