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(54) Title: PROCESS FOR MANUFACTURING MULTI-LAYERED THIN FILM BY DRY VACUUM VAPOR DEPOSITION

(57) Abstract: The present invention relates to a process for manufacturing multi-layered thin film by using dry vacuum vapor deposition, in particular, a process for manufacturing multi-layered thin film by using stable and simple dry vacuum vapor deposition, the process being capable of providing optical beautifulness and luxury impression to cases, windows, keypads, function key parts, various accessory parts or the like for mobile phone, MP3 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, etc.

PROCESS FOR MANUFACTURING

MULTI-LAYERED THIN FILM BY DRY VACUUM VAPOR DEPOSITION

TECHNICAL FIELD

5 The present invention relates to a process for manufacturing multi-layered thin film by using dry vacuum vapor deposition, in particular, a process for manufacturing multi-layered thin film by using stable and simple dry vacuum vapor deposition, the process being capable of providing optical beautifulness and luxury impression to cases, windows, keypads, function key parts, various accessory parts and the like for portable
10 electronic products such as mobile phone, MP3 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, etc. and display products.

BACKGROUND ART

15 Portable electronic products such as mobile phone, MP3 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, etc. and display products such as monitor, touchscreen, etc. use cases, windows, keypads, function key parts, various accessory parts or the like which are in sheet-type panel form or injection molding article made out of metal, glass, acryl
20 (acrylic resin), polycarbonate (PC), poly methyl methacrylate (PMMA), polyethylene terephthalate (PET), acrylonitrile butadiene styrene (ABS) copolymer resin and

combinations thereof. For such parts, vacuum vapor deposition coating with using metal and/or metal oxide is performed for providing optical beautifulness and luxury impression.

5 In case of mobile phone, particularly, for the stability of telecommunication quality, a non-conductive, dielectric thin film coating is formed on the front side and rear side of the case, window, keypad, window-integrated case, etc. thereof, by vacuum vapor deposition process with using metal oxide in stead of metal.

10 However, since the thin film of metal and/or metal oxide coated by vacuum vapor deposition process has low adhesion strength to the substrate, it shows low abrasion resistance, scratch resistance and pencil hardness, and it is hard to guarantee the reliability because the thin film of vacuum vapor deposition is detached by high temperature, high humidity and salt water.

15

Accordingly, to solve the problems in reliability and the like, UV coating or hard coating is performed by wet process such as dipping, spraying, spinning, inkjet printing, etc. before and after the vapor deposition process.

20 Particularly, if the vacuum vapor deposition process is introduced for providing optical design to a sheet-type panel form or injection molding article of acryl, polycarbonate

(PC), poly methyl methacrylate (PMMA), polyethylene terephthalate (PET), acrylonitrile butadiene styrene (ABS) copolymer resin or combinations thereof which is used for cases, windows, keypads, etc. of electronic products, a bottom coating and a top coating should be performed for the adhesion strength and stability of the vapor deposition layer, by using a separate wet process such as dipping method, spray method, spin-coating method, ink printing method or the like. In the case, however, since the wet process and the vacuum vapor deposition process are performed in an alternating manner, an extra cost due to the use of the different processes is incurred and a problem of inferiority occurrence during the conveyance between the different processes is caused.

That is, the wet process and the vacuum vapor deposition process (dry process) are performed in an alternating manner due to the introduction of the wet process, and thus the processing time for coating the parts becomes longer because the conveyance between the different processes and the mounting and demounting of coating object in each process should be done repeatedly.

Also, the productivity is lowered because of the processing inferiority which is occurred during the performances of the different processes and the high inferiority rate which is occurred during the conveyance between the different processes, and increased production time due to the many processes, which in turn results in high production cost

of the product.

Further, there is a tendency that such structural problem becomes still worse when the company performing the wet coating is different from the company performing the vacuum vapor deposition.

Also, as shown in Figure 4, the coating film 60 prepared on a surface of the product 10 through wet process is thicker, as compared with the coating film 70 prepared through vacuum vapor deposition process (dry process), by hundreds to thousands times and thus the unique properties of the substrate cannot be made to the best thereof due to the decrease of optical characteristics and deterioration of surface texture of the substrate.

DETAILED DESCRIPTION OF THE INVENTION

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TECHNICAL PURPOSE

As a solution to the above-mentioned problems of prior arts, the object of the present invention is to provide a process for manufacturing multi-layered thin film by forming a stable vacuum vapor deposition thin film on the front side and rear side of the case, window, keypad, function key part, window-integrated case and various accessory substrates of electronic products even through dry vacuum vapor deposition procedures as minimum as required in a vacuum vapor deposition device, the process being capable

of providing beautiful and luxury optical design to portable electronic products and display products and guaranteeing a reliability of the products.

Also, the other object of the present invention is to obtain effects of eliminating or
5 reducing environmental pollution by eliminating or minimizing the environmentally-problematic wet processes, as well as cost-saving effects from the reductions of production time and inferiority by guaranteeing the reliability of the thin film even with simplifying the process as minimum as required.

10

TECHNICAL SOLUTION

According to the present invention, a process for manufacturing multi-layered thin film, comprising the steps of forming a bottom-coating vapor-deposition layer on a substrate and forming an optical coating layer on the bottom-coating vapor-deposition layer where the bottom-coating vapor-deposition layer is to provide adhesion strength between the
15 substrate and the optical coating layer, wherein the formation of the multi-layered thin film is performed by dry vacuum vapor deposition, is provided.

The process of the present invention preferably further comprises a step of forming a middle-coating vapor-deposition layer after the step of forming the optical coating layer.

20

Also, the process of the present invention preferably further comprises a step of forming

a top-coating vapor-deposition layer, after the step of forming the middle-coating vapor-deposition layer or after the step of forming the optical coating layer.

According to the other aspect of the present invention, a multi-layered thin film coating
5 which is formed by the process for manufacturing multi-layered thin film of the present invention and comprises a bottom-coating vapor-deposition layer formed on a substrate and an optical coating layer formed on the bottom-coating vapor-deposition layer, is provided.

10 The multi-layered thin film coating of the present invention preferably further comprises a middle-coating vapor-deposition layer formed on the optical coating layer.

The multi-layered thin film coating of the present invention preferably further comprises a top-coating vapor-deposition layer formed on the middle-coating vapor-deposition
15 layer.

The multi-layered thin film coating of the present invention preferably further comprises a top-coating vapor-deposition layer formed on the optical coating layer.

20 According to another aspect of the present invention, an electronic product comprising the multi-layered thin film coating formed by the process for manufacturing multi-

layered thin film of the present invention, is provided.

ADVANTAGEOUS EFFECTS

If the dry vacuum vapor deposition process for manufacturing multi-layered thin film of
5 the present invention is used to coat the case, window, window-integrated case, keypad,
keypad-integrated window, function key parts, various accessory parts and the like of
portable electronic products such as mobile phone, MP3 player, portable multimedia
player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system,
notebook computer, etc. and display products such as monitor, touchscreen, etc. and
10 electronic home appliances such as refrigerator, air conditioner, television, etc., the
reliability of the products can be guaranteed with providing beautiful and luxury optical
designs therefor.

Also, the effects of eliminating or reducing environmental pollution by eliminating or
15 minimizing the environmentally-problematic wet processes can be obtained, as well as
the cost-saving effects from the reductions of production time and inferiority by
guaranteeing the reliability of the thin film even with simplifying the process as
minimum as required.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a process diagram for an embodiment of the vacuum vapor deposition

process for manufacturing multi-layered thin film of the present invention.

Figure 2 is a schematic constitution of the multi-layered thin film of vacuum vapor deposition manufactured according to an embodiment of the present invention.

5

Figure 3 is a drawing to represent the relationship between adhesion strength and surface contact angle.

Figure 4 is a drawing to compare the thicknesses of bottom and top coating layers formed by a conventional wet process with those formed by the vacuum vapor deposition process of the present invention.

10

Figure 5 is a photograph showing a contact angle of the surface of a plastic in-mold injection product.

15

Figure 6 is a photograph showing a contact angle of the surface after the vacuum vapor deposition of bottom coating in manufacturing the multi-layered thin film according to an embodiment of the present invention.

Figure 7 is a photograph showing a contact angle of the surface after completing the vacuum vapor deposition of top coating in manufacturing the multi-layered thin film

20

according to an embodiment of the present invention.

* Symbols shown in Figures

- 10: Substrate
- 5 20: Bottom-coating vapor-deposition layer
- 30: Optical coating layer
- 40: Middle-coating vapor-deposition layer
- 50: Top-coating vapor-deposition layer
- 60: Coating layer according to a conventional wet process
- 10 70: Multi-layered thin film of vacuum vapor deposition according to the dry process
of the present invention

EMBODIMENT TO CARRY OUT THE INVENTION

The vacuum vapor deposition process for manufacturing thin film of the present
15 invention is characterized in that the coating layers are formed in a vacuum vapor
deposition device by dry process, as compared with conventional coating layers
provided by wet process. The conventional coating layers provided by wet process so
far may include for example, UV (ultraviolet) hardening type coating layers, bottom
coating layers for increasing adhesion strength between substrate and optical coating
20 layer, and top coating layers for protecting optical single- or multi-layered coating.

In the vacuum vapor deposition process (dry process) of the present invention, the stable single- or multi-layered coating is provided by the ultra-thin coating method with the chemical agents for the formation of respective thin film layer in a vacuum vapor deposition device, preferably with using the carrier as described in Korean patent
5 application No. 10-2007-0075000.

Suitable substrates to which the process for manufacturing thin film of the present invention can be applied includes, but not limited thereto, cases, windows, window-integrated cases, keypads, keypad-integrated windows, function key parts and various
10 accessory parts for portable electronic products such as mobile phone, MP3 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, etc. and display products such as monitor, touchscreen, etc. The substrates can be in a sheet-type panel form or various injection molding article forms, but not limited thereto.

15

Metal, glass, acryl (acrylic resin), polycarbonate (PC), poly methyl methacrylate (PMMA), polyethylene terephthalate (PET), acrylonitrile butadiene styrene (ABS) copolymer resin and combinations thereof can be used as the material of the substrate,
but not limited thereto.

20

In the process for manufacturing thin film of the present invention, the bottom-coating

vapor-deposition layer formed on the substrate is a layer for providing adhesion strength between the substrate and an optical coating layer to be formed subsequently. Preferably, the bottom-coating vapor-deposition layer is formed to have nano-scale thin thickness of 10 Å to 1,000 Å (1 nm to 100 nm), and acts as so-called “nano primer” to increase the adhesion strength between the surface of the substrate and an optical single- or multi-coating layer to be formed in the subsequent step.

Also, according to surface characteristics of the substrate and multilayer design of the optical coating layer, the bottom-coating vapor-deposition layer can be deposited with a thickness of 10 Å to 1,000 Å by plasma-assisted vapor deposition method (ion assist) in the vacuum vapor deposition process, and thus can show hard coating characteristics and improve adhesion characteristics of the thin film vapor-deposition layer.

Preferably, as coating agents to form the bottom-coating vapor-deposition layer, carbon-based compounds having one or more functional groups selected from carboxyl group, phosphate group, silane group, amine group, hydroxyl group, aldehyde group, ketone group, ether group and ketal group can be used, and the molecular weight thereof can be 100 to 10,000 but not limited thereto.

In the process for manufacturing thin film of the present invention, the optical coating layer formed on the bottom-coating vapor-deposition layer can be a single- or multi-

layer and can provide beautiful and luxury optical design, various colors and effect of mirror or anti-mirror image to the external appearance of the product, i.e. the substrate.

As a material to form the optical coating layer, metal such as SUS (Steel Use Stainless),
5 nickel (Ni), aluminum (Al), chrome (Cr), tin (Sn), indium-tin (In-Sn) and the like; metal
oxide such as silicon oxide (SiO₂), titanium oxide (TiO₂), aluminum oxide (Al₂O₃),
zirconium oxide (ZrO₂), indium titanium oxide (In_xTi_yO₂, ITO), barium titanium oxide
(BaTiO₃), magnesium oxide (MgO) and the like; metal nitride such as SiN, TiN and the
like; or metal fluoride such as MgF₂ and the like can be used. These materials are
10 vaporized and deposited as a single layer or in an alternating manner to form a multi-
layer by using electron beam or resistance-heating device in a vacuum vapor deposition
device. There is no special limitation to the thickness of the optical coating layer. For
example, it can be formed in a single layer or multilayer of the single layer having
thickness variously, for example, in a range from nano-scale thickness of 10 Å - 1,000
15 Å (1 nm - 100 nm) to the thickness of micrometers.

According to one preferable embodiment of the present invention, after the step of
forming the optical coating layer, a middle-coating vapor-deposition layer can be formed
further on the surface. The middle-coating vapor-deposition layer plays a role of
20 strengthening salt water resistance, abrasion resistance, scratch resistance and the like
and assists the functions of additionally formable top-coating vapor-deposition layer.

According to surface characteristics of the optical coating layer and the multilayer design, the middle-coating vapor-deposition layer can be deposited with a thickness of 10 Å to 1,000 Å by plasma-assisted vapor deposition method (ion assist) in the vacuum vapor deposition process, and thus can strengthen the weak scratch resistance, salt water resistance, etc. of the thin film vapor-deposition layer.

Preferably, as coating agents to form the middle-coating vapor-deposition layer, carbon-based compounds having one or more functional groups selected from carboxyl group, phosphate group, silane group, amine group, hydroxyl group, aldehyde group, ketone group, ether group and ketal group can be used, and the molecular weight thereof can be 100 to 10,000 but not limited thereto.

According to one preferable embodiment of the present invention, after the step of forming the middle-coating vapor-deposition layer, a top-coating vapor-deposition layer can be formed further on the surface. The top-coating vapor-deposition layer plays a role of protecting the optical coating layer by providing contamination resistance (resistance to fingerprint) and easy cleaning properties as well as strengthening reliabilities such as salt water resistance, abrasion resistance, scratch resistance and the like.

According to surface characteristics of the middle-coating vapor-deposition layer and the multilayer design, the top-coating vapor-deposition layer can be deposited with a thickness of 10 Å to 1,000 Å by plasma-assisted vapor deposition method (ion assist) in the vacuum vapor deposition process.

5

Preferably, as coating agents to form the top-coating vapor-deposition layer, fluorocarbon-based compounds having one or more functional groups selected from carboxyl group, phosphate group, silane group, amine group, hydroxyl group, aldehyde group, ketone group, ether group and ketal group can be used, and the molecular weight

10 thereof can be 100 to 10,000 but not limited thereto.

In the present invention, the coating agents for the formation of respective thin film layer can be deposited by using electron beam, resistance-heating device, sputtering device or ion plating device, preferably with using the carrier as described in Korean patent

15 application No. 10-2007-0075000.

Also, preferably in the present invention, the formation of the multi-layered thin film structure proceeds continuously in a vacuum vapor deposition device.

20 The coating agents for the formation of respective thin film layer preferably comprise a solvent such as water, methanol, ethanol, acetone, acetyl acetone, glycol, ketone or the

like for the storage and stability of the agents.

The process for manufacturing multi-layered thin film of vacuum vapor deposition according to the present invention is explained step by step in detail below, with
5 concrete embodiments.

An embodiment of the process for manufacturing multi-layered thin film of vacuum vapor deposition according to the present invention is the same as shown in Figure 1. According to the process diagram shown in Figure 1, the present invention is
10 characterized in that all coating operations from the mounting to the demounting of the substrate, i.e. the product, in a vacuum vapor deposition device are performed through dry process in the vacuum vapor deposition device.

1: The mounting step

15 The substrate (or product) **10** such as case, window, window-integrated case, keypad, keypad-integrated window, function key part and various accessory part for portable electronic products such as mobile phone, MP3 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, etc. and display products such as monitor, touchscreen, etc. is
20 mounted in a vacuum vapor deposition device. To prevent the substrate from falling off during the vacuum vapor deposition process, the substrate is installed to a jig which

is designed so as to fit the substrate in various forms.

2: The evacuating step

When the mounting of the substrate in the vacuum vapor deposition device is completed,
5 the inside of vacuum vapor deposition chamber is evacuated to maintain a high-vacuum
state of 1.0×10^{-6} - 1.0×10^{-3} torr, preferably a high-vacuum state of 1.0×10^{-5} torr or higher
vacuum, in order to perform the vacuum vapor deposition coating with metal and/or
metal oxide. The temperature of the inside of vacuum vapor deposition chamber is set
to 20 to 300 °C depending on the material of the mounted substrate **10**.

10

3: The vapor depositing step for the bottom coating layer

When the suitable high-vacuum state is obtained, high voltage discharge is conducted by
using ion beam device under the flow of argon (Ar), nitrogen (N₂) and oxygen (O₂)
gases to generate plasma of the corresponding gas. The plasma gas with high energy is
15 applied for 10 seconds to 1,000 seconds depending on the condition of the surface of the
mounted substrate, to activate the surface of the mounted substrate **10** (plasma etching).

The bottom-coating vapor-deposition layer **20** is formed on the activated surface of the
substrate **10**. To form the bottom-coating vapor-deposition layer, the carrier as
20 described in Korean patent application No. 10-2007-0075000 can be used. The agent
for the bottom-coating is loaded in this carrier and in turn the carrier is installed to a

vaporization port using electron beam or a resistance-heating type vaporization port in the vacuum vapor deposition device, and then the carrier installed to the vaporization port is heated by using electron beam or resistance-heating boat to vaporize the coating agent loaded in the carrier, and the bottom-coating vapor-deposition layer is formed.

5

In the case of electron beam-heating type, all procedures of the coating process can be automated by using IC-5 (INFICON) which is one of the control devices for vacuum vapor deposition devices. The power of electron beam is controlled suitably between 1.5 % and 8.0 %, preferably between 2.0 % and 4.0 %.

10

The bottom-coating vapor-deposition layer formed as above preferably has a thickness of 10 Å to 1,000 Å (0.001 μm to 0.1 μm), most preferably about 100 Å (0.01 μm , 10 nm) or more or less. The plasma etching as described above can be applied thereto for 0 to 300 seconds, by which the bottom-coating vapor-deposition layer can be stabilized.

15

The coating formed on the surface of the substrate is associated with the surface energy. The strength of adhesion can be estimated by measuring the contact angle between the substrate and water drop on the surface of the substrate, as shown in Figure 3. As the contact angle becomes smaller, the adhesion strength becomes greater.

20

In case of plastic in-mold injection product, the contact angle on the surface of the

substrate before the coating was 74.3° (Figure 5) whereas the contact angle decreased to 32.2° after the formation of the bottom-coating vapor-deposition layer **20** on the surface of the product (Figure 6), and before and after the bottom-coating vapor deposition, the surface energy was changed from 33.02 mN/m to 47.98 mN/m. That is, the adhesion strength was improved by the bottom-coating vapor deposition.

To the surfaces of products of various materials, the changes of surface contact angle and surface energy before and after the formation of the bottom-coating vapor-deposition layer are shown in the following Tables 1 and 2, respectively:

10

[Table 1] Changes of surface contact angle before and after the bottom-coating formation

Results of contact angle (°) of coating on various materials					
Sample	A	B	C	Average	Before the coating
In-mold injection product	34.354	31.81	30.565	32.243	74.341
Co-injection molding case	34.099	34.614	34.972	34.562	73.828
PC (hard coating)	42.327	42.099	41.672	42.033	71.061
PMMA (hard coating)	37.081	39.265	36.848	37.731	72.689
SUS	36.848	40.449	38.341	38.546	68.604
Tempered glass	36.039	37.499	34.354	35.964	64.193

[Table 2] Changes of surface energy before and after the bottom-coating formation

Results of surface energy (mN/m) of coating on various materials					
Sample	A	B	C	Average	Before the coating
In-mold injection product	47.46	48.09	48.39	47.98	33.02
Co-injection molding case	47.53	47.4	47.31	47.41	33.24
PC (hard coating)	45.22	45.29	45.42	45.31	34.44

PMMA (hard coating)	46.71	46.13	46.81	46.56	33.74
SUS	46.81	45.79	46.39	46.33	35.49
Tempered glass	47.02	46.63	47.46	47.04	37.32

4: The multi-vapor depositing step (the optical coating layer forming step)

The optical coating layer **30** is formed on the bottom-coating vapor-deposition layer for providing beautiful and luxury optical design to the substrate, and showing various colors, effect of mirror or anti-mirror image, and antireflection effect.

The optical coating layer **30** is formed by vapor-depositing metal such as SUS (Steel Use Stainless), nickel (Ni), aluminum (Al), chrome (Cr), tin (Sn), indium-tin (In-Sn) and the like; metal oxide such as silicon oxide (SiO_2), titanium oxide (TiO_2), aluminum oxide (Al_2O_3), zirconium oxide (ZrO_2), indium titanium oxide ($\text{In}_x\text{Ti}_y\text{O}_2$, ITO), barium titanium oxide (BaTiO_3), magnesium oxide (MgO) and the like; metal nitride such as SiN, TiN and the like; or metal fluoride such as MgF_2 and the like, in a single layer or multilayer through alternating vapor deposition, by using electron beam or resistance-heating device in a vacuum vapor deposition device.

15

5: The vapor depositing step for the middle coating layer

Since the optical coating layer **30** is formed from metal, metal oxide, metal nitride or metal fluoride, it has various surface characteristics and a vulnerability to moisture and contamination, etc. due to the features of inorganic materials.

Therefore, on the optical coating layer **30**, the middle-coating vapor-deposition layer **40** is preferably formed with a thickness of about 100 Å or more or less, in order to provide a surface which is stable to various environments and to strengthen the abrasion resistance and reliability of the vacuum vapor deposition thin film resisting to the environment, according to different surface conditions.

According to the multilayer design of the optical coating layer, the middle-coating vapor-deposition layer **40** can be deposited by plasma-assisted vapor deposition method (ion assist) in the vacuum vapor deposition process, and thus can exhibit hard coating characteristics and strengthen the weak scratch resistance, salt water resistance, etc. of the thin film vapor-deposition layer.

The carrier as described in Korean patent application No. 10-2007-0075000 can be used to form the middle-coating vapor-deposition layer, as the same for the bottom-coating vapor-deposition layer. The agent for the middle-coating is loaded in this carrier and in turn the carrier is installed to a vaporization port using electron beam or a resistance-heating type vaporization port in the vacuum vapor deposition device, and then the carrier installed to the vaporization port is heated by using electron beam or resistance-heating boat to vaporize the coating agent loaded in the carrier, and the middle-coating vapor-deposition layer is formed.

The middle-coating vapor-deposition layer formed as above preferably has a thickness of 10 Å to 1,000 Å (0.001 μm to 0.1 μm), most preferably about 100 Å (0.01 μm, 10 nm) or more or less. The plasma etching as described above can be applied thereto for 5 0 to 300 seconds, by which the middle-coating vapor-deposition layer can be stabilized.

6: The vapor depositing step for the top coating layer

As explained above, since the optical coating layer 30 has various surface characteristics and a vulnerability to moisture and contamination, etc. due to the features of inorganic 10 materials, the top-coating vapor-deposition layer 50 is preferably provided over the optical coating layer 30 directly or with the intervention of the middle-coating vapor-deposition layer 40.

The top-coating vapor-deposition layer 50 can be formed by a method similar with the 15 bottom- and middle-coating vapor-deposition layers, in a thickness of 100 Å to 1,000 Å, without controlling the coating thickness specially.

The thin film coating formed through the top-coating vapor depositing step has a very low surface energy and a feature of low friction coefficient, thereby showing property of 20 very slippery surface, and thus the attachment of contamination sources such as fingerprint and soil etc. can be reduced remarkably. Even though the fingerprint and

soil are attached, they can be removed easily by the excellent easy cleaning function of the coating. Also, at the same time, characteristic properties such as water-repellent or oil-repellent property, scratch resistance, durability, etc. can be obtained, and thus a coating layer of vacuum vapor deposition which is stable after the test for reliability of a product having exterior coating as well as interior coating, can be formed.

As the contact angle becomes greater, the adhesion or attaching strength becomes worse, as shown in Figure 3. However, in terms of the attachment of contaminants, it means that the resistance to contamination becomes stronger. The coating surface having the top-coating vapor deposition layer treated as above is shown in Figure 7. The contact angle and surface energy when the top-coating vapor deposition layer is formed are shown in the following Tables 3 and 4, respectively.

[Table 3] Contact angles when the top-coating vapor deposition layer is formed

Measurement Results of contact angle (°)						
Sample	A	B	C	D	E	Average
Original	68.819	68.209	68.044	69.118	70.367	68.91
Multicoating + water-repellent coating	111.93	110.16	108.62	109.87	111	110.32

15

[Table 4] Surface energies when the top-coating vapor deposition layer is formed

Results of surface energy (mN/m)						
Sample	A	B	C	D	E	Average
Original	35.39	35.65	35.72	35.27	34.74	35.35
Multicoating + water-repellent	16.29	17.04	17.7	17.16	16.68	16.97

coating						
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7: The ventilating step (the vacuum-destruction step)

When the manufacture of the multi-layered thin film by the dry process is completed, the vacuum state of the inside of the vacuum vapor deposition device is destroyed.

5

8: The demounting step

After the destruction of the vacuum state of the vacuum vapor deposition device, the product for which the manufacture of the multi-layered thin film is completed is taken out of the vacuum vapor deposition device.

10

The present invention has been explained in detail according to the embodiments of the present invention as above. However, it should be understood that the above embodiments are never intended to limit the scope of the present invention.

INDUSTRIAL APPLICABILITY

The present invention can be applied to cases, windows, window-integrated cases, keypads, keypad-integrated windows, function key parts, various accessories and the like of display and accessory parts used in portable electronic products such as mobile phone, MP3 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, etc. and display products

such as monitor, touchscreen, etc. and electronic home appliances such as refrigerator, air conditioner, television, etc.

CLAIMS

1. A process for manufacturing multi-layered thin film, comprising the steps of:
forming a bottom-coating vapor-deposition layer on a substrate; and
5 forming an optical coating layer on the bottom-coating vapor-deposition layer,
where the bottom-coating vapor-deposition layer is to provide adhesion strength between the substrate and the optical coating layer,
wherein the formation of the multi-layered thin film is performed by dry
10 vacuum vapor deposition.
2. The process according to claim 1, further comprising a step of forming a middle-coating vapor-deposition layer after the step of forming the optical coating layer.
- 15 3. The process according to claim 2, further comprising a step of forming a top-coating vapor-deposition layer after the step of forming the middle-coating vapor-deposition layer.
4. The process according to claim 1, further comprising a step of forming a top-coating vapor-deposition layer after the step of forming the optical coating layer.
20

5. The process according to claim 1, wherein the substrate is case, window, window-integrated case, keypad, keypad-integrated window, function key part or accessory part of portable electronic product, display products or electronic home appliances.
- 5
6. The process according to claim 1, wherein the substrate is made out of a material selected from the group consisting of metal, glass, acryl, polycarbonate, PMMA, PET, ABS resin and combinations thereof.
- 10 7. The process according to claim 1, wherein the bottom-coating vapor-deposition layer is formed from carbon-based compound having one or more functional groups selected from carboxyl group, phosphate group, silane group, amine group, hydroxyl group, aldehyde group, ketone group, ether group and ketal group.
- 15
8. The process according to claim 1, wherein the bottom-coating vapor-deposition layer has a thickness of 10 Å to 1,000 Å.
9. The process according to claim 1, wherein the optical coating layer is formed
- 20 from a material selected from the group consisting of metal, metal oxide, metal nitride, metal fluoride and combinations thereof.

10. The process according to claim 2, wherein the middle-coating vapor-deposition layer is formed from carbon-based compound having one or more functional groups selected from carboxyl group, phosphate group, silane group, amine group, hydroxyl group, aldehyde group, ketone group, ether group and ketal group.
- 5
11. The process according to claim 3, wherein the top-coating vapor-deposition layer is formed from fluorocarbon-based compound having one or more functional groups selected from carboxyl group, phosphate group, silane group, amine group, hydroxyl group, aldehyde group, ketone group, ether group and ketal group.
- 10
12. The process according to claim 1, wherein the vacuum vapor deposition is performed by using electron beam, resistance-heating device, sputtering device or ion plating device.
- 15
13. The process according to claim 1, wherein the formation of the multi-layered thin film structure proceeds continuously in a vacuum vapor deposition device.
- 20
14. A multi-layered thin film coating which is formed by the process according to

any one of claims 1 to 13 and comprises a bottom-coating vapor-deposition layer formed on a substrate; and an optical coating layer formed on the bottom-coating vapor-deposition layer.

5 15. The multi-layered thin film coating according to claim 14, further comprising a middle-coating vapor-deposition layer formed on the optical coating layer.

16. The multi-layered thin film coating according to claim 15, further comprising a top-coating vapor-deposition layer formed on the middle-coating vapor-
10 deposition layer.

17. The multi-layered thin film coating according to claim 14, further comprising a top-coating vapor-deposition layer formed on the optical coating layer.

15 18. An electronic product comprising the multi-layered thin film coating formed by the process according to any one of claims 1 to 13.

19. The electronic product according to claim 18, which is a mobile phone, MP3
20 player, portable multimedia player (PMP), digital multimedia broadcasting (DMB) receiver, car navigation system, notebook computer, monitor, touchscreen, refrigerator, air conditioner or television.

20. The electronic product according to claim 18, wherein the multi-layered thin film coating is formed on a case, window, window-integrated case, keypad, keypad-integrated window, function key part or accessory part.

Figure 1

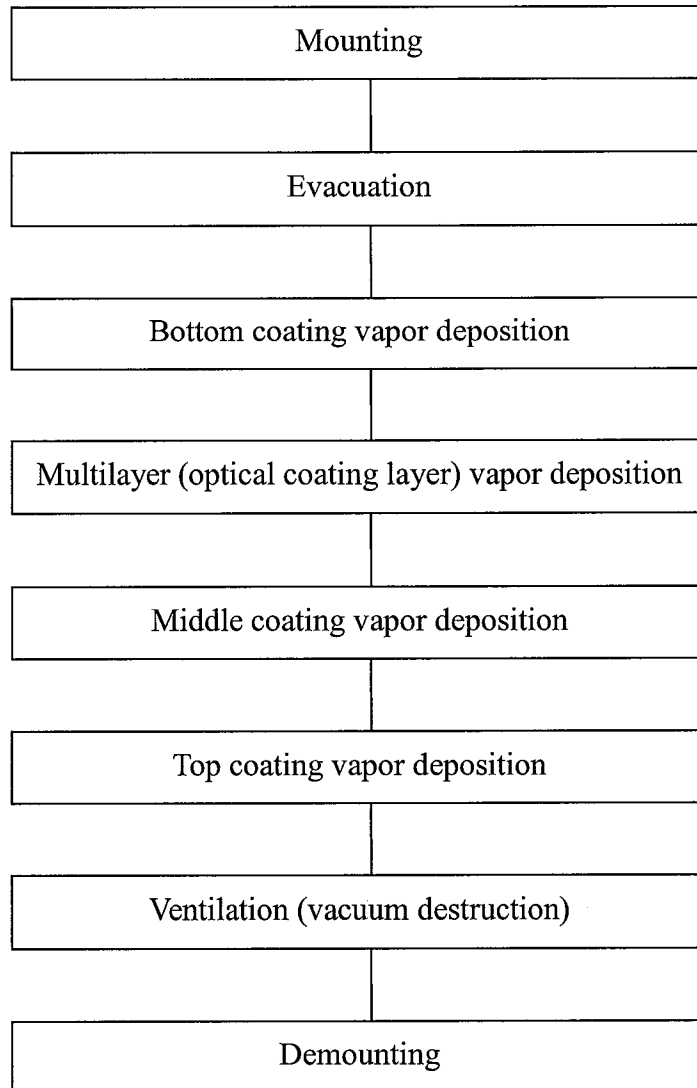


Figure 2

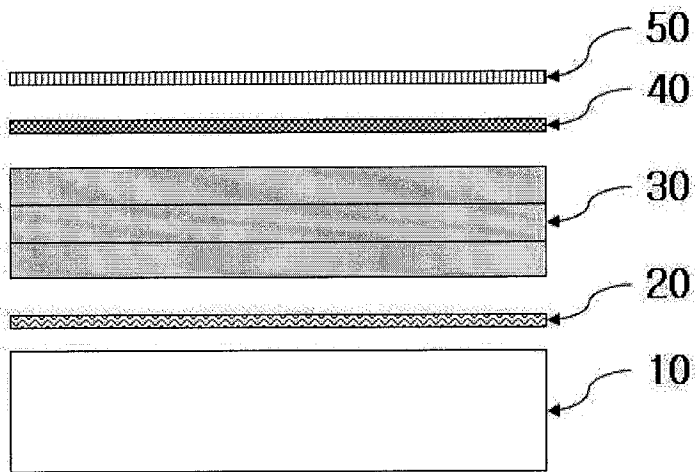


Figure 3

	<i>Contact</i>	<i>Wetting</i>
	$\theta =$	poor
	$180^\circ > \theta$	poor
	$\theta = 90^\circ$	Poor/ moderate
	$90^\circ > \theta$	good
	$\theta = 0^\circ$	spontaneous

Figure 4

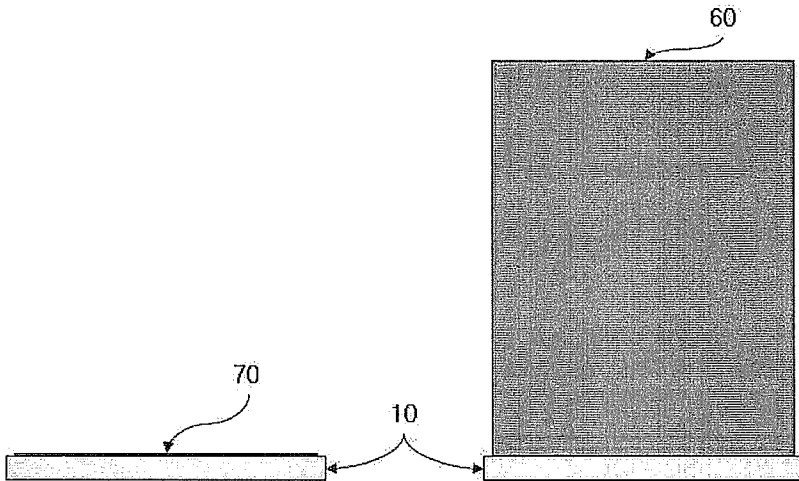


Figure 5

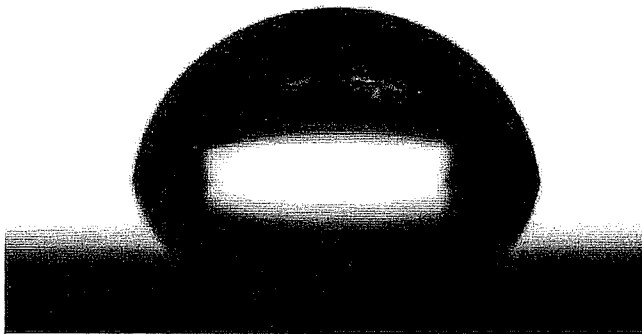


Figure 6



Figure 7

