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(54) **APPLICATION OF MULTI-LAYER ANTISTATIC/ANTIREFLECTIVE COATING TO VIDEO DISPLAY SCREEN BY SPUTTERING**

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(57) **ABSTRACT**

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A multi-layer antistatic/antireflective coating having high electrical conductivity (10^3 ohms) and low reflectivity (0.7%) is applied to the outer surface of a video display screen by sputtering. The multi-layer coating includes an inner antistatic layer deposited directly on the video display screen and comprised of ITO, TiO_2 , etc., having a light refractive index in the range of 1.8-2.2 and a thickness in the range of 18-35 nm. The outer antireflective layer is comprised of SiO_2 , MgO , etc., having a light refractive index in the range of 1.3-1.47 and a thickness in the range of 110-140 nm. The multi-layer coating is applied using a sputtering apparatus having a dual vacuum chamber, a diffusion pump connected to one of the chambers, and plural vacuum pumps connected to the diffusion pump and to the dual vacuum chamber with various gauges and valves for monitoring and controlling the sputtering operation.

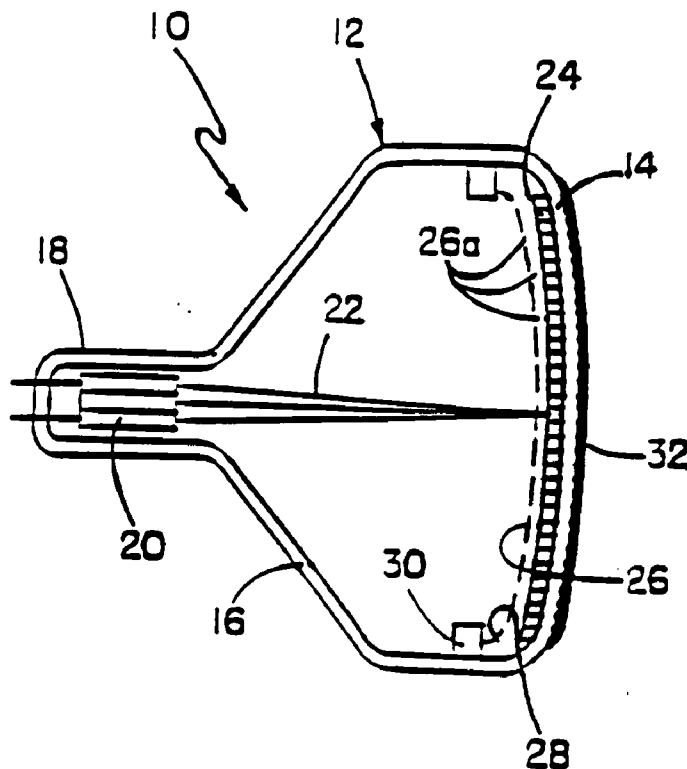
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Related U.S. Application Data

(62) **Division of application No. 10/002,936, filed on Nov. 15, 2001, now Pat. No. 6,764,580.**



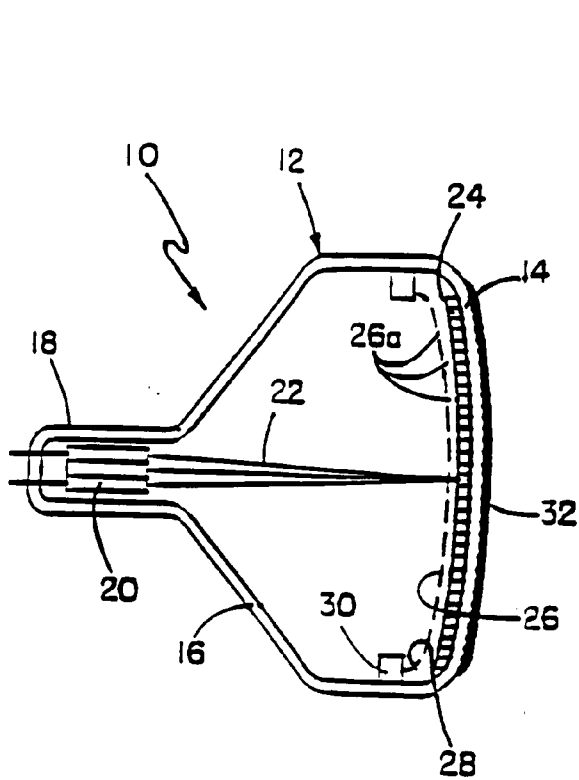


FIG. 1

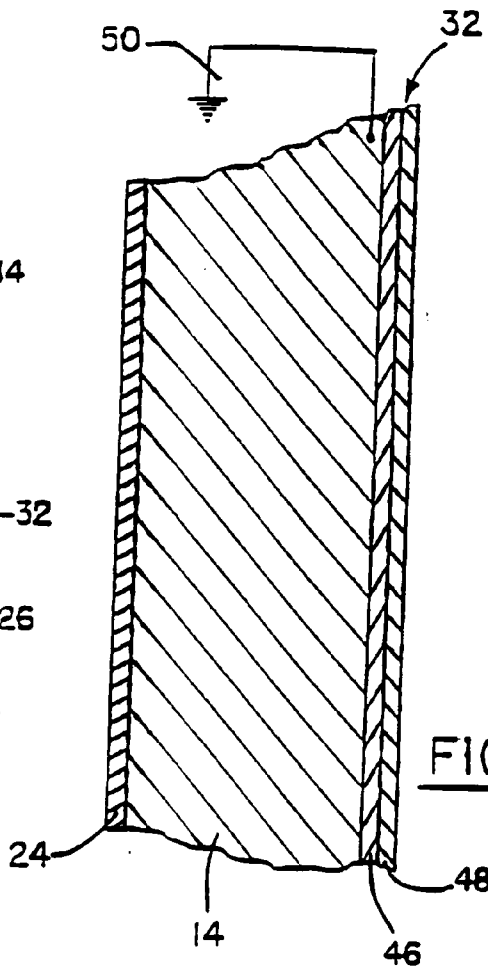


FIG. 2

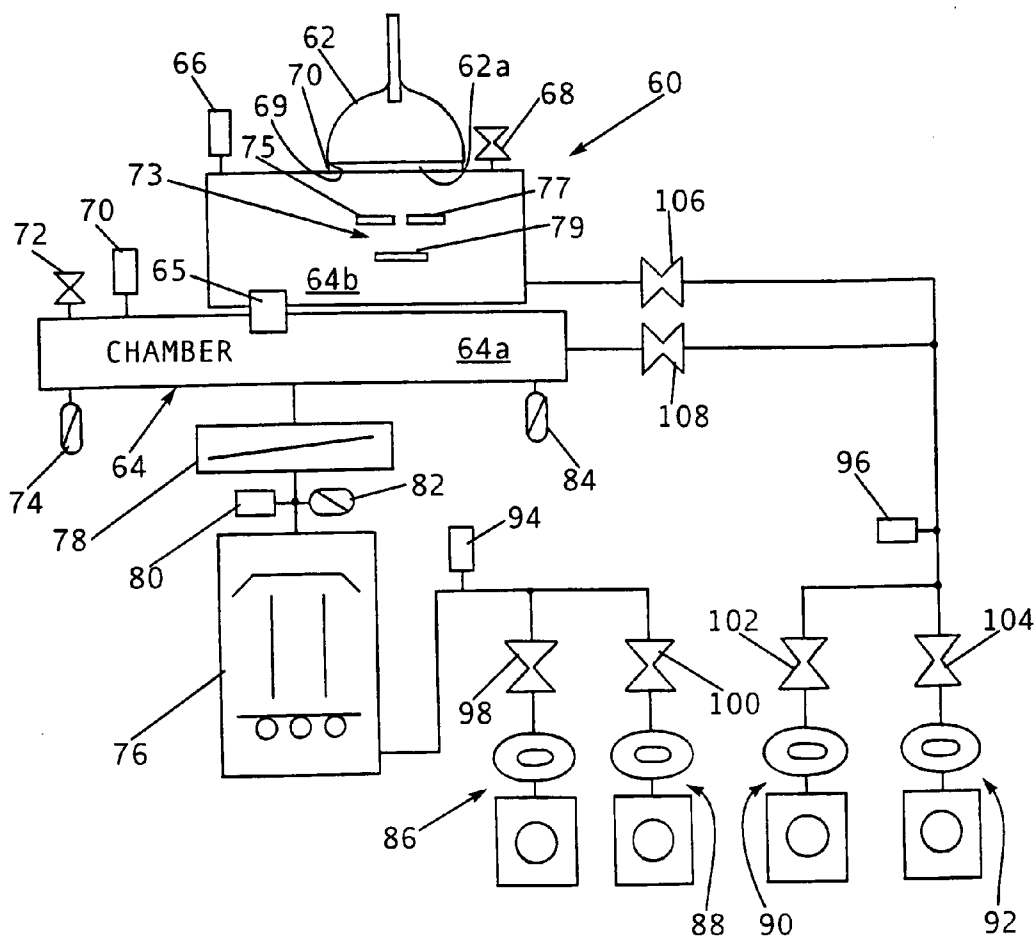


FIG. 3

**APPLICATION OF MULTI-LAYER
ANTISTATIC/ANTIREFLECTIVE COATING TO
VIDEO DISPLAY SCREEN BY SPUTTERING**

**CROSS REFERENCED RELATED
APPLICATION**

[0001] This patent application is a divisional patent application of U.S. patent application Ser. No. 10/002,936 filed on Nov. 15, 2001.

FIELD OF THE INVENTION

[0002] This invention relates generally to surface coatings for video display screens and is particularly directed to a multi-layer antistatic/antireflective coating which is applied to the video display screen by sputtering.

BACKGROUND OF THE INVENTION

[0003] The outer surface of a display screen, or panel, of a video display device such as a cathode ray tube (CRT) is typically provided with a multi-layer coating which performs various functions. These functions include reducing light transmission through the glass display screen/outer coating combination for improved video image contrast. In addition, an inner layer of the surface coating is electrically conductive in order to shield viewers of the video display device from low frequency electromagnetic radiation and to dissipate electrostatic charge on the display panel to neutral ground. The coating also typically provides an antireflective capability to reduce light reflection from the display screen for ease in viewing a video image on the display screen.

[0004] Various approaches are employed in applying the multi-layer coating to the outer surface of a display screen. These techniques include spin and spray coating, sometimes referred to as the wet method, vacuum vapor deposition, and sputtering. Spin and spray coating methods have been widely used with materials containing Ag—Pd or Ag—Au colloid. While the coating thus formed possesses good electrical conductivity and relatively low light reflectance, it is of relatively low quality and involves high processing costs. These wet approaches also suffer from problems with reproducibility and control of the thickness of the coating and can be used with only a limited number of solvents. In addition, the spin and spray coating methods have problems when used with materials comprised of very fine (small) particles in providing uniform particle dispersion. These approaches also suffer from the possibility of environmental contamination.

[0005] The vacuum vapor deposition approach involves high temperature heat treatment and is thus energy intensive and more expensive than the wet coating approach. The sputtering approach has encountered difficulties in forming at high speed a stable SiO₂ layer having a low refractive index for use in the antireflective layer. One approach involving sputtering for applying a light absorptive antireflective layer to a CRT display screen is disclosed in U.S. Pat. No. 5,691,044. This approach applies an inner layer of TiN to the surface of a glass substrate. The TiN layer suffers from instability at the high temperatures used for applying the multi-layer coating to the glass substrate. To improve the heat resistance of the TiN layer, an oxide barrier layer of metal nitride (TiN) is formed on the inner TiN layer. This approach requires various reacting gases such as N₂ and O₂

in the sputtering process which increases the cost and complexity of video display screen manufacture.

[0006] The present invention avoids the limitations of the prior art by providing a multi-layer antistatic/antireflective coating applied by sputtering to the outer surface of a video display screen which allows for precise control over the thickness of the multi-layer coating as well as its light transmission and electrical resistivity characteristics.

**OBJECTS AND SUMMARY OF THE
INVENTION**

[0007] Accordingly, it is an object of the present invention to deposit a multi-layer coating on a video display screen in an environmentally clean manner while maintaining the desired optical and electrical characteristics of the coating.

[0008] It is another object of the present invention to form a two-layer antistatic and antireflective coating on the surface of a video display screen by sputtering.

[0009] Yet another object of the present invention is to provide a low cost, highly reproducible composition for, and a method for applying to the surface of a video display screen, a multi-layer antistatic antireflective coating having a wide range of components.

[0010] A still further object of the present invention is to provide a sputter coating technique for depositing a multi-layer coating on the surface of a video display screen which eliminates the need for a reactive gas and allows for close control of coating conductivity and reflectance by precise control of individual layer thickness.

[0011] The present invention contemplates a process for forming an antistatic/antireflective coating on an outer surface of a video display screen comprising the steps of: sputter-depositing on the outer surface of the video display screen an inner metallic antistatic layer having a precisely controlled thickness within a range of 18-35 nm, wherein a light refractive index of the inner antistatic layer is also precisely controlled within a range of 1.8-2.2; and sputter-depositing on the inner antistatic layer an outer antireflective layer having a precisely controlled thickness within a range of 110-140 nm, wherein a light refractive index of the outer antireflective layer is also precisely controlled within a range of 1.3-1.47. This invention also contemplates a multi-layer coating for a video display panel having the aforementioned composition as well as apparatus for sputter depositing a multi-layer antistatic/antireflective coating on the surface of a video display screen.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The appended claims set forth those novel features which characterize the invention. However, the invention itself, as well as further objects and advantages thereof, will best be understood by reference to the following detailed description of a preferred embodiment taken in conjunction with the accompanying drawings, where like reference characters identify like elements throughout the various figures, in which:

[0013] **FIG. 1** is a longitudinal sectional view of a CRT incorporating an antireflective/antistatic coating in accordance with the principles of the present invention;

[0014] FIG. 2 is a partial sectional view of a flat display screen having an outer surface coating comprised of an inner antistatic layer and an outer antireflective layer in accordance with the present invention; and

[0015] FIG. 3 is a simplified combined schematic and block diagram of apparatus for applying a multi-layer antireflective/antistatic coating on the outer surface of a video display screen by sputtering in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] Referring to FIG. 1, there is shown a longitudinal sectional view of a color CRT 10 incorporating an antistatic/antireflective coating 32 applied by sputtering in accordance with the present invention. In the following discussion the terms "display screen", "display panel" and "faceplate" are used interchangeably. In addition, the terms "layer" and "coating" are used synonymously. CRT 10 includes a sealed glass envelope 12 having a forward faceplate or display screen 14, an aft neck portion 18, and an intermediate funnel portion 16. Disposed on the inner surface of glass display screen 14 is a phosphor screen 24 which includes plural discrete phosphor deposits, or elements, which emit light when an electron beam is incident thereon to produce a video image on the display screen. Color CRT 10 includes three electron beams 22 directed onto and focused upon the CRT's glass display screen 14. Disposed in the neck portion 18 of the CRT's glass envelope 12 are plural electron guns 20 typically arranged in an inline array for directing the electron beams 22 onto the phosphor screen 24. The electron beams 22 are deflected vertically and horizontally in unison across the phosphor screen 24 by a magnetic deflection yoke which is not shown in the figure for simplicity. Disposed in a spaced manner from phosphor screen 24 is a shadow mask 26 having a plurality of spaced electron beam passing apertures 26a and a skirt portion 28 around the periphery thereof. The shadow mask skirt portion 28 is securely attached to a shadow mask mounting fixture 30 around the periphery of the shadow mask. The shadow mask mounting fixture 30 is attached to an inner surface of the CRT's glass envelope 12 and may include conventional attachment and positioning structures such as a mask attachment frame and a mounting spring which also are not shown in the figure for simplicity. The shadow mask mounting fixture 30 may be attached to the inner surface of the CRT's glass envelope 12 and the shadow mask 26 may be attached to the mounting fixture by conventional means such as weldments or a glass-based frit.

[0017] Referring to FIG. 2, there is shown a partial sectional view of a portion of the CRT's glass display screen 14 having the aforementioned phosphor layer 24 on the inner surface thereof and an outer antistatic/antireflective coating 32 on the outer surface thereof in accordance with the present invention. The glass display screen 14 of FIG. 2 is shown as being flat as the present invention is applicable to both curved display screens as shown in FIG. 1 as well as to flat display screens as shown in FIG. 2. In addition, while the present invention has been illustrated in the figures in terms of use on the outer surface of the display screen of a CRT, the present invention is not limited to use with this type of display device. For example, the antistatic/antireflective coating 32 of the present invention may be used

equally as well on the outer surface of the display panel of virtually any type of self-emitting color display device, i.e., where the video image is produced by phosphor activated by energetic electrons incident thereon. Self-emitting color display devices other than CRTs include field emission displays, plasma discharge panels, vacuum fluorescent screens, and gas discharge screens. The phosphor layer 24 disposed on the inner surface of the glass display screen 14 may be in the form of a large number of discrete dots or stripes.

[0018] In accordance with the present invention, the antistatic/antireflective coating 32 includes an inner antistatic layer 46 and an outer antireflective layer 48. A conductor 50 may be attached to the inner antistatic layer 46 or to the outer surface portion of the display screen 14 for electrically coupling the display screen to neutral ground potential. In this manner, the build up of electrostatic charge on the display screen 14 is limited by discharging the electrostatic charge on the display screen to neutral ground via the electrically conductive inner antistatic layer 46.

[0019] Shown in FIG. 3 is a simplified combined schematic and block diagram of a sputter deposition apparatus 60 for applying an antistatic/antireflective coating to the outer surface of the glass display screen 62a of a CRT 62 in accordance with one aspect of the present invention. Sputter deposition apparatus 60 includes a dual chamber 64 comprised of a larger chamber 64a and a smaller chamber 64b which are connected together by means of a valve 65. A conventional sputtering system 73 is disposed within the smaller vacuum chamber 64b for sputtering targets onto the outer surface of the display screen 62a of CRT 62. Each of the larger chamber 64a and the smaller chamber 64b has its own vacuum gauge and valve for controlling the respective pressures therein. Thus, the larger vacuum chamber 64a is provided with vacuum gauges 70, 74, and 84 for monitoring the pressure therein. A discharge valve 72 allows for air to enter the larger chamber 64a such as for performing maintenance on the larger chamber. Vacuum gauge 66 permits monitoring of the pressure in the smaller vacuum chamber 64b, while a discharge valve 68 allows for the entry of air into the smaller chamber for inserting or removing the display screen 62a of CRT 62. A diffusion pump 76 is connected to the combination of the larger chamber 64a and smaller chamber 64b via a gate 78. Vacuum gauges 80 and 82 are also connected between the diffusion pump 76 and the combination of the larger chamber 64a and smaller chamber 64b for monitoring the vacuum level within the diffusion pump. A pair of mechanical pumps 86 and 88 are connected to the diffusion pump 76 by means of respective valves 98 and 100. A vacuum gauge 94 is also connected between the mechanical pumps 86, 88 and the diffusion pump 76 for monitoring the pressure of the vacuum pumps. The combination of a pair of mechanical pumps 90 and 92 is coupled to the larger chamber 64a and the smaller chamber 64b by means of respective valves 108 and 106. In addition, mechanical pumps 90 and 92 are coupled to the valves 106 and 108 by means of valves 102 and 104, respectively, as well as by means of a vacuum gauge 96. Vacuum gauge 96 allows for monitoring the pressure of the vacuum pumps 90 and 92. The use of the larger chamber 64a in combination with the smaller chamber 64b allows for a reduction in the pumping time required for evacuating these chambers. The combination of diffusion pump 76 and mechanical pumps

86, 88, 90 and **92** are used for evacuating the larger and smaller chambers **64a** and **64b**.

[0020] Disposed within the smaller vacuum chamber **64b** are first and second cathodes **75** and **77**. The first cathode **75** is comprised of the material to be sputtered on the outer surface of the CRT's display screen **62a** in the form of the first, inner antistatic layer. The second cathode **77** is comprised of the material for forming the second, outer antireflective layer deposited on the inner antistatic layer. The operation of the first and second cathodes **75, 77** is sequential, with the first cathode initially actuated for depositing the inner layer, followed by activation of the second cathode **77** for deposit of the outer layer of the multi-layer coating. The first and second cathodes **75, 77** are sequentially bombarded by positive ions using a positive ion source **79** as is conventional in sputtering devices. As a result of this ion bombardment, the first and second cathodes **75, 77** emit extremely small particles of the cathode material which are deposited uniformly on the outer surface of the CRT's display screen **62a**.

[0021] The sputter deposition apparatus **60** operates in the following manner. Mechanical pumps **86** and **88** are turned on for pumping the diffusion pump **76** with valves **98** and **100** in the open position. Mechanical pumps **90** and **92** are turned on for pumping the larger vacuum chamber **64a** with valves **102, 104** and **108** all in the open position. Valves **98, 100, 102** and **104** are always open. When the pressure of the diffusion pump **76** and the pressure in the larger vacuum chamber **64a** reach the working pressure, gate **78** opens and valve **108** closes. The display screen **62a** of CRT **62** is then loaded in an aperture **69** in the smaller vacuum chamber **64b** and valve **106** opens for pumping the smaller vacuum chamber down to the working pressure by means of mechanical pumps **90** and **92**. A seal **71** is disposed about aperture **69** in the smaller vacuum chamber **64b** to maintain the smaller vacuum chamber under vacuum when the CRT **62** is inserted in the smaller vacuum chamber for coating its display screen **62a**. When the pressure within the smaller vacuum chamber **64b** reaches the working pressure, valve **65** disposed between the larger and smaller vacuum chambers **64a, 64b** opens to equalize the pressure between the two chambers. The sputtering system within the smaller vacuum chamber **64b** then deposits the sputtering targets onto the outer surface of the CRT's display screen **62a**. This is accomplished by first bombarding the first cathode **75** with positive ions to produce small particles of the first cathode's composition which are deposited on the outer surface of the CRT's display screen **62a**. This first layer is the inner antistatic layer. The second cathode **77** is then bombarded by positive ions to produce small particles of the second cathode's composition which are deposited in the form of a second outer layer on the inner antistatic layer. The second outer layer is the antireflective layer of the multi-layer coating on the CRT's display screen **62a**. After coating the outer surface of the CRT's display screen **62a** with the multi-layer antistatic/antireflective coating of the present invention, valve **65** closes and valve **68** opens for allowing air into the smaller vacuum chamber **64b** while the larger chamber **64a** is maintained under vacuum. The CRT **62** is then unloaded, or removed, from the smaller vacuum chamber **64b** and another CRT is loaded in the smaller vacuum chamber. For coating the display screen of the next CRT, only the smaller chamber **64b** needs to be evacuated by pumping. Once the smaller chamber **64b** is evacuated, gate

65 is opened and the pressure in the larger and smaller chambers is equal. This arrangement and procedure reduces the time for reaching the working pressure in the two chambers. The above described sequence of steps is then repeated for the new CRT now loaded in the small vacuum chamber **64b**. Periodically the larger and smaller vacuum chambers **64a, 64b** must be cleaned. Closure of gate **78** allows the two chambers to be isolated from the diffusion pump **76** while the pump continues to run for cleaning the chambers. Once cleaned, the vacuum chambers are reconnected to the diffusion pump **76** for evacuation. This procedure reduces downtime for maintenance and allows for the processing of a larger number of CRTs.

[0022] The sputter deposition apparatus **60** of FIG. 3 permits the thickness of the inner antistatic layer **46** to be controlled with great precision. The thickness of the inner antistatic layer **46** may be controlled to within 2-8 nm and is preferably in the range of 18-35 nm. The inner antistatic layer **46** is preferably formed of a doped metallic oxide, such as indium oxide doped with tin (ITO), tin oxide doped with fluorine (SnO₂:F), zinc oxide doped with indium (ZnO:In), zinc oxide doped with fluorine (ZnO:F), zinc oxide doped with aluminum (ZnO:Al), zinc oxide doped with tin (ZnO:Sn), or mixtures thereof. By precisely controlling the thickness of the inner antistatic layer **46**, its light refractive index may be controlled to be within the range of 1.8-2.2. The inner antistatic layer **46** is preferably provided with a low conductivity such as on the order of 10³ ohms and a low reflectance on the order of 0.7%. The outer antireflective layer **48** preferably includes aluminum oxide (Al₂O₃), titanium oxide (TiO₂), zinc oxide (ZnO), zirconium oxide (ZrO₂), chrome oxide (Cr₂O₃), silica (SiO₂), or mixtures thereof. The thickness of the outer antireflective layer **48** may also be precisely controlled so as to be within a range of 110-140 nm. By thus controlling the thickness of the outer antireflective layer **48**, its light refractive index may be precisely controlled to be within the range of 1.3-1.47. The multi-layer antistatic/antireflective coating **32** preferably has high electrical conductivity (n 10³ ohms) and low light reflectivity (n 0.7%).

[0023] While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the relevant arts that changes and modifications may be made without departing from the invention in its broader aspects. Therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention. The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only and not as a limitation. The actual scope of the invention is intended to be defined in the following claims when viewed in their proper perspective based on the prior art.

I claim:

1. A multi-layer coating for a video display panel, said coating comprising:

an inner metallic antistatic layer disposed on an outer surface of the video display panel having a precisely controlled thickness within a range of 18-35 nm, wherein a light refractive index of said inner antistatic layer is determined by the thickness of said inner antistatic layer and said light refractive index is also precisely controlled within a range of 1.8-2.2; and

an outer antireflective layer disposed on said inner antistatic layer and having a precisely controlled thickness within a range of 110-140 nm, wherein a light refractive index of said outer antireflective layer is also precisely controlled within a range of 1.3-1.47.

2. The coating of claim 1 wherein said inner antistatic layer is comprised of a doped metallic oxide.

3. The coating of claim 2 wherein said doped metallic oxide is ITO, SnO₂:F, ZnO:In, ZnO:F, ZnO:Al, ZnO:Sn, or mixtures thereof.

4. The coating of claim 1 wherein said outer antireflective layer is comprised of Al₂O₃, TiO₂, ZnO, ZrO₂, Cr₂O₃, MgO, SiO₂, or mixtures thereof.

5. The coating of claim 2 wherein said multi-layer coating has an electrical conductivity on the order of 10³ ohms.

6. The coating of claim 4 wherein said multi-layer coating has a reflectivity on the order of 0.7%.

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