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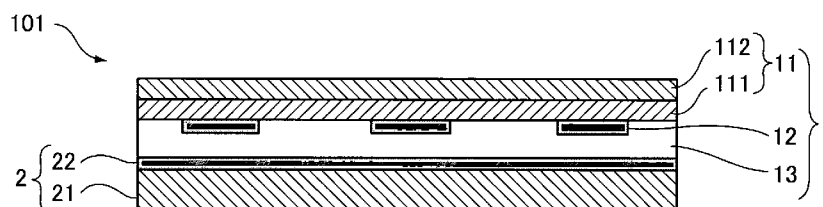
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(54) Title: TRANSPARENT PLANAR BODY AND TRANSPARENT TOUCH SWITCH

[Fig.1]



(57) Abstract: Disclosed are a transparent planar body and a transparent touch switch, which are capable of providing improved visibility. The transparent planar body I includes a silicon-containing layer 11, an adhesive layer 13 disposed on at least one side of the silicon-containing layer 11, and a patterned transparent conductive layer 12 disposed between the silicon-containing layer 11 and the adhesive layer 13. With respect to the absolute value of the difference between the reflectance of a pattern-forming region, where the transparent conductive layer 12 is formed, at each wavelength of light applied thereto through the silicon-containing layer II and the reflectance of a pattern-non-forming region, where the transparent conductive layer 12 is not formed, at each wavelength of light applied thereto through the silicon-containing layer 11, the difference between the maximum and minimum of the absolute value is 0.65 or less at 450 nm to 700 nm.

Description

TRANSPARENT PLANAR BODY AND TRANSPARENT TOUCH SWITCH

Technical Field

[0001]

The present invention relates to a transparent planar body and a transparent touch switch.

Background Art

[0002]

Various structures have been proposed for touch switches for detecting the location of input. As an example thereof, a capacitive touch switch is known. For example, a touch switch disclosed in Patent Document 1 comprises a dielectric layer lying between a pair of transparent planar bodies each provided with a transparent electric conductor patterned into a predetermined shape. When a finger or the like touches the operation surface, utilizing the change in capacitance caused by grounding through the human body, the touch location can be detected.

[0003]

Patent Document 1: JP-A-2003-173238 (Figs. 1 and 5)

Disclosure of the Invention

Problems to be Solved by the Invention

[0004]

Such a touch switch is mounted on the surface of a liquid crystal display, CRT, or the like. However, there is a problem in that the pattern shape of the transparent electric conductor formed in the transparent planar body is conspicuous, resulting in reduced visibility. Such a problem is present not only in capacitive touch switches but also in touch switches with a matrix pattern, etc.

[0005]

Thus, an object of the invention is to provide a transparent planar body and a transparent touch switch, which are capable of providing improved visibility.

Means for Solving the Problems

[0006]

The object of the invention mentioned above can be achieved by a transparent planar body comprising a silicon-containing layer; an adhesive layer disposed on at least one side of the silicon-containing layer; and a patterned transparent conductive layer disposed between the silicon-containing layer and the adhesive layer. With respect to the absolute value of the difference between the reflectance of a pattern-forming region, where the transparent conductive layer is formed, at each wavelength of light applied thereto through the silicon-containing layer and the reflectance of a pattern-non-forming region, where the transparent conductive layer is not formed, at each wavelength of light applied thereto through the silicon-containing layer, the difference between the maximum and minimum of the absolute value is 0.65 or less at 450 nm to 700 nm.

[0007]

In the transparent planar body, it is preferable that the maximum is 0.8 or less.

[0008]

It is preferable that the silicon-containing layer includes a low-refractive-index layer and a high-refractive-index layer having a higher optical refractive index than the low-refractive-index layer, and the transparent conductive layer is formed on the low-refractive-index-layer side of the silicon-containing layer.

[0009]

It is preferable that the low-refractive-index layer has an optical refractive index of 1.45 to 1.47, and the high-refractive-index layer has an optical refractive index of more than 1.47 and not more than 1.53.

[0010]

It is preferable that the low-refractive-index layer is made of SiO₂, and the high-refractive-index layer is made of a glass material.

[0011]

It is preferable that the transparent conductive layer has a thickness of 12 nm or less.

[0012]

It is also preferable that the transparent conductive layer has a thickness of 12 nm or more and 14 nm or less, and the low-refractive-index layer has a thickness of 10 nm to 45 nm.

[0013]

It is preferable that the thickness of the low-refractive-index layer is not greater than the value calculated by the following equation 1:

$$\text{Equation 1: } 0.3409X^2 - 16.705X + 217.73$$

wherein X represents the thickness of the transparent conductive layer.

[0014]

It is preferable that the thickness of the low-refractive-index layer is not greater than the value calculated by the following equation 2:

$$\text{Equation 2: } -10X + 185$$

wherein X represents the thickness of the transparent conductive layer.

[0015]

The object of the present invention can also be achieved by a transparent touch switch comprising the above transparent planar body, the transparent planar body being arranged in such a manner that the transparent conductive layer of the transparent planar body and a second transparent conductive layer that is different from the transparent conductive layer of the transparent planar body face each other or face the same direction.

Advantage of the Invention

[0016]

According to the invention, a transparent planar body and a transparent touch switch, which are capable of providing improved visibility, can be provided.

Brief Description of the Drawings

[0017]

Fig. 1 a schematic cross-sectional view of a transparent touch switch according to an embodiment of the invention.

Fig. 2 is a plane view of a portion of the transparent touch switch shown in Fig. 1.

Fig. 3 is a plane view of another portion of the transparent touch switch shown in Fig. 1.

Fig. 4 is a plane view of a portion of a variation of the transparent touch switch shown in Fig. 1.

Fig. 5 is a plane view showing another portion of the variation of the transparent touch switch shown in Fig. 1.

Fig. 6 is a schematic cross-sectional view of a transparent planar body forming the transparent touch switch shown in Fig. 1.

Fig. 7 shows the results of measurement of the difference in reflectance depending on the presence of a transparent conductive layer in a sample.

Fig. 8 shows the results of simulation of the difference in reflectance

depending on the presence of a transparent conductive layer when the transparent conductive layer thickness is 8 nm.

Fig. 9 shows the results of simulation of the difference in reflectance depending on the presence of a transparent conductive layer when the transparent conductive layer thickness is 10 nm.

Fig. 10 shows the results of simulation of the difference in reflectance depending on the presence of a transparent conductive layer when the transparent conductive layer thickness is 12 nm.

Fig. 11 shows the results of simulation of the difference in reflectance depending on the presence of a transparent conductive layer when the transparent conductive layer thickness is 14 nm.

Fig. 12 is a graph showing the relation between the thickness of a low-refractive-index layer that allows the difference between the maximum and minimum of the reflectance difference to be 0.65 or less or 0.5 or less and the thickness of a transparent conductive layer.

Fig. 13 is a graph showing the relation between the thickness of a low-refractive-index layer that allows where the maximum of the reflectance difference to be 0.8 or less or 0.7 or less and the thickness of a transparent conductive layer.

Best Mode for Carrying Out the Invention

[0018]

Hereinafter, some embodiments of the invention will be described with reference to the attached drawings. In order to facilitate understanding of the configuration, the drawings are not to scale, and components are partially enlarged or reduced.

[0019]

Fig. 1 is a schematic cross-sectional view of a transparent touch switch according to one embodiment of the invention. The transparent touch switch 101 is a capacitive touch switch, and includes a first transparent planar body 1 and a second transparent planar body 2. The first transparent planar body 1 includes a transparent silicon-containing layer 11, an adhesive layer 13 disposed on at least one side of the silicon-containing layer 11, and a patterned transparent conductive layer 12 disposed between the silicon-containing layer 11 and the adhesive layer 13. The second transparent planar body 2 includes a patterned transparent conductive layer 22 on one side of a transparent substrate 21. The first transparent planar body 1 and the second transparent planar body 2 are arranged

in such a manner that the transparent conductive layers 12 and 22 face each other. They may also be arranged in such a manner that the transparent conductive layers 12 and 22 face the same direction.

[0020]

The silicon-containing layer 11 includes a low-refractive-index layer 111 and a high-refractive-index layer 112 having a higher optical refractive index than the low-refractive-index layer 111. The transparent conductive layer 12 is formed on the low-refractive-index-layer-111 side of the silicon-containing layer 11. The low-refractive-index layer 111 may be made of SiO₂, for example. The low-refractive-index layer 111 preferably has an optical refractive index within a range of 1.45 to 1.47. The high-refractive-index layer 112 may be made of a glass material, such as soda glass, alkali-free glass, or borosilicate glass, for example. The thickness of the high-refractive-index layer 112 is not limited. However, it is preferable that the high-refractive-index layer 112 has a thickness of about 0.3 to about 5.0 mm and an optical refractive index of more than 1.47 and not more than 1.53. If the surface of the silicon-containing layer 11 is to be touched by a pen or a finger, such a surface may be treated for improving transparency, abrasion resistance, wear resistance, and non-glare properties. It is also possible to put a film thereon for preventing cracks.

[0021]

The transparent substrate 21 is preferably made of a highly transparent material. Specific examples thereof include flexible films of polyethylene terephthalate (PET), polyimide (PI), polyethylene naphthalate (PEN), polyethersulfone (PES), polyetheretherketone (PEEK), polycarbonate (PC), polypropylene (PP), polyamide (PA), polyacryl (PAC), acryl, amorphous polyolefinic resins, cyclic polyolefinic resins, alicyclic polyolefins, transparent thermoplastic norbornene resins, and the like; laminates of two or more kinds thereof; glass; etc.

[0022]

Examples of materials for the transparent conductive layers 12 and 22 include transparent conductive materials such as indium tin oxide (ITO), indium oxide, antimony-doped tin oxide, fluorine-doped tin oxide, aluminum-doped zinc oxide, potassium-doped zinc oxide, silicon-doped zinc oxide, zinc-oxide- and tin-oxide-based materials, indium-oxide- and tin-oxide-based materials, zinc-oxide-, indium-oxide-, and magnesium-oxide-based materials, zinc oxide, and tin oxide films; metal materials such as tin, copper, aluminum, nickel, and chromium; and metal oxide materials. Combined use of two or more kinds of these materials

is also possible. Elemental metals sensitive to acid and alkali may also be used as conductive materials. The transparent conductive layers 12 and 22 can be formed by a PVD method, such as sputtering, vacuum deposition, or ion plating, a CVD method, a coating method, a printing method, etc., for example. The transparent conductive layers 12 and 22 each preferably have a thickness of 14 nm or less, and more preferably 12 nm or less. When the thickness is 5 nm or less, such a layer is less likely to be a continuous film, making it difficult to form a stable conductive layer.

[0023]

It is also possible to use, as a material for a transparent conductive layer, a composite material prepared by dispersing ultrafine conductive carbon fibers, such as carbon nanotubes, carbon nanohorns, carbon nanowires, carbon nanofibers, or graphite fibrils, in a non-conductive polymer material.

[0024]

As shown in Fig. 2 and Fig. 3, the transparent conductive layers 12 and 22 are formed as assemblies of a plurality of parallel, belt-like conductive members 12a and 22a, respectively. The belt-like conductive members 12a and 22a of the transparent conductive layers 12 and 22 are arranged orthogonal to each other. The transparent conductive layers 12 and 22 are connected to an external drive circuit (not illustrated) via a routing circuit (not illustrated) made of conductive ink, etc. The pattern shapes of the transparent conductive films 12 and 22 are not limited to those described in this embodiment, and any shapes are possible as long as the finger contact area, for example, can be detected. For example, as shown in Figs. 4 and 5, the transparent conductive films 12 and 22 may be configured to include a plurality of linearly connected, diamond-shaped conductive members 12b and 22b, respectively. They may be arranged in such a manner that the direction in which the diamond-shaped conductive members 12b of the transparent conductive layer 12 are connected is orthogonal to the direction in which the diamond-shaped conductive members 22b of the transparent conductive layer 22 are connected, and also that, in plane view, upper and lower diamond-shaped conductive members 12b/22b do not overlap each other. Regarding the operation performance, such as resolution, of the transparent touch switch 101, when the first transparent planar body 1 and the second transparent planar body 2 are put together, if there is a smaller area that has no conductive member, then such a configuration achieves higher performance. From this point of view, with respect to the pattern shapes of the transparent conductive layers 12 and 22, the configuration having a plurality of linearly connected, diamond-shaped conductive members 12b and 22b is preferred to a configuration having rectangular pattern

shapes.

[0025]

The transparent conductive layers 12 and 22 can be patterned as follows. A mask portion having a desired pattern shape is formed on the surface of each of the transparent conductive films 12 and 22 formed on a silicon-containing layer and a transparent substrate, respectively, and exposed portions are removed by etching with an acid liquid or the like. The mask portion is then dissolved by an alkaline liquid, etc.

[0026]

The adhesive layer 13 may be made of an ordinary transparent adhesive, such an epoxy-based or acrylic adhesive, and may include a core material formed of a transparent film of a norbornene resin. The adhesive layer may be formed by stacking several sheets of an adhesive material or by stacking sheets of several kinds of adhesive materials. The thickness of the adhesive layer 13 is not limited. In practical application, the thickness is preferably 100 μm or less, and particularly preferably 25 μm to 75 μm . The adhesive layer preferably has an optical refractive index of 1.40 to 1.70, and more preferably 1.46 to 1.57. As the refractive index of the adhesive layer approaches the refractive index of the transparent conductive layer (increase), the difference in refractive index at the interface decreases, resulting in improved effects in making the pattern shape inconspicuous. However, in order to increase the refractive index of the adhesive layer, it is necessary to add particulates of a high-refractive-index material thereto, for example, and this causes a problem in that the transmittance as a transparent planar body decreases. Further, because the adhesive layer is in contact with the transparent conductive layer, the adhesive layer preferably contains no material that may damage the transparent conductive layer, such as acid.

[0027]

In the transparent touch switch 101 configured as above, the method for detecting the touch location is the same in known capacitive touch switches. When a finger or the like touches the first transparent planar body 1 at any position on its surface, the transparent conductive layers 12 and 22 are grounded through the capacitance of the human body at the touch location, and the value of current flowing through the transparent conductive layers 12 and 22 is detected, thereby calculating the coordinates of the touch location.

[0028]

As shown in the schematic cross-sectional view of the transparent planar body 1 in Fig. 6, with respect to the absolute value of the difference between

the reflectance of a pattern-forming region, where the transparent conductive layer 12 is formed, at each wavelength of reflection L1 of light applied thereto through the silicon-containing layer 11 and the reflectance of a pattern-non-forming region, where the transparent conductive layer 12 is not formed, at each wavelength of reflection L2 of light applied thereto through the silicon-containing layer 11, it is preferable that the difference between the maximum and minimum of the absolute value is 0.65 or less, more preferably 0.5 or less, and still more preferably 0.4 or less, at a wavelength in the visible range, 450 nm to 700 nm. When the difference between the maximum and the minimum is 0.65 or less, the pattern shape of the transparent conductive layer 12 can be made inconspicuous, thereby improving visibility.

[0029]

The present inventors produced samples of transparent planar bodies configured as above. With respect to the absolute value of the difference between the reflectance of a pattern-forming region, where the transparent conductive layer 12 was formed, at each wavelength of reflection L1 of light applied thereto through the silicon-containing layer 11 and the reflectance of a pattern-non-forming region, where the transparent conductive layer 12 was not formed, at each wavelength of reflection L2 of light applied thereto through the silicon-containing layer 11, the difference between the maximum and the minimum of the absolute value was measured. The maximum of the reflectance difference was also measured. At the same time, sensory testing was performed to determine whether the pattern shape of the transparent conductive layer 12 was conspicuous. The samples have a structure as shown in Fig. 6. The high-refractive-index layer 112 and the low-refractive-index layer 111 forming the silicon-containing layer 11 were formed of a soda glass plate and a SiO₂ thin film, respectively. An ITO film was employed as the transparent conductive layer 12, and a film made of an acrylic pressure sensitive adhesive (refractive index: 1.52) was employed as the adhesive layer 13. The samples were thus configured. Five kinds of samples were prepared, varying the thickness of the transparent conductive layer 12 (ITO film) (8 nm, 10 nm, 12 nm, 14 nm, 16 nm). In each of the samples, the thickness of the high-refractive-index layer 112 (glass plate) was 1.1 mm, the thickness of the low-refractive-index layer 111 (SiO₂ thin film) was 12.5 nm, and the thickness of the adhesive layer 13 was 25 μ m. The low-refractive-index layer 111 (SiO₂ thin film) and the transparent conductive layer 12 (ITO film) were deposited by sputtering on the glass plate.

[0030]

These five kinds of samples were each measured for the spectral

reflectance (first spectral reflectance) of a pattern-forming region, where the transparent conductive layer 12 was formed, at each wavelength of reflection of light applied thereto through the silicon-containing layer 11 and the spectral reflectance (second spectral reflectance) of a pattern-non-forming region, where the transparent conductive layer 12 was not formed, at each wavelength of reflection of light applied thereto through the silicon-containing layer 11. Fig. 7 shows the relation between the absolute value of the difference between the obtained first spectral reflectance and second spectral reflectance and wavelength. Fig. 7 shows the results of measurement at wavelengths within the visible range of light, 450 nm to 700 nm. For the measurement of spectral reflectance, an apparatus manufactured by JASCO (V670+ integrating sphere unit) was used. The measurement conditions were as follows: photometry mode: %R, measurement range: 800 to 300 nm, data collection interval: 5 nm, UV/Vis bandwidth: 5.0 nm, NIR bandwidth: 2.0 nm, response: Medium, scattering rate: 400 nm/min, light source switching: 340 nm, diffraction grating switching: 850 nm, light source: D2/WI, filter switching: step, correction: baseline.

[0031]

The maximum and minimum of the absolute value of the difference between the above-obtained first spectral reflectance and second spectral reflectance were calculated. The difference between the maximum and the minimum was also calculated. Table 1 shows the difference between the maximum and the minimum (reflectance difference Δ), as well as the maximum of the reflectance difference, obtained by calculation. The surface resistance (R_s) of each sample is also shown in Table 1. Surface resistance (R_s) was measured using a resistivity meter Loresta EP MCP-T360 manufactured by MITSUBISHI CHEMICAL ANALYTECH. Table 1 also shows the results of sensory testing for each sample about the conspicuousness of the pattern shape. The test was performed under an ordinary fluorescent lamp in a room and under a three-band fluorescent lamp in a booth covered with a black sheet.

Table 1

ITO Film Thickness	R_s (Ω/sq)	Reflectance Difference Δ	Maximum	Results of Sensory Testing
8 nm	495	0.1963	0.21543	Good
10 nm	240	0.24849	0.29538	Good
12 nm	198	0.37534	0.42805	Good
14 nm	165	0.61381	0.77014	Fair
16 nm	143	0.74003	1.11408	Poor

Good: Pattern shape is hardly recognizable even under a three-band fluorescent lamp

Fair: Pattern shape is hardly recognizable under an ordinary fluorescent lamp, but is recognizable under a three-band fluorescent lamp

Poor: Pattern shape confirmation is recognizable even under an ordinary fluorescent lamp

[0032]

The results in Table 1 show that when the thickness of the transparent conductive layer 12 (ITO film) is 8 nm, 10 nm, or 12 nm, the pattern shape of the transparent conductive layer 12 (ITO film) is barely noticeable, achieving excellent visibility. Fig. 7 shows that in such cases, at a wavelength in the visible range, 450 nm to 700 nm, the difference (reflectance difference Δ) between the maximum and minimum of the absolute value of the difference between the first spectral reflectance and the second spectral reflectance is 0.5 or less, and the absolute value of the difference between the first spectral reflectance and the second spectral reflectance is 0.7 or less. Further, even when the thickness of the transparent conductive layer 12 (ITO film) is 14 nm, although the pattern shape is recognizable under severe evaluation conditions, i.e., under a three-band fluorescent lamp, the pattern shape is barely visible under an ordinary fluorescent lamp. This shows that when the reflectance difference Δ is 0.65 or less, and the absolute value of the difference between the first spectral reflectance and the second spectral reflectance is 0.8 or less, practically usable visibility is achieved. The results also show that in the case where the thickness of the ITO film is 16 nm, where the reflectance difference Δ is more than 0.65 and the absolute value of the difference between the first spectral reflectance and the second spectral reflectance is more than 0.8, poor visibility is resulted. In Table 1, the surface resistance (R_s) increases with a decrease in the thickness of the transparent conductive layer 12 (ITO film). However, when the thickness is less than 8 nm, the surface resistance exceeds 500 Ω/sq , and this may cause a decrease in the sensing accuracy of the touch switch. Therefore, the thickness of the transparent conductive layer 12 (ITO film) is particularly preferably 8 nm or more.

[0033]

The present inventors simulated a transparent planar body configured as above. The model used in the simulation has a structure as shown in Fig. 6, and the settings for the simulation were as follows. The silicon-containing layer 11 was formed to include a low-refractive-index layer 111 made of SiO_2 (optical refractive index: 1.46) and a high-refractive-index layer 112 made of soda glass

(optical refractive index: 1.52). The transparent conductive layer 12 was an ITO film (optical refractive index: 2.0). The adhesive layer 13 was made of an acrylic pressure sensitive adhesive (optical refractive index: 1.52).

[0034]

In the transparent planar body 11 having such settings, the thickness of the transparent conductive layer 12 (ITO film) and the thickness of the low-refractive-index layer 111 of the silicon-containing layer 11 were each varied, and the difference in light reflectance (%) between the part in which the transparent conductive layer 12 was formed (pattern-forming region) and the part in which the transparent conductive layer 12 was not formed (pattern-non-forming region) was determined by the simulation. The reflectance was calculated using a thin-film designing software (OPTAS-FILM) manufactured by CYBERNET SYSTEMS. As compared with the low-refractive-index layer 111 of the silicon-containing layer 11 and the transparent conductive layer 12, which have nano-scale thickness, the high-refractive-index layer 112 of the silicon-containing layer 11 and the adhesive layer 13 are members of much greater thickness; in this simulation, reflectance was calculated assuming the thickness of such a member as ∞ (infinite).

[0035]

The inconspicuousness of the pattern shape of a transparent conductive layer 12 is correlated to the difference in reflectance between the part in which the transparent conductive film 12 is formed and the part in which it is not formed. The smaller the absolute value of the reflectance difference in the entire visible region (wavelength: 450 to 700 nm), the less conspicuous the pattern shape and the better the visibility. When the maximum of the reflectance difference is 0.8 or less, good visibility can be achieved. A maximum of 0.7 or less provides better visibility, and a maximum of 0.5 or less provides even better visibility. Further, when the difference between the maximum and minimum of the absolute value of the reflectance difference is 0.65 or less at a wavelength in the visible range, 450 nm to 700 nm, the pattern shape of the transparent conductive layer is even less conspicuous, resulting in even better visibility.

[0036]

The following explains the simulation results. Fig. 8 shows the results of simulation where the thickness of the transparent conductive layer 12 (ITO film) was 8 nm, and the thickness of the low-refractive-index layer 111 (SiO_2 film) of the silicon-containing layer 11 was varied (0 nm, 10 nm, 20 nm, 30 nm). Fig. 9 shows the results of simulation where the thickness of the transparent conductive layer 12 (ITO film) was 10 nm, and the thickness of the

low-refractive-index layer 111 (SiO_2 film) of the silicon-containing layer 11 was varied (0 nm, 10 nm, 20 nm, 30 nm). Fig. 10 shows the results of simulation where the thickness of the transparent conductive layer 12 (ITO film) was 12 nm, and the thickness of the low-refractive-index layer 111 (SiO_2 film) of the silicon-containing layer 11 was varied (0 nm, 10 nm, 20 nm, 30 nm). Fig. 11 shows the results of simulation where the thickness of the transparent conductive layer 12 (ITO film) was 14 nm, and the thickness of the low-refractive-index layer 111 (SiO_2 film) of the silicon-containing layer 11 was varied (0 nm, 10 nm, 20 nm, 30 nm).

[0037]

Table 2 shows the difference between the maximum and minimum of the reflectance difference at a wavelength in the visible range, 450 nm to 700 nm, which was derived from the simulation results shown in Figs. 8 to 11. In the simulation results shown in Figs. 8 to 11, the maximum of the reflectance difference is the value of reflectance difference at a wavelength of 450 nm, while the minimum of the reflectance difference is the value of reflectance difference at a wavelength of 700 nm.

Table 2

		ITO Film Thickness (nm)			
		8	10	12	14
SiO ₂ Film Thickness (nm)	0	0.186	0.285	0.402	0.535
	10	0.135	0.226	0.335	0.463
	20	0.106	0.194	0.303	0.431
	30	0.103	0.195	0.311	0.461

[0038]

Table 3 shows the derived maximum of the reflectance difference at a wavelength in the visible range, 450 nm to 700 nm.

Table 3

		ITO Film Thickness (nm)			
		8	10	12	14
SiO ₂ Film Thickness (nm)	0	0.319	0.492	0.699	0.936
	10	0.229	0.385	0.575	0.799
	20	0.164	0.309	0.492	0.71
	30	0.133	0.277	0.462	0.703

[0039]

As shown in Figs. 8 to 11 and Table 2, when the thickness of the transparent conductive layer 12 (ITO film) was 12 nm or less, the difference between

the maximum and minimum of the reflectance difference was 0.65 or less. As shown in Figs. 8 to 11 and Table 3, when the thickness of the transparent conductive layer 12 (ITO film) was 12 nm or less, the maximum of the reflectance difference was 0.8 or less. These simulation results are accepted as consistent with the measurement values obtained above from the samples.

[0040]

Further, the results in Figs. 8 to 11 and Tables 2 and 3 show that in the case where the thickness of the transparent conductive layer 12 (ITO film) is 14 nm, when the thickness of the low-refractive-index layer 111 (SiO₂ film) is within a range of 0 to 30 nm, the difference between the maximum and minimum of the reflectance difference is 0.65 or less. The results also show that when the thickness of the low-refractive-index layer 111 (SiO₂ film) is 10 nm, 20 nm, or 30 nm, the maximum of the reflectance difference is 0.8 or less, while when the thickness of the low-refractive-index layer 111 (SiO₂ film) is 0 nm, the maximum of the reflectance difference is more than 0.8.

[0041]

Next, the thickness of the low-refractive-index layer 111 (SiO₂ film) was further varied, and the maximum thickness of the low-refractive-index layer 111 (SiO₂ film) that allowed the difference between the maximum and minimum of the reflectance difference to be 0.65 or less was calculated by the above simulation. The results are shown in Table 4. Table 4 shows the derived difference between the maximum and minimum of the reflectance difference at a wavelength in the visible range, 450 nm to 700 nm. With an increase in the thickness of the low-refractive-index layer 111 (SiO₂ film), the difference between the maximum and minimum of the reflectance difference changes from a downward trend to an upward trend. Therefore, the calculation of the difference between the maximum and minimum of the reflectance difference is partially omitted.

Table 4

		ITO Film Thickness (nm)					
		8	10	12	13	14	16
SiO ₂ Film Thickness (nm)	0	0.186	0.285	0.402	0.48	0.535	-
	10	0.135	0.226	0.335	0.408	0.463	0.62
	20	0.106	0.194	0.303	0.375	0.431	0.591
	30	0.103	0.195	0.311	0.388	0.461	0.621
	35	-	-	-	0.414	0.491	-
	40	-	-	-	0.451	0.532	0.71
	45	-	-	-	0.499	0.585	-

	50	-	0.317	0.47	0.556	0.648	-
	55	-	-	0.529	0.587	-	-
	60	-	-	0.59	0.644	-	-
	65	-	0.47	0.653	-	-	-
	70	-	0.52	0.714	-	-	-
	75	-	0.571	-	-	-	-
	80	-	0.615	-	-	-	-
	85	-	0.651	-	-	-	-
	90	0.489	0.680	-	-	-	-
	95	0.504	-	-	-	-	-
	100	0.511	-	-	-	-	-

[0042]

Table 4 shows that the maximum thickness of the low-refractive-index layer 111 (SiO₂ film) that allows the difference between the maximum and minimum of the reflectance difference to be 0.65 or less is about 85 nm when the thickness of the transparent conductive layer 12 (ITO film) is 10 nm, while it is about 65 nm when the thickness of the transparent conductive layer 12 (ITO film) is 12 nm. It is also shown that the maximum thickness is 60 nm when the thickness of the transparent conductive layer 12 (ITO film) is 13 nm, while it is 50 nm when the thickness of the transparent conductive layer 12 (ITO film) is 14 nm.

[0043]

Fig. 12 shows the relation between the maximum thickness of a low-refractive-index layer 111 (SiO₂ film) that allows the difference between the maximum and minimum of the reflectance difference to be 0.65 or less and the thickness of the transparent conductive layer 12 (ITO film), plotting the maximum thickness on the ordinate and the thickness of the transparent conductive layer 12 (ITO film) on the abscissa. Fig. 12 also shows approximate curves obtained from the relation between the maximum thickness and the thickness of the transparent conductive layer 12 (ITO film). Taking the thickness of the transparent conductive layer 12 (ITO film) as X[nm] and the maximum thickness of the low-refractive-index layer 111 (SiO₂ film) as Y1[nm], such an approximate curve is represented by the following equation:

$$\text{Equation 1: } Y1 = 0.3409X^2 - 16.705X + 217.73.$$

Fig. 12 also shows the relation between the maximum thickness of a low-refractive-index layer 111 (SiO₂ film) that allows the difference between the maximum and minimum of the reflectance difference to be 0.5 or less and the thickness of the transparent conductive layer 12 (ITO film), as well as approximate curves

obtained from the relation.

[0044]

As shown above, when the thickness of the low-refractive-index layer 111 is not greater than the value calculated by the equation 1, the difference between the maximum and minimum of the difference in reflectance at each wavelength between the part in which the transparent conductive layer 12 is formed (pattern-forming region) and the part in which the transparent conductive layer 12 is not formed (pattern-non-forming region) can be 0.65 or less. Therefore, in a transparent touch switch 101 configured as shown in Fig. 1, in relation with the thickness of a transparent conductive layer 12, by forming a low-refractive-index layer 111 to have a thickness not greater than the value calculated by the equation 1, the transparent touch switch 101 can be provided with excellent visibility, where the pattern shape of the transparent conductive layer 12 is inconspicuous.

[0045]

The maximum thickness of a low-refractive-index layer 111 (SiO₂ film) that allowed the maximum of the reflectance difference at a wavelength in the visible range, 450 nm to 700 nm, to be 0.8 or less was also calculated by the simulation. The results are shown in Table 5. With an increase in the thickness of the low-refractive-index layer 111 (SiO₂ film), the maximum of the reflectance difference changes from a downward trend to an upward trend. Therefore, the calculation of the maximum of the reflectance difference is partially omitted.

Table 5

		ITO Film Thickness (nm)					
		8	10	12	13	14	16
SiO ₂ Film Thickness (nm)	0	0.319	0.492	0.699	0.836	0.936	-
	10	0.229	0.385	0.575	0.701	0.799	0.96
	20	0.164	0.309	0.492	0.613	0.71	0.865
	30	0.133	0.277	0.462	0.584	0.703	0.968
	35	-	-	-	0.595	0.717	1.027
	40	-	-	-	0.62	0.746	-
	45	-	-	-	0.66	0.792	-
	50	-	0.366	0.587	0.714	0.852	-
	55	-	-	0.646	0.770	-	-
	60	-	-	0.712	0.832	-	-
	65	-	0.527	0.784	-	-	-

	70	-	0.588	0.858	-	-	-
	75	-	0.651	-	-	-	-
	80	-	0.711	-	-	-	-
	85	-	0.765	-	-	-	-
	90	0.552	0.814	-	-	-	-
	95	0.585	-	-	-	-	-
	100	0.611	-	-	-	-	-

[0046]

Table 5 shows that the maximum thickness of the low-refractive-index layer 111 (SiO₂ film) that allows the maximum of the reflectance difference to be 0.8 or less is 85 nm when the thickness of the transparent conductive layer 12 (ITO film) is 10 nm, while it is 65 nm when the thickness of the transparent conductive layer 12 (ITO film) is 12 nm. It is also shown that in the case where the thickness of the transparent conductive layer 12 (ITO film) is 8 nm, even when the maximum thickness is 100 nm, the maximum of the reflectance difference is 0.8 or less. It is also shown that when the thickness of the transparent conductive layer 12 (ITO film) is 14 nm, the maximum thickness of the low-refractive-index layer 111 (SiO₂ film) that allows the maximum of the reflectance difference to be 0.8 or less is 45 nm.

[0047]

Fig. 13 shows the relation between the maximum thickness of a low-refractive-index layer 111 (SiO₂ film) that allows the maximum of the reflectance difference to be 0.8 or less and the thickness of the transparent conductive layer 12 (ITO film), plotting the maximum thickness on the ordinate and the thickness of the transparent conductive layer 12 (ITO film) on the abscissa. Fig. 13 also shows approximate lines obtained from the relation between the maximum thickness and the thickness of the transparent conductive layer 12 (ITO film). Taking the thickness of the transparent conductive layer 12 (ITO film) as X[nm] and the maximum thickness of the low-refractive-index layer 111 (SiO₂ film) as Y2[nm], such an approximate line is represented by the following equation:

$$\text{Equation 2: } Y2 = -10X + 185.$$

When the thickness of the low-refractive-index layer 111 (SiO₂ film) is not greater than the value calculated by the equation, the maximum of the reflectance difference will be 0.8 or less (however, when the thickness of the transparent conductive layer 12 (ITO film) is 12 nm to 14 nm, the cases where the thickness of the low-refractive-index layer 111 (SiO₂ film) is less than 10 nm are excluded). Fig. 13 also shows the relation between the maximum thickness of a low-refractive-index

layer 111 (SiO_2 film) that allows the maximum of the reflectance difference to be 0.7 or less and the thickness of the transparent conductive layer 12 (ITO film), as well as approximate lines obtained from the relation.

[0048]

As shown above, when the thickness of the low-refractive-index layer 111 is not greater the value calculated by the equation 2, the maximum of the difference in reflectance at each wavelength between the part where the transparent conductive layer 12 is formed (pattern-forming region) and the part where the transparent conductive layer 12 is not formed (pattern-non-forming region) can be 0.8 or less. Therefore, in a transparent touch switch 101 configured as shown in Fig. 1, in relation with the thickness of a transparent conductive layer 12, by forming a low-refractive-index layer 111 to have a thickness not greater than the value calculated by the equation 2, the transparent touch switch 101 can be provided with excellent visibility, where the pattern shape of the transparent conductive layer 12 is inconspicuous.

[0049]

Embodiments of the transparent planar body 1 and the transparent touch switch 101 using the same according the invention have been described above; however, the specific configurations are not limited to the above embodiments. For example, although the patterned transparent conductive layer 22 is formed on one side of the transparent substrate 21 to form the second transparent planar body 2 in the above embodiments, it is also possible to use a silicon-containing layer 11 in place of the transparent substrate 21, and provide the second transparent planar body 2 with the same configuration as the first transparent planar body 1.

[0050]

In addition, although the silicon-containing layer 11 includes the low-refractive-index layer 111 and the high-refractive-index layer 112 in the above embodiments, the silicon-containing layer 11 may be formed only of a high-refractive-index layer 112. With reference to the simulation results shown in Figs. 8 to 11, even when the silicon-containing layer 11 is formed only of a high-refractive-index layer 112 (even when the thickness of the low-refractive-index layer 111 made of SiO_2 is 0 nm), at a wavelength in the visible range, 450 nm to 700 nm, the difference between the maximum and minimum of the difference in reflectance at each wavelength between the part in which the transparent conductive layer 12 is formed (pattern-forming region) and the part in which the transparent conductive layer 12 is not formed (pattern-non-forming region) can be 0.65 or less. Accordingly, a transparent planar body 1 and a

transparent touch switch 101 with excellent visibility, where the pattern shape of the transparent conductive layer 12 is inconspicuous, can be obtained.

Explanation of Reference Numerals

[0051]

- 101 Transparent touch switch
- 1 First transparent planar body
- 2 Second transparent planar body
- 11 Silicon-containing layer
- 111 Low-refractive-index layer
- 112 High-refractive-index layer
- 12 Transparent conductive layer
- 13 Adhesive layer
- 21 Transparent substrate
- 22 Transparent conductive layer

Claims

1. A transparent planar body comprising
a silicon-containing layer;
an adhesive layer disposed on at least one side of the silicon-containing layer; and
a patterned transparent conductive layer disposed between the silicon-containing layer and the adhesive layer,
with respect to an absolute value of the difference between the reflectance of a pattern-forming region, where the transparent conductive layer is formed, at each wavelength of light applied thereto through the silicon-containing layer and the reflectance of a pattern-non-forming region, where the transparent conductive layer is not formed, at each wavelength of light applied thereto through the silicon-containing layer, the difference between the maximum and minimum of the absolute value being 0.65 or less at 450 nm to 700 nm.
2. A transparent planar body according to claim 1, wherein the maximum is 0.8 or less.
3. A transparent planar body according to claim 1 or 2, wherein
the silicon-containing layer includes a low-refractive-index layer and a high-refractive-index layer having a higher optical refractive index than the low-refractive-index layer, and
the transparent conductive layer is formed on the low-refractive-index-layer side of the silicon-containing layer.
4. A transparent planar body according to claim 3, wherein
the low-refractive-index layer has an optical refractive index of 1.45 to 1.47, and
the high-refractive-index layer has an optical refractive index of more than 1.47 and not more than 1.53.
5. A transparent planar body according to claim 3 or 4, wherein
the low-refractive-index layer is made of SiO₂, and
the high-refractive-index layer is made of a glass material.
6. A transparent planar body according to any one of claims 1 to 5, wherein

the transparent conductive layer has a thickness of 12 nm or less.

7. A transparent planar body according to any one of claims 1 to 5, wherein the transparent conductive layer has a thickness of 12 nm or more and 14nm or less, and the low-refractive-index layer has a thickness of 10 nm to 45 nm.

8. A transparent planar body according to any one of claims 3 to 7, wherein the thickness of the low-refractive-index layer is not greater than a value calculated by the following equation 1:

$$\text{Equation 1: } 0.3409X^2 - 16.705X + 217.73$$

wherein X represents the thickness of the transparent conductive layer.

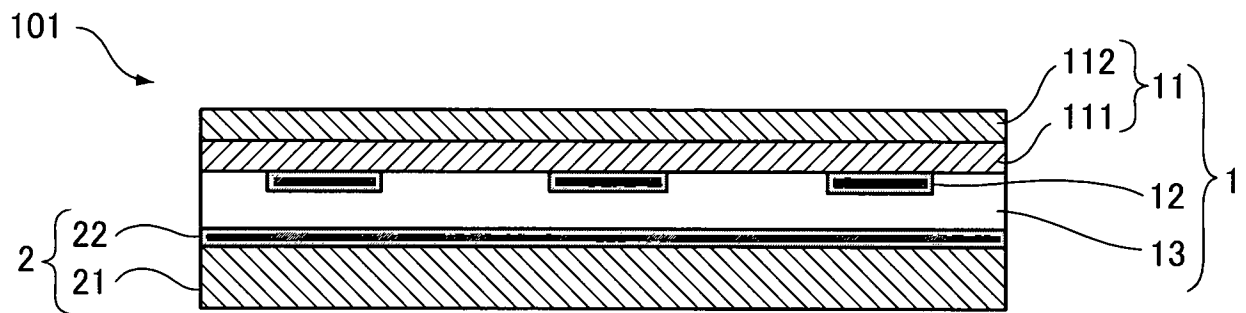
9. A transparent planar body according to claim 8, wherein the thickness of the low-refractive-index layer is not greater than a value calculated by the following equation 2:

$$\text{Equation 2: } -10X + 185$$

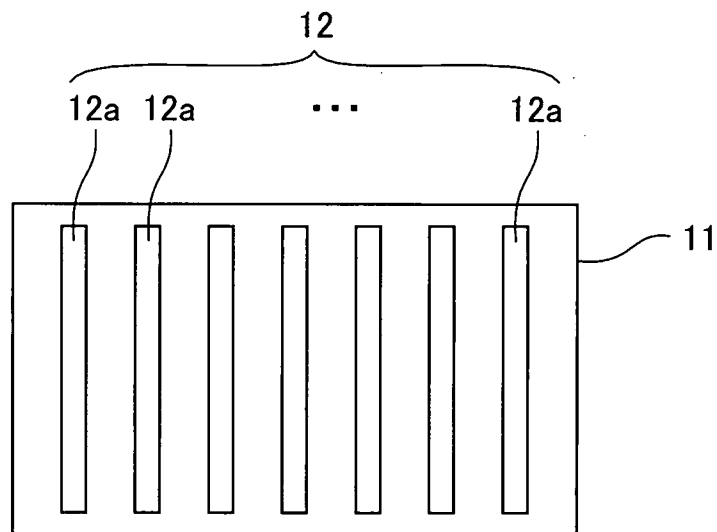
wherein X represents the thickness of the transparent conductive layer.

10. A transparent touch switch comprising at least one transparent planar body of any one of claims 1 to 9, the transparent planar body being arranged in such a manner that the transparent conductive layer of the transparent planar body and a second transparent conductive layer that is different from the transparent conductive layer of the transparent planar body face each other or face the same direction.

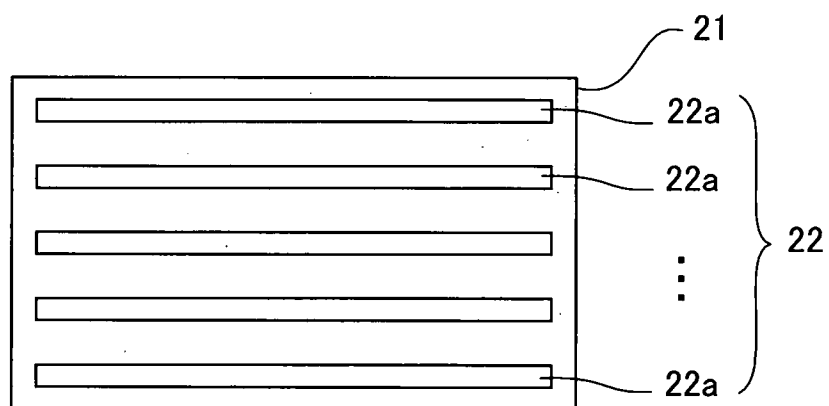
[Fig.1]



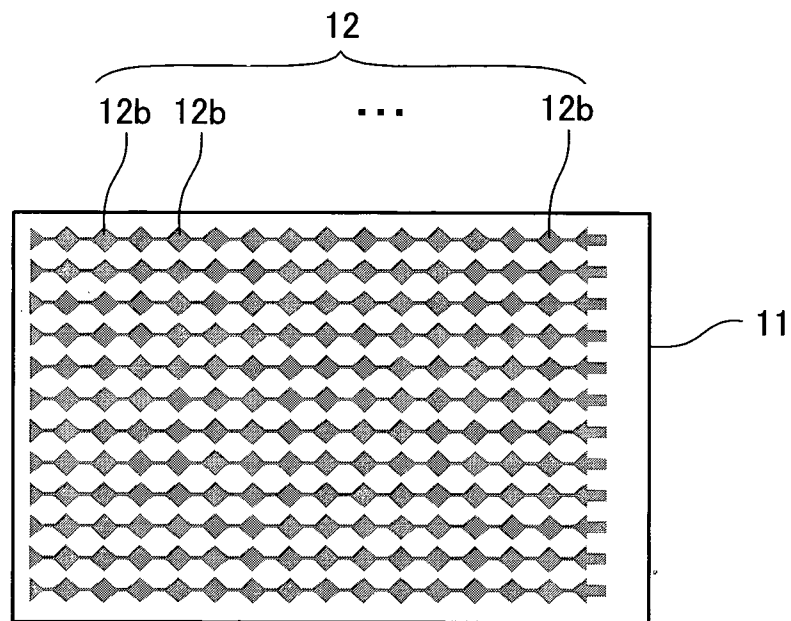
[Fig.2]



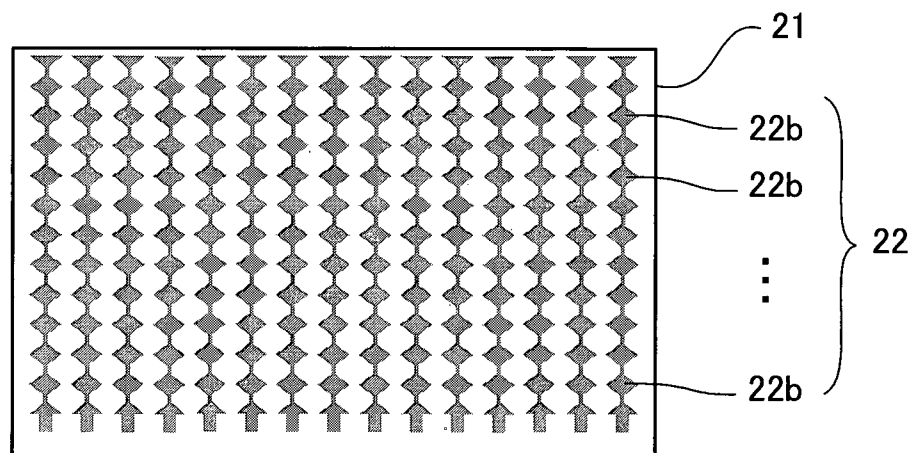
[Fig.3]



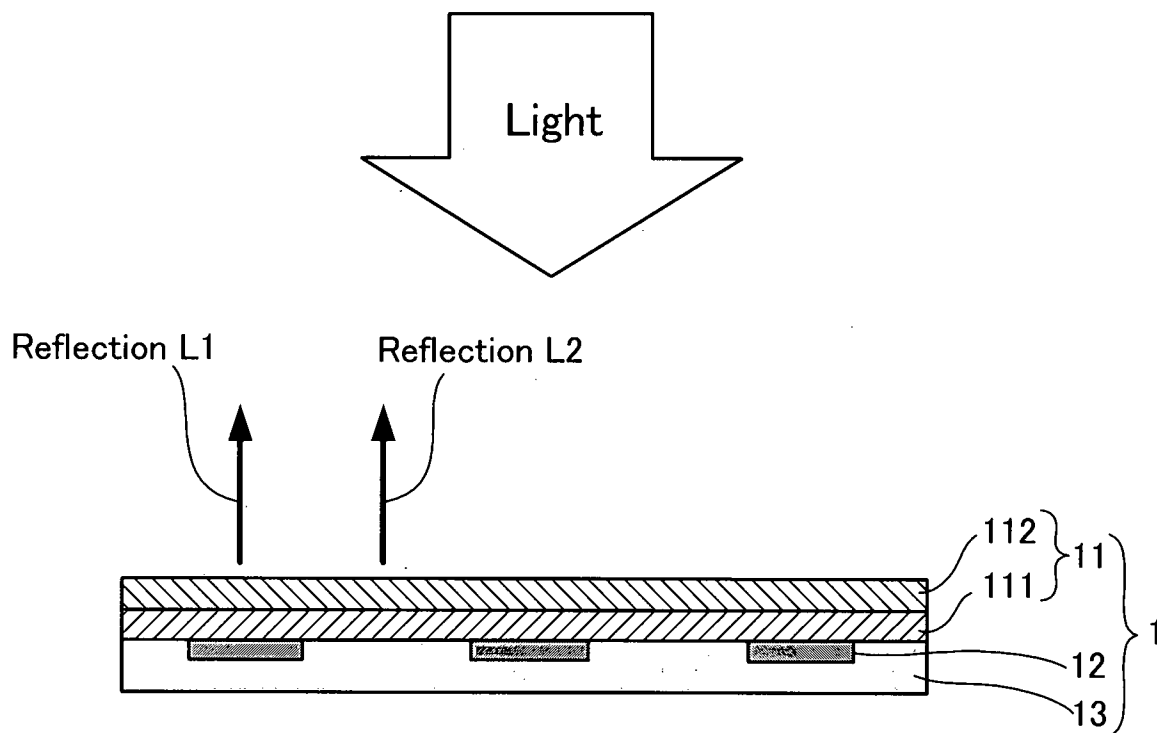
[Fig.4]



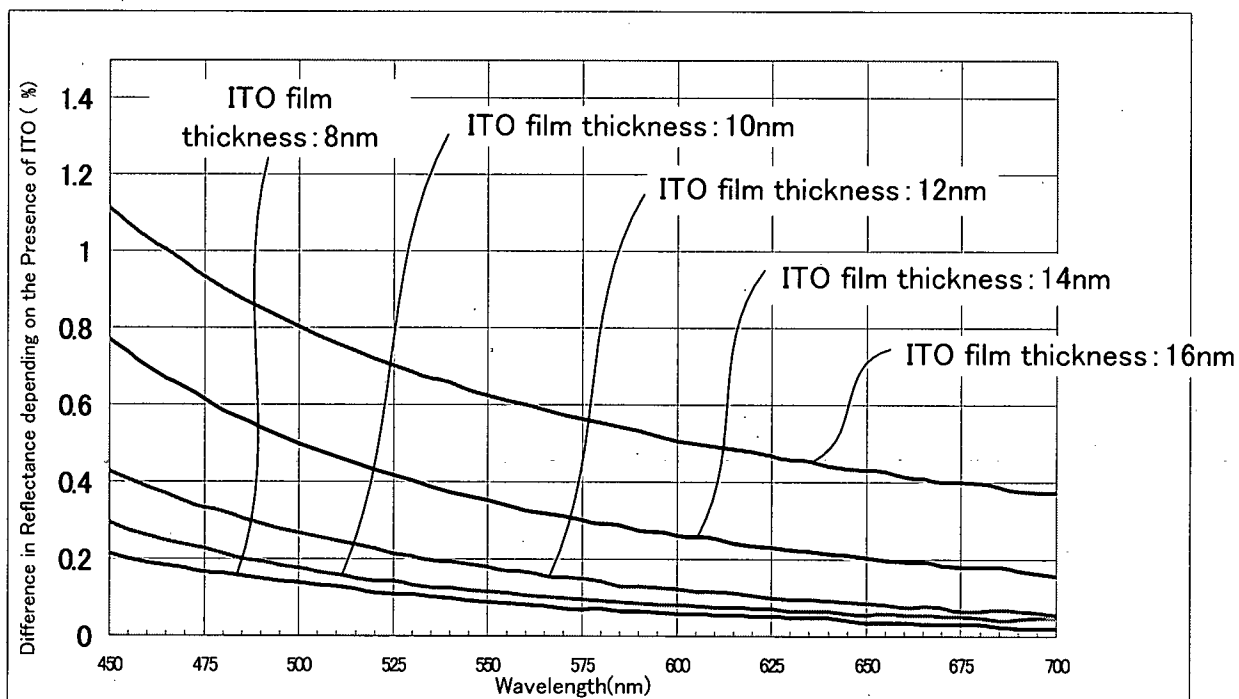
[Fig.5]



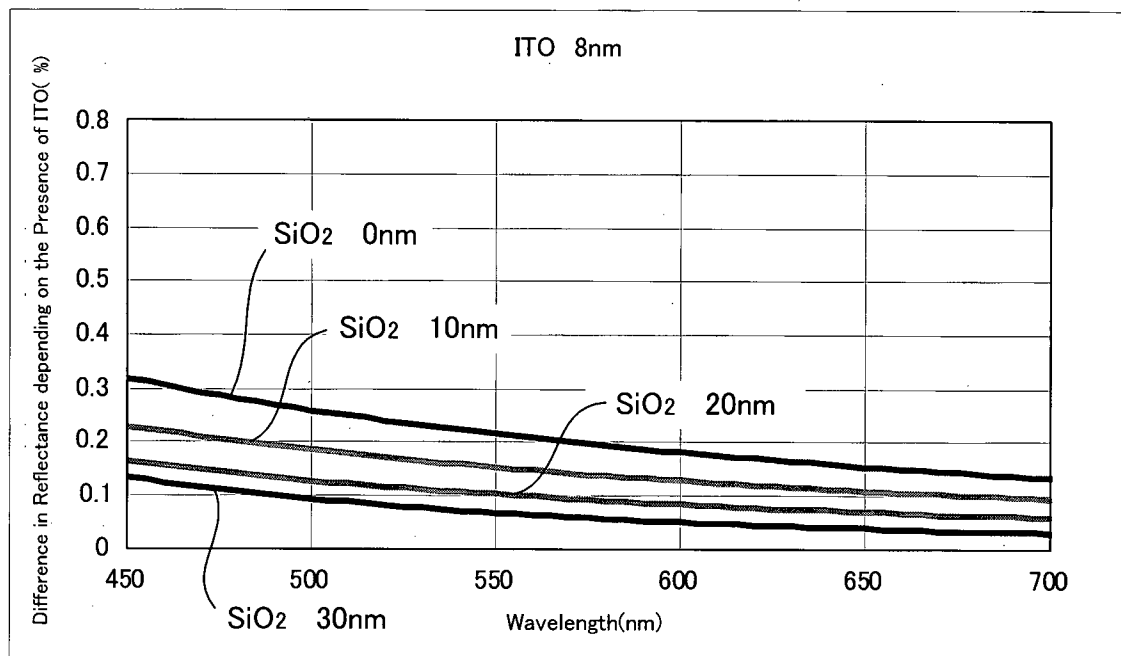
[Fig.6]



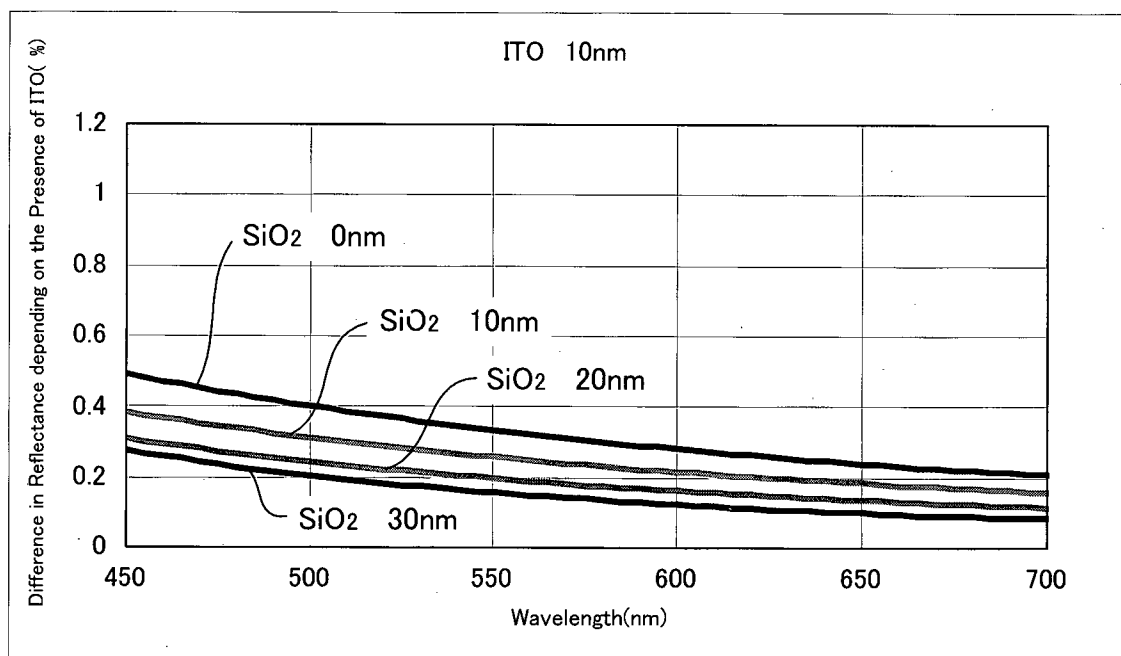
[Fig.7]



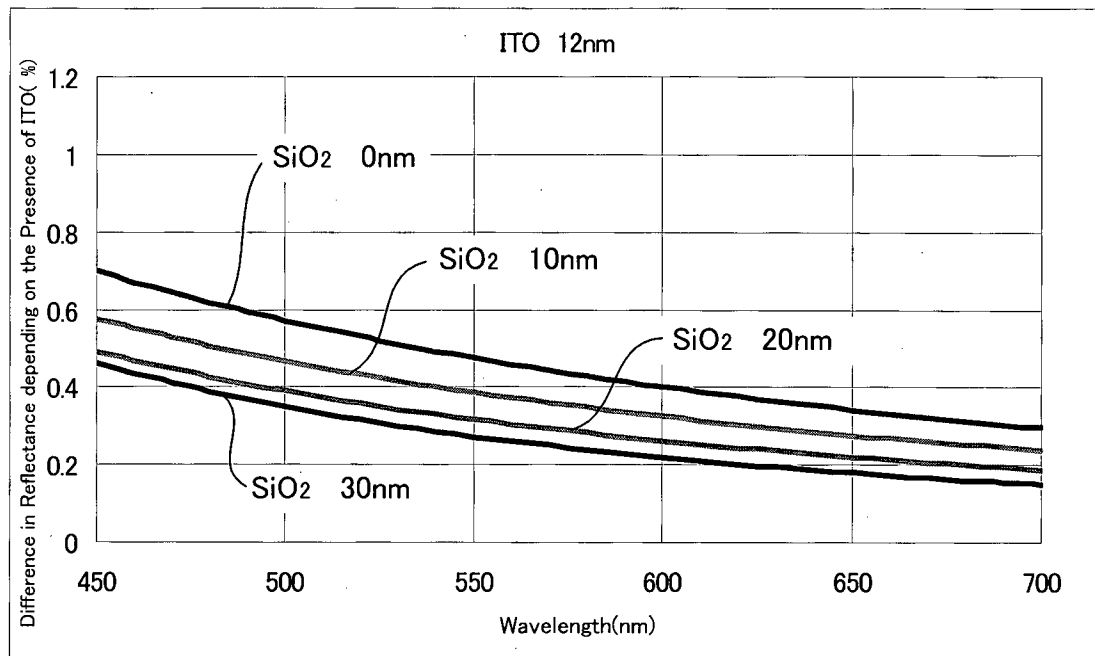
[Fig.8]



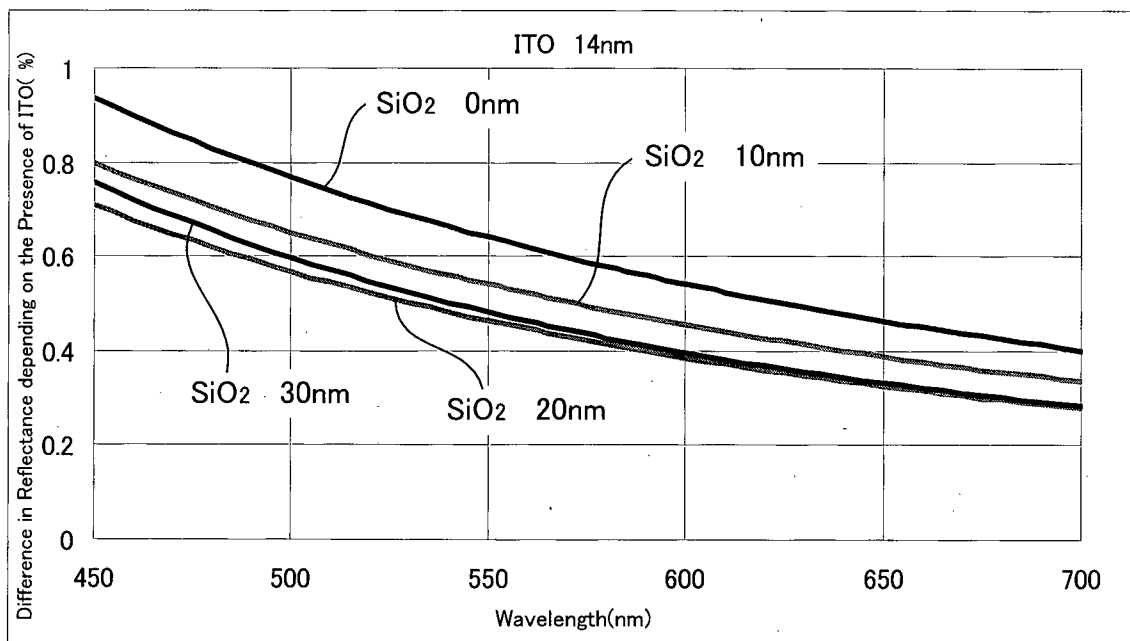
[Fig.9]



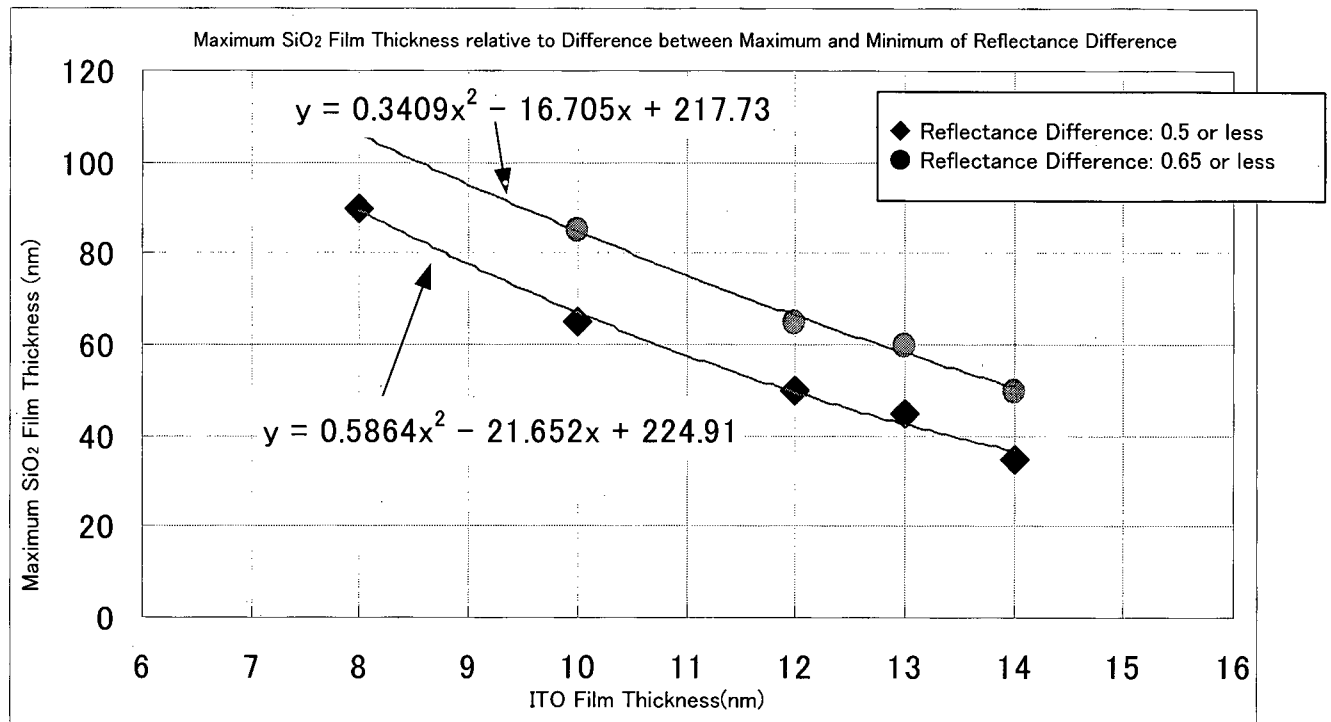
[Fig.10]



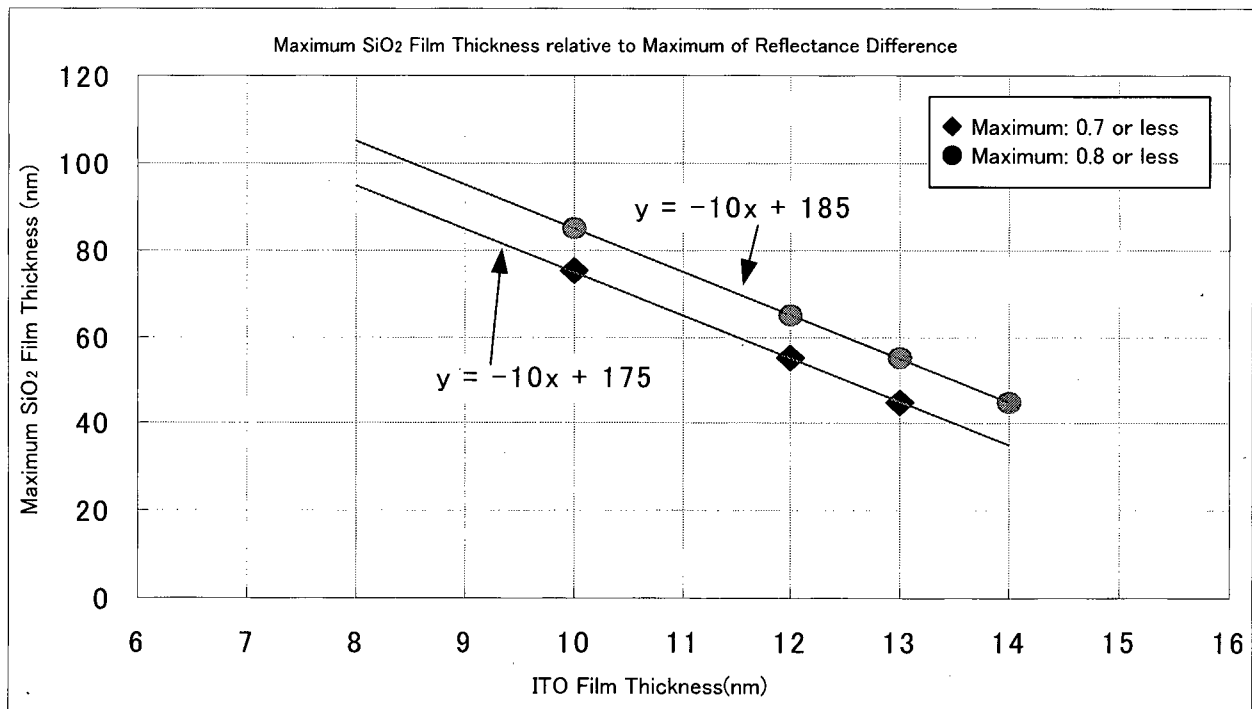
[Fig.11]



[Fig.12]



[Fig.13]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/052669

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. G06F3/041 (2006.01) i, B32B3/22 (2006.01) i, B32B7/02 (2006.01) i,
G06F3/044 (2006.01) i, H01B5/14 (2006.01) i, H01H36/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. B32B1/00-43/00, G06F3/03-3/047, H01B5/00-5/16, H01H36/00-36/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2011
Registered utility model specifications of Japan 1996-2011
Published registered utility model applications of Japan 1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-259203 A (EPSON IMAGING DEVICES CORPORATION) 2009.11.05, Full Text; all drawings & US 2009/0244028 A1	1-10
A	JP 2009-076432 A (NITTO DENKO CORPORATION) 2009.04.09, Full Text; all drawings & US 2008/0176042 A1 & EP 1947551 A2	1-10
A	JP 2008-137190 A (JSR CORPORATION) 2008.06.19, Full Text; all drawings (Family: none)	1-10
A	JP 2008-268569 A (INNOVATION & INFINITY GLOBAL CORP.) 2008.11.06, Full Text; all drawings (Family: none)	1-10



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

26.04.2011

Date of mailing of the international search report

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