REFLECTIVE SOLAR CONTROL COATINGS, AND ARTICLES COATED THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Patent Application No. 17/506,184, filed October 20, 2021, which claims the benefit of U.S. Provisional Patent Application No. 63/094,510, filed October 21, 2020, the disclosures of which are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates generally to reflective coatings and articles coated with reflective coatings.

Description of Related Art

[0003] Solar control coatings are known in the field of architectural transparencies. Solar control coatings block or filter selected ranges of electromagnetic radiation, such as in the solar infrared or solar ultraviolet ranges, to reduce the amount of solar energy entering the building. This reduction of solar energy transmittance helps reduce the load on the cooling units of the building. In some architectural applications, it may be desirable to have a reflective outer (or inner) surface so as to decrease visibility of one side of the transparency.

[0004] It would be desired to produce a coating with a specified reflectance (inner and/or outer) and/or transmittance to achieve desirable optical and aesthetic properties.

SUMMARY

[0005] The present disclosure provides a coated article includes at least a first substrate having a first surface and a second surface opposite of the first surface. A coating may be positioned over one of the surfaces of the first substrate including the following layers. A first dielectric layer is positioned over at least a portion of the substrate. A first metallic layer is positioned over at least a portion of the first dielectric layer. A first primer layer is positioned over at least a portion of the first metallic layer. A second dielectric layer is positioned over at least a portion of the first primer layer. The second dielectric layer includes a zinc stannate film. A second metallic layer is positioned over at least a portion of the second dielectric layer. A second primer layer

is positioned over at least a portion of the second metallic layer. A third dielectric layer is positioned over at least a portion of the second primer layer. A third metallic layer is positioned over at least a portion of the third dielectric layer. A third primer layer is positioned over at least a portion of the third metallic layer. A fourth dielectric layer is positioned over at least a portion of the third dielectric layer. A protective layer is positioned over at least a portion of the fourth dielectric layer. The second metallic layer is a discontinuous metallic layer having an effective thickness in the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc Stannate film of the second dielectric layer. The coated article has an exterior reflectance of between 10% and 50%. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0005a] In one aspect, the present disclosure provides a coated article, comprising:

at least a first substrate having a first surface and a second surface opposite of the first surface; and

a coating over at least a portion of one of the surfaces of the first substrate, the coating comprising:

a first dielectric layer over at least a portion of the substrate;

a first metallic layer over at least a portion of the first dielectric layer;

a first primer layer over at least a portion of the first metallic layer;

a second dielectric layer over at least a portion of the first primer layer, the second dielectric layer comprising a zinc stannate film;

a second metallic layer over at least a portion of the second dielectric layer;

a second primer layer over at least a portion of the second metallic layer;

a third dielectric layer over at least a portion of the second primer layer;

a third metallic layer over at least a portion of the third dielectric layer;

a third primer layer over at least a portion of the third metallic layer;

a fourth dielectric layer over at least a portion of the third dielectric layer; and

a protective layer over at least a portion of the fourth dielectric layer;

wherein the second metallic layer is a discontinuous metallic layer having an effective thickness in the range of from 5 Å to 20 Å and which is formed directly over at least a portion of the zinc stannate film of the second dielectric layer; and

wherein the coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4 while maintaining a reflective aesthetic CIELAB L*a*b* color a* value of no less than -10.

[0006] The present disclosure provides a coated article includes at least a first substrate having a first surface and a second surface opposite of the first surface. A coating may be positioned over one of the surfaces of the first substrate including the following layers. A first metallic layer is positioned over at least a portion of the first dielectric layer. A first primer layer is positioned over at least a portion of the first metallic layer. A second dielectric layer is positioned over at least a portion of the first primer layer. The second dielectric layer includes a zinc stannate film. A second metallic layer is positioned over at least a portion of the second dielectric layer. A second primer layer is positioned over at least a portion of the second metallic layer. A third dielectric layer is positioned over at least a portion of the second primer layer. A third metallic layer over at least a portion of the third dielectric layer. A third primer layer is positioned over at least a portion of the third metallic layer. A fourth dielectric layer is positioned over at least a portion of the third dielectric layer. A protective layer is positioned over at least a portion of the fourth dielectric layer. The second metallic layer is a discontinuous metallic layer having an effective thickness in the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The third dielectric layer includes a first film comprising zinc oxide and having a thickness in the range of from 1 Å to 50 Å; and a second film over at least a portion of the first film of the third dielectric layer. The second film includes an oxide of a zinc alloy. The coated article may have an exterior reflectance of between 10% and 50%. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0007] The present disclosure provides a method of forming a coated article includes providing at least a first substrate having a first surface and a second surface opposite of the first surface. A coating is applied over at least a portion of one of the surfaces of the first substrate. A first dielectric layer is applied over at least a portion of the substrate. A first metallic layer is applied over at least a portion of the first dielectric layer. A first primer layer is applied over at least a portion of the first metallic layer. A second dielectric layer is applied over at least a portion of the first primer layer. A second metallic layer is applied over at least a portion of the second dielectric layer. A second primer layer is applied over at least a portion of the second metallic layer. A third dielectric layer is applied over at least a portion of the second primer layer. A third metallic layer is applied over at least a portion of the third dielectric layer. A third primer layer is applied over at least a portion of the third metallic layer. A fourth dielectric layer is applied over at least a portion of the third dielectric layer. A protective layer is applied over at least a portion of the fourth dielectric layer. The applying the second dielectric layer step includes applying a zinc stannate film. The second metallic layer is a discontinuous metallic layer having a thickness in the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The coated article may have an exterior reflectance of between 10% and 50%. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0007a] In another aspect, the present disclosure provides a method of forming a coated article comprising the steps of:

providing at least a first substrate having a first surface and a second surface opposite of the first surface; and

applying a coating over one of the surfaces of the first substrate, the applying the coating step comprising:

applying a first dielectric layer over at least a portion of the substrate;

applying a first metallic layer over at least a portion of the first dielectric layer;

applying a first primer layer over at least a portion of the first metallic layer;

applying a second dielectric layer over at least a portion of the first primer layer;

applying a second metallic layer over at least a portion of the second dielectric layer;

applying a second primer layer over at least a portion of the second metallic layer;

applying a third dielectric layer over at least a portion of the second primer layer;

applying a third metallic layer over at least a portion of the third dielectric layer;

applying a third primer layer over at least a portion of the third metallic layer;

applying a fourth dielectric layer over at least a portion of the third dielectric layer; and

applying a protective layer over at least a portion of the fourth dielectric layer;

wherein the applying the second dielectric layer step comprises applying a zinc stannate film;

wherein the second metallic layer is a discontinuous metallic layer having a thickness in the range of from 5 Å to 20 Å and which is formed directly over at least a portion of the zinc stannate film of the second dielectric layer; and

wherein the coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4 while maintaining a reflective aesthetic CIELAB L*a*b* color a* value of no less than -10.

[0008] The present disclosure provides a method of forming a coated article includes providing at least a first substrate having a first surface and a second surface opposite of the first surface. A coating is applied over at least a portion of one of the surfaces of the first substrate. A first metallic layer is applied over at least a portion of the first dielectric layer. A first primer layer is applied

over at least a portion of the first metallic layer. A second dielectric layer is applied over at least a portion of the first primer layer. A second metallic layer is applied over at least a portion of the second dielectric layer. A second primer layer is applied over at least a portion of the second metallic layer. A third dielectric layer is applied over at least a portion of the second primer layer. A third metallic layer is applied over at least a portion of the third dielectric layer. A third primer layer is applied over at least a portion of the third metallic layer. A fourth dielectric layer is applied over at least a portion of the third dielectric layer. A protective layer is applied over at least a portion of the fourth dielectric layer.

The applying the second dielectric layer step includes applying a zinc stannate film. The second metallic layer is a discontinuous metallic layer having a thickness in the range of from 5 Å to 20 Å and which is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The applying a third dielectric layer step includes applying the first film including zinc oxide and having a thickness in the range of from 1 Å to 50 Å; and applying a second film over at least a portion of the first film of the third dielectric layer, the second film containing an oxide of a zinc alloy. The coated article may have an exterior reflectance of between 10% and 50%. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0009] The present disclosure provides a coated article includes at least a first substrate having a first surface and a second surface opposite of the first surface. A coating may be positioned over one of the surfaces of the first substrate including the following layers. A first metallic layer is positioned over at least a portion of the first dielectric layer. A first primer layer is positioned over at least a portion of the first metallic layer. A second dielectric layer is positioned over at least a portion of the first primer layer. The second dielectric layer includes a zinc stannate film. A second metallic layer is positioned over at least a portion of the second dielectric layer. A second primer layer is positioned over at least a portion of the second metallic layer. A third dielectric layer is positioned over at least a portion of the second primer layer. A third metallic layer is positioned over at least a portion of the third dielectric layer. A third primer layer is positioned over at least a portion of the third metallic layer. A fourth dielectric layer is positioned over at least a portion of the third dielectric layer. A protective layer is positioned over at least a portion of the fourth dielectric layer. The second metallic layer is a discontinuous metallic layer having an effective thickness in the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The coated article may have a visible light transmittance in the range of from 40% to 60%. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0010] The present disclosure provides a coated article includes at least a first substrate having a first surface and a second surface opposite of the first surface. A coating may be positioned over one of the surfaces of the first substrate including the following layers. A first metallic layer is positioned over at least a portion

of the first dielectric layer. A first primer layer is positioned over at least a portion of the first metallic layer. A second dielectric layer is positioned over at least a portion of the first primer layer. The second dielectric layer includes a zinc stannate film. A second metallic layer is positioned over at least a portion of the second dielectric layer. A second primer layer is positioned over at least a portion of the second metallic layer. A third dielectric layer is positioned over at least a portion of the second primer layer. A third metallic layer is positioned over at least a portion of the third dielectric layer. A third primer layer is positioned over at least a portion of the third metallic layer. A fourth dielectric layer is positioned over at least a portion of the third dielectric layer. A protective layer is positioned over at least a portion of the fourth dielectric layer. The second metallic layer is a discontinuous metallic layer having an effective thickness in the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The third dielectric layer includes the first film comprising zinc oxide and having a thickness in the range of from 1 Å to 50 Å, and a second film over at least a portion of the first film of the third dielectric layer. The second film includes an oxide of a zinc alloy. The coated article may have a visible light transmittance in the range of from 40% to 60%. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0011] The present disclosure provides a coated article includes at least a first substrate having a first surface and a second surface opposite of the first surface. A coating may be positioned over one of the surfaces of the first substrate including the following layers. A first metallic layer is positioned over at least a portion of the first dielectric layer. A first primer layer is positioned over at least a portion of the first metallic layer. A second dielectric layer is positioned over at least a portion of the first primer layer. The second dielectric layer includes a zinc stannate film. A second metallic layer is positioned over at least a portion of the second dielectric layer. A second primer layer is positioned over at least a portion of the second metallic layer. A third dielectric layer is positioned over at least a portion of the second primer layer. A third metallic layer is positioned over at least a portion of the third dielectric layer. A third primer layer is positioned over at least a portion of the third metallic layer. A fourth dielectric layer is positioned over at least a portion of the third dielectric layer. A protective layer is positioned over at least a portion of the fourth dielectric layer. The second metallic layer is a discontinuous metallic layer having an effective thickness in

the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0012] The present disclosure provides a coated article includes at least a first substrate having a first surface and a second surface opposite of the first surface. A coating may be positioned over one of the surfaces of the first substrate including the following layers. A first metallic layer is positioned over at least a portion of the first dielectric layer. A first primer layer is positioned over at least a portion of the first metallic layer. A second dielectric layer is positioned over at least a portion of the first primer layer. The second dielectric layer includes a zinc stannate film. A second metallic layer is positioned over at least a portion of the second dielectric layer. A second primer layer is positioned over at least a portion of the second metallic layer. A third dielectric layer is positioned over at least a portion of the second primer layer. A third metallic layer is positioned over at least a portion of the third dielectric layer. A third primer layer is positioned over at least a portion of the third metallic layer. A fourth dielectric layer is positioned over at least a portion of the third dielectric layer. A protective layer is positioned over at least a portion of the fourth dielectric layer. The second metallic layer is a discontinuous metallic layer having an effective thickness in the range of from 5 Å to 20 Å and is formed directly over at least a portion of the zinc stannate film of the second dielectric layer. The third dielectric layer includes a first film, which has zinc oxide and a thickness in the range of from 1 Å to 50 Å, and a second film over at least a portion of the first film of the third dielectric layer, the second film having an oxide of a zinc alloy. The coated article has a neutral transmitted aesthetic CIELAB L*a*b* color value comprising an a* of greater than -4 and a b* in the range of from -4 to 4.

[0013] Various preferred and non-limiting examples or aspects of the present disclosure will now be described and set forth in the following numbered clauses:

[0014] Clause 1: A coated article, comprising: at least a first substrate having a first surface and a second surface opposite of the first surface; and a coating over at least a portion of one of the surfaces of the first substrate, the coating comprising: a first dielectric layer over at least a portion of the substrate; a first metallic layer over at least a portion of the first dielectric layer; a first primer layer over at least a portion of the first metallic layer; a second dielectric layer over at least a portion of the first primer