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(54) **Electromagnetic shield**

(57) A display screen filter is provided which effectively shields the electromagnetic waves emanating from the screen of a device, allows a large amount of visible light to penetrate, and causes the surface reflection of visible light to decrease. The filter, which is used as an electromagnetic shield, comprises a transparent substrate, an electroconductive lattice pattern and an electroconductive layer selected from: (i) an electroconductive layer comprising at least one metal layer and at least one dielectric layer, said metal and dielectric layers being arranged in alternating positions, and (ii) an electroconductive layer comprising at least one layer with a high refractive index and at least one layer with a low refractive index, said high-and low-refractive index layers being arranged in alternating positions.

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Description

[0001] The present invention relates to a shield against electromagnetic waves (, hereinafter referred to as a electromagnetic shield).

[0002] Display devices have been known to be utilized with a display screen filter, i.e. a front panel, comprising an electromagnetic shield which can shield electromagnetic wave leakage which radiates from the devices. The plasma display panel (,hereinafter referred to as PDP,) has been developed to obtain a relatively large and flat display. PDP generates a comparably larger electromagnetic wave leakage than the prior cathode ray tube display (, hereinafter referred to as CRT,) and therefore, it is desirable to develop a display screen filter that shields electromagnetic waves more efficiently, especially for PDP.

[0003] Several electromagnetic shields which can be used for a front panel for a display device have been known, such as a shield comprising a transparent substrate and an electroconductive lattice pattern thereon and a shield comprising a transparent substrate and an electroconductive layer thereon. In these electromagnetic shields, the decrease in size of openings in the electroconductive lattice pattern, the increase in line width of the lattice(s), or the increase in thickness of the electroconductive layer is necessary in order to effectively shield the electromagnetic waves by utilizing these electromagnetic shields for the front panel for PDP. Consequently, the visible light transmittance of these electromagnetic shields tends to be low.

[0004] An electromagnetic shield wherein the electroconductive lattice pattern and an electroconductive layer are arranged on a transparent substrate has also been known (Japanese Patent Application Laid-Open (JP-A) No. 57-154898; corresponding to United States Patent (USP) 4,412,255) for such utilization. The electroconductive layer of this conventional electromagnetic shield is made of either only a metal layer or a complex oxide layer consisting of indium oxide and tin oxide. (Hereinafter, the complex oxide consisting of indium oxide and tin oxide is referred to as ITO.) When the said electromagnetic shield is used as a front panei for PDP, the visible light transmittance of the electromagnetic shield tends to be low and/or the visible light reflection on the surface of the electromagnetic shield tends to be high. Furthermore, in the said electromagnetic shield, the electroconductive lattice pattern is in contact with the electroconductive layer inside of the transparent substrate, and the reflection on the surface of the electromagnetic shield tends to be high when the shied is used without another layer such as an anti-reflection layer being arranged onto the surface of the shield.

[0005] The present inventors have tried to develop an electromagnetic shield which efficiently shields electromagnetic wave leakage from the screen of a display device, of which visible light transmittance is high and of which visible light reflection on the surface is low. As a result, it has been found that an electromagnetic shield comprising a transparent substrate, an electroconductive lattice pattern and a specific electroconductive layer can efficiently shield electromagnetic wave, the visible light transmittance thereof is high and the visible light reflection on the surface thereof is low. The present invention has been accomplished on the basis of the above findings.

[0006] Consequently, the present invention provides an electromagnetic shield comprising a transparent substrate, an electroconductive lattice pattern and an electroconductive layer selected from (i) an electroconductive layer comprising a metal layer and a dielectric layer, each layer arranged in alternating positions, or (ii) an electroconductive layer comprising a layer with a high-refraction index and a layer with a low-refraction index, each layer arranged in alternating positions.

[0007] The present invention also provides a front panel for a display, which comprises the said electromagnetic shield.

[0008] The present invention further provides a display comprising the said electromagnetic shield.

[0009] The present invention still further provides a method of shielding against electromagnetic waves generated by a display, which comprises placing the said electromagnetic shield in front of the display.

[0010] Figure 1, Figure 2, Figure 4 and Figure 6 set forth the cross sectional views of the electromagnetic shields obtained in Example 1, Comparative Example 1, Example 3 and Comparative Example 5, respectively.

[0011] Figure 3 and Figure 5 set forth the cross sectional view of the electromagnetic shield-intermediate obtained during the procedures of Example 3 and Comparative Example 5, respectively.

[0012] The present invention sets forth an electromagnetic shield which effectively shields the electromagnetic waves emanating from the display device. This electromagnetic shield allows a relatively large amount of visible light to penetrate, allows the surface reflection of visible light to decrease, and can be used effectively as a display screen filter, especially for a front panel for PDP. More specifically, the present invention provides an electromagnetic shield comprising a transparent substrate, an electroconductive lattice pattern and an electroconductive layer selected from (i) an electroconductive layer comprising a metal layer and a dielectric layer, each layer arranged in alternating positions, or (ii) an electroconductive layer comprising a layer with a high-refraction index and a layer with a low-refraction index, each layer arranged in alternating positions.

[0013] The electromagnetic shield of the present invention comprises a transparent substrate. Examples of the transparent substrate include a glass panel and a synthetic resin panel. Examples of the synthetic resin include thermoplastic resins such as acrylic resins, polycarbonate resins, polyethylene teraphthalates and polyolefins. The transparent substrate may be one panel, or may be made of two or more panels of the same or different substrates. The transparent substrate may be laminated with a hard coat layer. The hard coat layer on the substrate allows another different layer superimposed on the hard coat layer not to be separated from the substrate.

[0014] To improve the visibility of the display screen through the electromagnetic shield, the transparent substrate may be colored with pigments, dyes, or the like.

[0015] The thickness of the transparent substrate is not particularly restricted and is preferably decided depending on the utilization of the electromagnetic shield. The thickness is usually in the range of about 0.1 mm to about 20 mm, preferably about 0.3 mm to 10 mm.

[0016] The electromagnetic shield of the present invention comprises an electroconductive lattice pattern. When the degree of openings in the lattice pattern, a pitch, is measured with the Tyler scale which is based on the size of openings in wire cloth having 200 openings per 1 inch (25.4mm) (=200 mesh), the lattice pattern in the present invention usually has the pitch of about 40 to about 250 mesh, wherein a line width of the lattice is about 100 μm or less. Preferably, the lattice pattern has a pitch of about 50 to about 200 mesh, wherein a line width of the lattice is about 70 μm or less. When the pitch is ever 250 mesh, the visible light transmittance of the electromagnetic shields tends to be low, causing a visual recognition of the display screen through the electromagnetic shield to decrease. On the other hand, when the pitch is less than 40 mesh, the lattice pattern tends to be discernible, causing the visibility of the display screen through the electromagnetic shield to decrease. Furthermore, when the line width of the lattice is over 100 μm, the lattice pattern tends to be discernible, which also causes a decreased visibility of the display screen. Hence, the lattices such that the line width is less than 10 μm rend to be complicated to manufacture and, therefore, the lattices with a line width of 10 μm or more are preferable.

[0017] The thickness of the lattice pattern is preferably about 2 μm or more, since the lattices such that the thickness is less than about 2 μm, tend to decrease electromagnetic shielding performance.

[0018] The electroconductive lattice pattern may be placed in any location in the electromagnetic shield, such as upon the surface(s) of the transparent substrate(s), and/or in the inner region of the electromagnetic shield, for example, sandwiched between two transparent substrates or buried inside of the substrate. It is preferable to place the said electroconductive lattice pattern into the inner region of the electromagnetic shield, since such placement enable the electroconductive lattice pattern to be preserved tightly in the electromagnetic shield.

[0019] When the electroconductive lattice pattern is placed on the transparent substrate in the electromagnetic shield, the following method may be conducted;

a method comprising the step of laminating an electroconductive mesh onto the transparent substrate, or
a method comprising the steps of appiying a paste made from a metal powder such as silver powder, aluminum powder, gold powder and copper powder, and a binder, which is a kind of a resin for binding a metal powder, on the transparent substrate to form an intended pattern by printing method, and then being cured or being heat-stenciled to be hardened.

[0020] Examples of said electroconductive mesh include a mesh-like sheet comprising a woven fabric made from at least one electroconductive material or a woven resin fabric (a fabric made of synthesized fibers) having metal compounds on the surface. The electroconductive mesh may be colored with a dark coloring material, for example, colored black on the surface in order to decrease the visible light reflection on the surface.

[0021] When the electroconductive lattice pattern is placed inside of the transparent substrate in the electromagnetic shield, the following method may be conducted;

a method comprising the step of polymerizing a monomer and/or a oligomer, while the electroconductive mesh is immersed into the monomer and/or the polymerable oligomer,
a method comprising the step of interposing the electroconductive mesh between two plates of transparent substrates, or
a method comprising the step of superimposing one transparent substrate on the electroconductive lattice pattern which is previously arranged on the other transparent substrate.

[0022] When the electroconductive mesh is interposed between two plates of transparent substrates, an adhesive may be serviced between one substrate, the electroconductive mesh and the other substrate to adhere them one another. An electroconductive mesh, which is immersed with a resin such as an ultraviolet ray curing resin and a heat curing resin, may be arranged between two plates of transparent substrates and then the resin may be cured with ultraviolet radiation or heat. The transparent substrate, electroconductive mesh, and another transparent substrate may also be heat-pressed after adhesive films are interposed between each electroconductive mesh and substrate, respectively. Any adhesive film may be usually employed for the present invention as long as the film has a low softening point and can acquire an adhesiveness in a heat-melting condition to stick to each substrate when heat-pressed. When the transparent substrate is made of acrylic resin, an acrylic-resin film with a low softening point can be used, as the adhesive film. When the transparent substrate is made of a thermoplastic resin, the electroconductive mesh may be sandwiched between two plates of transparent substrates and these two plates are melted to be fixed to each other by being heat-pressed without any adhesive films.

[0023] The electromagnetic shield of the present invention comprises an electroconductive layer. The electroconductive layer is selected from (i) an electroconductive layer comprising a metal layer and a dielectric layer, each layer arranged in alternating positions, or (ii) an electroconductive layer comprising a layer with a high-refraction index and a layer with a low-refraction index, each layer arranged in alternating positions. These electroconductive layers are advantageous from the point that the layers decrease the visible light reflection on the surface of the electromagnetic shield when utilized.

[0024] Examples of metals employed to the metal layer include gold, silver, platinum, palladium, copper, titanium, chrome, molybdenum, nickel, zirconium, and alloys comprising any of the above. Among them, silver and an alloy mainly containing silver are preferred in the view of the electroconductive properties.

[0025] Examples of dielectric materials employed to the dielectric layer include oxides such as indium oxide, tin oxide, silicon oxide, titanium oxide, tantalum oxide, zirconium oxide and zinc oxide, and the complex oxide such as ITO. Among them, indium oxide and ITO are preferred.

[0026] Examples of materials with a high-refraction index employed to the layer with a high-refraction index include oxides such as tin oxide, and the complex oxide such as ITO.

[0027] Examples of the materials with a low-refraction index employed to the layer with a low-refraction index include oxides such as silicon oxide and aluminum oxide.

[0028] It is appropriate if either materials with a high-refraction index or materials with a low-refraction index, or both of them exhibit electroconductivity. Within the materials with a high-refraction index or materials with a low-refraction index listen above, tin oxide, ITO and so on exhibit high electroconductivity.

[0029] Examples of the preferable electroconductive layers include (i) an electroconductive laver comprising a silver-layer or an alloy-layer mainly containing silver, as the metal layer, and an indium oxide-layer or ITO-layer, as the dielectric layer and (ii) the electroconductive layer comprising silicon oxide-layer, as the layer with a low-refraction index, and complex oxide-layers consisting of indium oxide-layer and tin oxide-layer, as the layer with a high-refraction index.

[0030] It is preferred that the most outer layer of both sides of the electroconductive layer is the dielectric layer or the layer with a low-refraction index. Furthermore it is preferred that at least one pair of the metal layer and the dielectric layer, or at least one pair of the layer with a high-refraction index and the layer with a low-refraction index is arranged in the electroconductive layer of the present invention.

[0031] The electroconductive layer in the present invention, which is selected from (i) the electroconductive layer comprising the metal layer and the dielectric layer, each layer arranged in alternating positions, or (ii) the electroconductive layer comprising the layer with a high-refraction index and the layer with a low-refraction index, each layer arranged in alternating positions, reflects less visible light on the surface than a layer made of a metal only, a metal oxide only or ITO layer only, and also reflects less visible light than the transparent substrate only. When the electroconductive layer is used as the most outer layer of the electromagnetic shield, visible light reflection of the shield is desirably decreased without placing another layer such as an anti-reflection layer. In this case, it is preferred that the electroconductive lattice pattern is in the inner region of the transparent substrate, or is on the opposite surface of the substrate to the surface on which the electroconductive layer is.

[0032] The electroconductive layer can be formed, for example, by a vacuum deposition method, a sputtering method or an ion-plating method.

[0033] In the present invention, the electroconductive layer may be directly established to the transparent substrate, or may be established on to the electroconductive lattice pattern which has been previously placed on the transparent substrate. For, example, the electroconducive layer may be established to one or both surfaces of a transparent substrate on which the electroconductive lattice pattern has been previously placed. In this case, the electroconducive layer may be accompanied by another transparent substrate. When the most outer layer of the electromagnetic shield is the electroconductive lattice pattern, it is preferred to establish the electroconductive layer on the opposite surface (of the transparent substrate) to the surface on which the electroconductive lattice pattern exists. When the electroconductive lattice pattern is sandwiched between two transparent substrates or buried inside in the transparent substrate, the electroconductive layer may be established on one or both surfaces of such a transparent substrate. In this case, if (i) a transparent substrate on which the electroconductive layer has been previously placed and (ii) another transparent substrate on which the electroconductive lattice pattern has been previously placed are used to produce the electromagnetic shield, the substrate (i) is preferably placed on to the substrate (ii) so that the opposite surface (of the substrate (i)) to the surface on which the electroconductive layer exists. faces to the surface (of the substrate (ii)) on which the electroconductive lattice pattern exists.

[0034] When the electroconductive layer is placed on the substrate, it is preferable that a substrate of which the thickness is comparably thin is used and the substrate is treated in the form of film-roll, since the electroconductive layer can be placed continuously in a vacuumed environment, resulting in high productivity of placing the electroconductive layer.

[0035] When the electromagnetic shield is used as a display screen filter, it is preferred that both the electroconductive lattice pattern and the electroconductive layer are grounded in order to shield the electromagnetic waves, more effectively. The method of grounding is not restricted. The following method is one example thereof. First, one part of the electroconductive lattice pattern and one part of the electroconductive layer are exposed, and are fixed to an electroconductive material such as an electroconductive tape or an electroconductive paste, and then the electroconductive material is grounded. The electroconductive tape and the electroconductive paste may be used individually or at the same time. For example, when the exposed part of the electroconductive lattice pattern and/or the electroconductive layer is small, the electroconductive paste is attached to the part and the electroconductive tape is superimposed on to the electroconductive paste. In this case, the electromagnetic shield can be effectively grounded by grounding the electroconductive paste.

[0036] The electromagnetic shield of the present invention is a superb electromagnetic shield that effectively shields the electromagnetic waves emanating from the screen of the device, allows a large amount of visible light to penetrate, and allows the surface reflection of visible light to decrease. Therefore, the electromagnetic shield of the present invention can be effectively used for a display screen filter, especially for a front panel for PDP, without decreasing the visibility of the display screen.

[0037] The entire disclosure of the Japanese Patent Application No. 9-243747 filed on September 9, 1997 indicating specification, claims, drawings and summary, are incorporated herein by reference in its entirety.

Examples

[0038] The present invention is described in more detail by following Examples, which should not be construed as a limitation upon the scope of the present invention.

[0039] The evaluation of the acquired electromagnetic shield was conducted by the methods below.

(1) Transmittance rate of visible light:

The transmittance of all the visible light waves (Tt) of the obtained electromagnetic shield was measured with a hazemeter (manufactured by Suga Test Instruments Co., Ltd.) and was set forth as the transmittance rate of the shield.

(2) Reflection rate of visible light:

By using an automatic-recording spectrometer Model MIPS-2000 (manufactured by Shimadzu Corporation), the relative spectral luminous reflection efficacy. which was based on the reflection spectrum in the range of 300 nm to 800 nm, of the obtained electromagnetic shield was measured and was set forth as the reflection rate of the shield.

(3) Electromagnetic wave shielding performance:

Electromagnetic wave strength was measured by a shield material evaluation system Model R 2547 (manufactured by Advantest Corporation), and the electromagnetic wave shielding performance of the obtained electromagnetic shield was calculated according to the following equation. When this value is higher, the electromagnetic wave shielding ability of the electromagnetic shield is higher.

$$\text{Electromagnetic wave shielding performance(dB)} = 20\mathrm{Log}_{10}(X_0/X)$$

(X_0 : electromagnetic wave strength when the electromagnetic shield is not installed, X: electromagnetic wave strength when the electromagnetic shield is installed)

The measurements were conducted at the frequencies of 30MHz, 50MHz, 70MHz, and 100MHz.

Example 1

[0040] An electroconductive mesh, Figure 1 #2, of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 90 mesh, line width: 52 µm, manufactured by Daiwabou Products Co., Ltd.] was fixed to one side of surface of an acrylic plate #1 [size: 200 mm x 200 mm, thickness: 3 mm] by using an adhesive and was cut so that the outer limits of the mesh extruded 5mm beyond the acrylic plate, to obtain an electroconductive lattice-pattern layer. The electroconductive lattice-pattern layer was fixed to an electroconductive film #3 [size: 200 mm x 200 mm] which is made of a polyethylene teraphthalate film [thickness: 50 µm] and an electroconductive layer comprising four indium oxide layers and three silver layers, each arranged in alternating position (i-e-, in order. an indium oxide layer, silver layer, indium oxide layer, silver layer, indium oxide layer, silver layer, indium oxide layer), by using an adhesive, so that the opposite surface (of the eiectroconductive lattice-pattern layer) to the surface on which the said electroconductive mesh #2 is established, faced to the opposite surface (of the electroconductive film #3) to the surface on which the said electroconductive layer is established. Then, a part of the electroconductive film #3, extruding from the acrylic plate, was cut off so that the size of the electroconductive film #3 was adjusted to the size of the acrylic plate. The part of the electroconductive mesh #2, extruding from the acrylic plate, are then folded onto the side surfaces #4. A copper electroconductive tape #5, thinned copper adhesive tape 8321 [width: 20mm, manufactured by Teraoka Manufacturing Co., Ltd.], was arranged to cover the part of the electroconductive mesh that was folded onto the outer boundaries of the acrylic panel for reinforcement, to obtain an electroconductive shield. The cross sectional view of the obtained electroconductive shield is shown in Figure 1. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Example 2

[0041] The same procedure as in Example 1 was conducted except that an electroconductive mesh of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 60 mesh, line width: 55 µ m, manufactured by Daiwabou Products Co., Ltd.] was used instead of the electroconductive mesh #2 [pitch: 90 mesh, line width: 52 µm], to obtain another electroconductive shield. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Comparative Example 1

[0042] The same procedure as in Example 1 was conducted except that the electroconductive film #3 was not used and that an electroconductive mesh #2a of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 140 mesh, line width: 39 µ m, manufactured by Daiwabou Products Co., Ltd.] was used instead of the electroconductive mesh #2 [pitch: 90 mesh, line width: 52 µm], to obtain another electroconductive shield. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Comparative Example 2

[0043] The same procedure as in Comparative Example 1 was conducted except that an electroconductive mesh of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 100 mesh, line width: 44 µm, manufactured by Daiwabou Products Co., Ltd.] was used instead of the electroconductive mesh [pitch: 140 mesh, line width: 39 µm], to obtain another electroconductive shield. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Comparative Example 3

[0044] The same procedure as in Comparative Example 1 was conducted except that an electroconductive mesh of which the surface was colored biack. [size: 210 mm x 210 mm, pitch: 90 mesh, line width: 52 µm, manufactured by Daiwabou Products Co., Ltd.] was used instead of the electroconductive mesh [pitch: 140 mesh, line width: 39 µm], to obtain another electroconductive shield. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Comparative Example 4

[0045] The same procedure as in Comparative Example 1 was conducted except that an electroconductive mesh of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 60 mesh, line width: 55 µm, manufactured by Daiwabou Products Co., Ltd.] was used instead of the electroconductive mesh [pitch: 140 mesh, line width: 39 µm], to obtain another electroconductive shield. The evaluation resuits of the obtained electromagnetic shield are given in Table 1.

Example 3

[0046] Onto each surface of an electroconductive mesh 2b of which the surface was colored black, [size: 210 mm × 210 mm, pitch: 140 mesh, line width: 39 µm, manufactured by Daiwabou Products Co., Ltd.], was placed an adhesive acrylic film 6b, Sandurren 002AN [thickness: 50 µm, manufactured by Kanebuchi Chemical Co., Ltd.]. Further onto each surface thereof, was superimposed an acrylic substrate 1b [thickness: 1.5 mm]. The resulting body was them heat-pressed. After cooling, onto one surface of the said body, was fixed an electroconductive film 3b [size: 210 mm x 210 mm] which is made of a polyethylene teraphthalate film [thickness: 50 µm] and an electroconductive layer comprising four indium oxide layers and three silver layers, each arranged in alternating position (i.e., in order, an indium oxide layer, silver layer, indium oxide layer, silver layer, indium oxide layer, silver layer, indium oxide layer), by using an adhesive, so that the opposite surface (of the electroconductive film 3b) to the surface on which the said electroconductive layer is established, faced to the said body. The resulting body (electromagnetic shield-intermediate) obtained by the above-mentioned procedure is shown in Figure 3.

[0047] A 200 mm x 200 mm sector was then cut out of the electromagnetic shield-intermediate, so that the size of the electroconductive mesh 2b was adjusted to the size of the electromagnetic shield-intermediate and the cross section of the electroconductive mesh 2b was exposed at the cut surface 4b. After an electroconductive paste 7b [silver paste] was applied onto the cut surface 4b, an electroconductive copper tape 5b, thinned copper adhesive tape 8321 manufactured by Teraoka Manufacturing Co., Ltd. was further arranged to cover the electroconductive paste 7b at the cut surface 4b, to obtain an electromagnetic shield. The cross sectional view of the obtained electromagnetic shield is shown in Figure 4. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Example 4

[0048] The same procedure as in Example 3 was conducted except that the following electroconductive film 3c [size: 210 mm x 210 mm] was used instead of the electroconductive film 3b, to obtain another electroconductive shield. The electroconductive film 3c is made of (i) a methacrylic plate having a hard-coat layer, (ii) an electroconductive layer comprising, in order, an ITO layer, silicon oxide layer, ITO laver. silicon oxide laver, being arranged by the DC magnetron sputtering method onto the surface of the hard-coat layer and (iii) an anti-reflection layer. being arranged onto the surface of the electroconductive layer. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Comparative Example 5

[0049] Onto each surface of an electroconductive mesh 2d of which the surface was colored black, [size: 210 mm x 210 mm pitch: 140 mesh, line width: 39 µm, manufactured by Daiwabou Products Co., Ltd.], was placed an adhesive acrylic film 6d, Sandurren 002 AN [thickness: 50 µm, manufactured by Kanebuchi Chemical Co., Ltd.]. Further onto each surface thereof, was superimposed an acrylic substrate 1b [thickness: 1.5 mm]. The resulting body was then heat-pressed. The resulting body (electromagnetic shield-intermediate) obtained by the above-mentioned procedure is shown in Figure 5. A 200 mm x 200 mm sector was then cut out of the electromagnetic shield-intermediate so that the size of the electroconductive mesh 2d was adjusted to the size of the electromagnetic shield-intermediate, and the cross section of the electroconductive mesh 2d was exposed at the cut surface 4d. After an electroconductive paste 7d [silver paste] was applied onto the cut surface 4d, an electroconductive copper tape 5d, thinned copper adhesive tape 8321 manufactured by Teraoka Manufacturing Co., Ltd. was further arranged to cover the electroconductive paste 7d at the cut surface 4d, to obtain an electromagnetic shield. The cross sectional view of the obtained electromagnetic shield is shown in Figure 6. The evaluation results of the obtained electromagnetic shield are given in Table 1

Comparative Example 6

[0050] The same procedure as in Comparative Example 5 was conducted except that an electroconductive mesh of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 80 mesh, line width: 57 µm, manufactured by Serten Co., Ltd.] was used instead of the electroconductive mesh [pitch: 140 mesh, line width: 39 µm], to obtain another electroconductive shield. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Comparative Example 7

[0051] The same procedure as in Comparative Example 5 was conducted except that an electroconductive mesh of which the surface was colored black, [size: 210 mm x 210 mm, pitch: 135 mesh, line width: 44 µm, manufactured by Serten Co., Ltd.] was used instead of the electroconductive mesh [pitch: 140 mesh, line width: 39 µm], to obtain another electroconductive shield. The evaluation results of the obtained electromagnetic shield are given in Table 1.

Table 1

	Transmittance rate (%)	Reflection rate (%)	Electromagnetic wave shielding performance(dB) 30 (MHz)	50 (MHz)	70 (MHz)	100 (MHz)
Example 1	44	5.1	70	73	70	68
Example 2	51	5.2	73	79	75	73
Comparative Exp.1	48	7.2	58	57	58	58
Comparative Exp.2	55	7.3	54	54	54	54
Comparative Exp.3	55	7.3	50	50	50	50
Comparative Exp.4	63	7.2	43	43	43	43
Example 3	45	3.7	72	77	73	73
Example 4	55	1.6	73	73	75	69
Comparative Exp.5	54	4.7	63	64	65	64
Comparative Exp.6	63	5.4	57	58	57	56
Comparative Exp.7	55	5.1	64	66	66	64

Claims

1. An electromagnetic shield comprising a transparent substrate, an electroconductive lattice pattern and an electroconductive layer selected from: (i) an electroconductive layer comprising at least one metal layer and at least one dielectric layer, said metal and dielectric layers being arranged in alternating positions, and (ii) an electroconductive layer comprising at least one layer with a high refractive index and at least one layer with a low refractive index, said high-and low-refractive index layers being arranged in alternating positions.

2. An electromagnetic shield according to claim 1, wherein the electroconductive lattice pattern has a pitch of 40 to 250 mesh and a lattice line width of 100µm or less.

3. An electromagnetic shield according to claim 1 or 2, wherein the thickness of the lattice pattern is 2µm or more.

4. An electromagnetic shield according to any one of claims 1 to 3, wherein the electroconductive lattice pattern comprises a mesh-like electroconductive sheet.

5. An electromagnetic shield according to any one of claims 1 to 4, comprising two or more plates of transparent substrate.

6. An electromagnetic shield according to any one of claims 1 to 5, wherein the electroconductive lattice pattern is sandwiched between two transparent substrates or buried inside the substrate as an inner layer of the electromagnetic shield.

7. An electromagnetic shield according to any one of claims 1 to 6, wherein the outermost layer of both sides of the electroconductive layer is the dielectric layer or the layer with a low refractive index.

8. An electromagnetic shield according to any one of claims 1 to 7, wherein the electroconductive layer comprises a silver layer or an alloy layer mainly containing silver, as the metal layer, and an indium oxide layer or a complex oxide layer consisting of an indium oxide layer and a tin oxide layer, as the dielectric layer.

9. An electromagnetic shield according to any one of claims 1 to 7, wherein the electroconductive layer comprises a silicon oxide layer, as the layer with a low refractive index, and a complex oxide layer consisting of an indium oxide layer and a tin oxide layer, as the layer with a high refractive index.

10. An electromagnetic shield according to any one of claims 1 to 9, wherein the electroconductive layer is used as the outermost layer of the electromagnetic shield.

11. A front panel for a display, which comprises an electromagnetic shield according to any one of claims 1 to 10.

12. A front panel for a plasma display panel, which comprises an electromagnetic shield according to any one of claims 1 to 10.

13. A display, which comprises an electromagnetic shield according to any one of claims 1 to 10.

14. A plasma display panel, which comprises an electromagnetic shield according to any one of claims 1 to 10.

15. A method of shielding against electromagnetic waves generated by a display, which comprises placing an electromagnetic shield according to any one of claims 1 to 10 in front of the display.

16. Use of an electromagnetic shield according to any one of claims 1 to 10 as a front panel for a display.

Figure 1

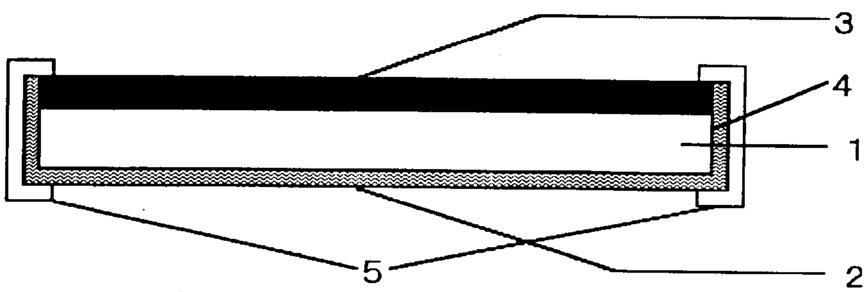

Figure 2

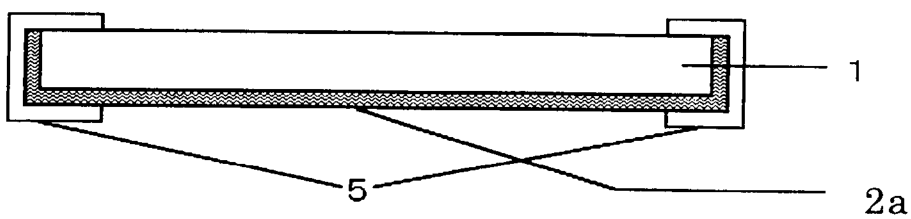

Figure 3

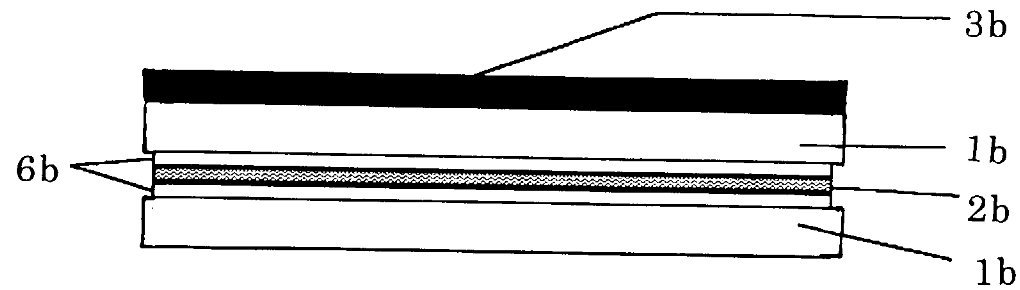

Figure 4

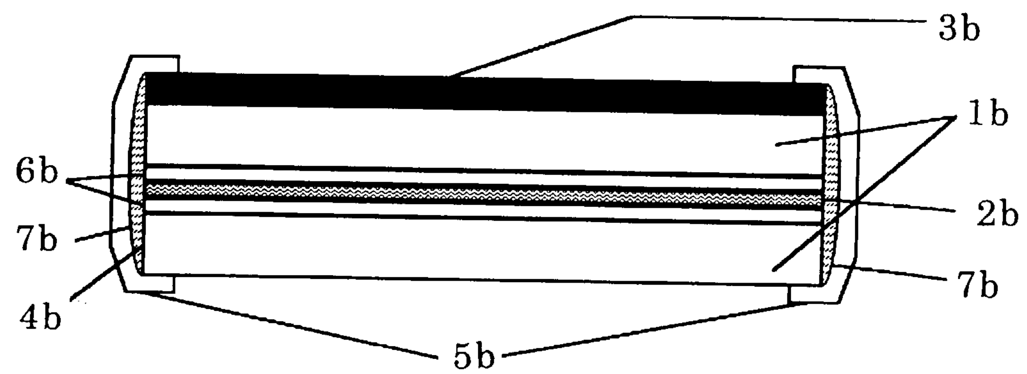

Figure 5

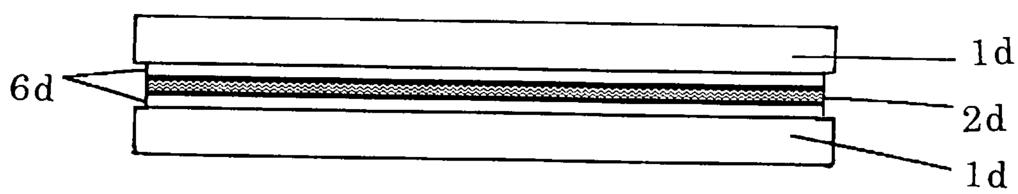

Figure 6