CLAIMS

1. A low emissivity transparent composite film comprising:

a transparent film substrate;

an underlayer of abrasion resistant hardcoat material compatible with the transparent film substrate; and

at least one infrared reflective layer;

the composite film having an emissivity of less than about 0.30 and wherein the underlayer is disposed between the transparent film substrate and the infrared reflective layer.

2. The composite of claim 1 wherein the infrared reflecting layer comprises a metallic layer selected from the group consisting of aluminum, copper, gold, nickel, silver, platinum, palladium, tungsten, titanium, or alloys thereof.

3. The composite of claim 2 further comprising a transparent protective top coat having a dried thickness of less than about 0.5 microns, wherein the protective top coat is disposed over the infrared reflective layer.

4. The composite of claim 1, the underlayer having an abrasion delta haze of less than about 5 percent.

5. The composite of claim 3 wherein the infrared reflective layer includes at least one thin metal film capable of protecting the infrared reflective layer.

6. The composite of claim 5 wherein the thin metal film is comprised of a metal selected from the group consisting of nickel, chromium, nobium, platinum, cobalt, zinc, molybdenum, zirconium, vanadium and alloys thereof.

7. The composite of claim 6 wherein the thin metal film is comprised of a nickel-chromium alloy.

8. The composite of claim 2 wherein the infrared reflective layer includes at least one spacer layer comprised of a transparent conductive layer, a dielectric layer, or combinations thereof.

9. The composite of claim 8 wherein the spacer layer comprises a material selected from the group consisting of indium oxide, indium zinc oxide, or indium tin oxide.

10. The composite of claim 1 wherein the infrared reflective layer includes a plurality of thin spacer layers disposed between a plurality of transparent conductive layers.

11. A low emissivity transparent composite film comprising:

a transparent film substrate;

an underlayer of abrasion resistant hardcoat material compatible with the transparent film substrate; and

at least one infrared reflective layer;

the composite film having an emissivity of less than about 0.25.

12. The composite of claim 11, the composite film having an emissivity of less than about 0.20.

13. The composite of claim 12, the composite having a visible light transmission of up to about 75 percent.

14. The composite of claim 11, the composite film having an emissivity of less than about 0.10.

15. The composite of claim 14, the composite having a visible light transmission of about 28 percent to about 47 percent.

16. The composite of claim 14, the composite film having a visible light transmission up to about 70 percent.

17. The composite of claim 11 wherein the abrasion resistant hardcoat material is selected from the group consisting of highly crosslinked polymer coatings, thermally cured acrylate coatings, thermally cured sol gel coatings based on silicates, titanates, zirconates, or mixtures thereof, hybrid organic-inorganic sol gel materials, thermally cured siloxane hardcoats, and thermally cured polyacrylate coatings.

18. The composite of claim 17 wherein the underlayer is comprised of an ultraviolet cured polyacrylate composition containing metal oxide nanoparticles.

19. The composite of claim 11 wherein the infrared reflecting layer comprises a metallic layer selected from the group consisting of aluminum, copper, gold, nickel, silver, platinum, palladium, tungsten, titanium, or alloys thereof.

20. A method of manufacturing of a low emissivity transparent composite film, the method comprising:

providing a transparent film substrate;

mixing an abrasion resistant hardcoat material comprising a polyacrylate composition to form a mixture;

applying the mixture to one side of the transparent film substrate;

curing the coated side of the substrate to form an underlayer; and

sputtering an infrared reflecting layer on the underlayer.

Claims

1. A low emissivity transparent composite film comprising:

a transparent film substrate;

an underlayer of abrasion resistant hardcoat material deposited on the surface of the film substrate and comprising a crosslinked acrylate polymer and metal oxide nanoparticles, the underlayer having a dried thickness of about 2 to about 6 microns;

at least one infrared reflective layer; and

a transparent, protective top coat disposed over the infrared reflective layer, the protective top coat having a thickness of less than 0.5 microns and comprising a polysilazane, fluoro silane, fluoroalkyl silane, or combination thereof;

wherein the composite film has an emissivity of less than about 0.30.

2. The composite film of claim 1 wherein the infrared reflecting layer comprises at least one metallic layer selected from the group consisting of aluminum, copper, gold, nickel, silver, platinum, palladium, tungsten, titanium, and alloys thereof.

3. The composite film of claim 2 wherein the infrared reflective layer comprises at least one spacer layer comprising a transparent conductive layer, a dielectric layer, or combinations thereof.

4. The composite film of claim 3 wherein the spacer layer comprises at least one metal oxide selected from the group consisting of indium oxide, indium zinc oxide, and indium tin oxide.

5. The composite film of claim **1**, wherein the underlayer has an abrasion delta haze of 5 percent or less.

6. The composite film of claim **1** wherein the infrared reflective layer comprises at least one thin metal film capable of protecting the infrared reflective layer.

7. The composite film of claim **6** wherein the thin metal film comprises at least one metal selected from the group consisting of nickel, chromium, nobium, platinum, cobalt, zinc, molybdenum, zirconium, vanadium and alloys thereof.

8. The composite film of claim **7** wherein the thin metal film comprises a nickel-chromium alloy.

9. The composite film of claim **1** wherein the infrared reflective layer comprises a plurality of thin spacer layers disposed between a plurality of transparent conductive layers.

10. A low emissivity transparent composite film comprising:

a transparent polyester film substrate;

an underlayer of abrasion resistant hardcoat material deposited on the surface of the film substrate and comprising a crosslinked acrylate polymer and about 21 to about 65 weight percent of metal oxide nanoparticles, the underlayer having a dried thickness of about 2 to about 6 microns and an abrasion delta haze of about 3 to about 5%;

at least one infrared reflective layer; and

a transparent, protective top coat disposed over the infrared reflective layer, the protective top coat having a thickness of less than about 0.5 microns and comprising a polysilazane, fluoro silane, fluoroalkyl silane, or combination thereof;

wherein the composite film has an emissivity of less than about 0.25.

11. The composite film of claim **10** which has an emissivity of less than about 0.20.

12. The composite film of claim **11** which has a visible light transmission of up to about 75 percent.

13. The composite film of claim **10** which has an emissivity of less than about 0.10.

14. The composite film of claim **13** which has a visible light transmission of about 28 percent to about 47 percent.

15. The composite film of claim **13** which has a visible light transmission up to about 70 percent.

16. The composite film of claim **10** wherein the metal oxide nanoparticles comprise silicon dioxide, aluminum oxide, or a combination thereof.

17. The composite film of claim **10** wherein the infrared reflecting layer comprises at least one metallic layer selected from the group consisting of aluminum, copper, gold, nickel, silver, platinum, palladium, tungsten, titanium, and alloys thereof.

18. A method of manufacturing the low emissivity transparent composite film of claim **1**, comprising:

coating a mixture of an abrasion resistant hardcoat material comprising a polyacrylate polymer and metal oxide nanoparticles to one side of a transparent film substrate;

curing the coated side of the film substrate to form an underlayer having a dried thickness of about 2 to about 6 microns;

sputtering an infrared reflecting layer on the underlayer; and

applying a transparent, protective top coat over the infrared reflective layer, the protective top coat having a thickness of less than 0.5 microns and comprising a polysilazane, fluoro silane, fluoroalkyl silane, or combination thereof;

wherein the composite film has an emissivity of less than about 0.30.