the coating material. For example for hybrid materials, in EP 1555249 A1 (Nanogate), silicone alkoxides are used as precursors for the coating material.

For many of the anti-fingerprint coatings in the market, it is also true that their combined adhesion and hardness properties, so to say their scratch resistance, is not that good what would be expected for pieces under daily use, including mobile phone window and PC-tablet glass window applications, so the AFP and/or E2C effect will be quickly eroded off from the coated surface.

Summary

It is an aim of the present disclosure to provide chemically and mechanically and environmentally highly stabile coating material layer for substrate surfaces, which has combined anti-smudge/easy-to-clean and anti-reflectivity properties.

It is an aim of the present disclosure to provide liquid phase coating materials, which can be applied by an atmospheric deposition process, such as spin, dip, spray, ink-jet, gravure, slit/slot, roll-to-roll, drip, curtain and roller coating processes.

In particular it is an aim of the present disclosure to provide materials which will give the properties of anti-smudge and easy-to-clean together with anti-reflectivity properties combined in a single coating layer.

Thus, it is an aim of the present disclosure to provide new material compositions that have suitable properties to be used as single layer anti-smudge/easy-to-clean and anti-reflectivity coating on glass surfaces.

It is a further aim of the present disclosure to provide material compositions that are suitable for producing films (and structures) by using conventional and cost-efficient processing from the liquid phase, including spin-on, dip, spray, ink-jet, roll-to-roll,

gravure, flexo-graphic, curtain, drip, roller, screen printing coating methods, extrusion coating and slit coating, but are not limited to these.

It is also an aim of the present disclosure to provide material compositions that are capable of producing optically good quality films even on structured (textured) glass substrate surfaces.

It is a further aim of the present disclosure to provide a computer or personal communication device, comprising a central processing unit (CPU) and a display wherein the display comprises an array of optical elements; a touch sensor; and a glass cover having a coating that is antireflective and oleophobic hard coating.

In an aspect, there is provided a computer or personal communication device, comprising:

central processing unit (CPU);

wherein the display comprises;

an array of optical elements;

a touch sensor; and

a glass cover having a coating that is oleophobic;

wherein the coating is a polymer having silicon, oxygen and carbon in the backbone, and further optionally comprising fluorine, and wherein the coating has a water contact angle of 65 or more, an oil contact angle of 20 degrees or more, and a pencil hardness of 7H or more.

It is an aim of the present disclosure to provide a glass substrate having an antireflective and oleophobic hard coating thereon, wherein the coating is a polymer having silicon, oxygen and carbon in the backbone, and wherein the coating has a refractive index of 1.22 to 1.7, a pencil hardness of 6H or more preferably 8H or more, a water contact angle of 65 degrees or more, e.g. 70 degrees or more, and an oil contact angle of 20 degrees or more, e.g. 30 degrees or more.

In another aspect, there is provided a glass substrate having an antireflective and oleophobic coating thereon, wherein the coating is a polymer having silicon, oxygen and carbon in the backbone, and wherein the coating has a refractive index of 1.22 to 1.7, a pencil hardness of 7H or more, a water contact angle of 90 degrees or more and an oil contact angle of 20 degrees or more.

Thus, the materials combine properties of hydro- and oleophobicity.

In another aspect, there is provided a display with a touch sensitive screen, comprising,

an array of optical elements;

a touch sensor layer;

a cover glass with first optical layer formed thereon;

wherein the first optical layer comprises a polymer having silicon, oxygen and carbon in the backbone, and wherein the optical layer has a refractive index of from 1.22 to 1.46, a pencil hardness of 6H or more, a water contact angle of 65 degrees or more, and an oil contact angle of 20 degrees or more.

It is an aim of the present disclosure to provide a method for making coated glass and coated polymer sheets.

It is an aim of the present disclosure to provide a method of increasing the anti-reflectivity, hardness and oleophobicity of a computer or personal communication device having a touch sensitive screen.

The present disclosure provides material compositions comprising hybrid siloxane polymers.

Suitable materials of the present kind can be produced by hydrolysing silane monomer(s); condensation polymerizing the hydrolysed silane monomer(s) to form a carbosiloxane prepolymer; and mixing the carbosiloxane polymer with at least one solvent capable of dissolving said polymer and, optionally with at least one additive, in order to formulate a carbosiloxane prepolymer liquid composition.

Monomers for use in the present disclosure include, for example, monomers according to formula I

$$R^1_aSiX_{4-a} \qquad I$$

and formula II

$$R^2_bSiX_{4-b} \qquad II$$

wherein R^1 and R^2 are independently selected from the group consisting of hydrogen, linear and branched alkyl and cycloalkyl, alkenyl, alkynyl, (alk)acrylate, epoxy, allyl, vinyl and alkoxy and aryl having 1 to 6 rings; each X represents independently a hydrolysable group or a hydrocarbon residue; and
a and b is an integer 1 to 3;

and monomers of formula III

$$R^3_cSiX_{4-c} \qquad III$$

wherein R^3 stands for hydrogen, alkyl or cycloalkyl which optionally carries one or several substituents, or alkoxy;
each X represents independently a hydrolysable group or a hydrocarbon residue having the same meaning as above; and
c is an integer 1 to 3,

and monomers of formula VI

$$(R^6)_3Si\text{-}Y\text{-}Si(R^7)_3, \qquad VI$$

wherein R^6 and R^7 are independently selected from hydrogen and a group consisting of linear or branched alkyl, cycloalkyl, alkenyl, alkynyl, (alk)acrylate, epoxy, allyl, vinyl, alkoxy and aryl having 1 to 6 rings, and wherein the group is substituted or unsubstituted; and

Y is a linking group selected from unsubstituted and substituted bivalent aliphatic and aromatic groups, such as alkylene, arylene, -O-alkylene-O-; -O-arylene-O-; alkylene-O-alkylene, arylene-O-arylene; alkylene-$Z^1C(=O)Z^2$-alkylene, arylene-$Z^1C(=O)Z^2$-arylene and -O-alkylene-$Z^1(=O)Z^2$-alkylene-O-; –O-arylene-$Z^1(=O)Z^2$-arylene-O-, wherein Z^1 and Z^2 are each selected from a direct bond or -O-.

The monomers are homo- or copolymerized to yield corresponding siloxane polymers.

Optionally the monomers are homo- or copolymerized to yield corresponding siloxane polymers or prepolymers, which can be further cured to yield high-molecular weight coatings.

The present disclosure also provides a method of producing hybrid siloxane prepolymer compositions, comprising

- hydrolysing silane monomer or monomers,
- condensating and polymerzing the silane monomers to a siloxane polymer having a molecular weight of about 1500 to 150,000 g/mol, and
- incorporating solvent or solvents and optionally additive(s) for the siloxane polymer, in order to formulate a siloxane prepolymer liquid composition

The present disclosure further provides a method of using the hybrid siloxane prepolymer composition in as anti-smudge/easy-to-clean and anti-reflection hard coating layer, comprising

- optionally adjusting the solid content of the hybrid siloxane prepolymer composition material to the required film thickness of the deposited film and selecting the proper solvent for a specific coating method,
- optionally adding photoactive or thermally active additives or catalysts to the composition,
- depositing the composition on a substrate to form a layer having a film thicknesses of 5 nm – 30 μm,
- optionally heat treating the deposited film,
- optionally subjecting the deposited material layer to UV exposure,
- optionally removing the non-exposed areas of the film in a development step, by contacting the layer with an aqueous basic developer solution, and
- optionally heat treating/curing the exposed material.

The present disclosure provides a method for making a coated glass, comprising:

- providing glass to be coated;
- coating the glass with a liquid phase coating;
- thermally curing and/or UV hardening the coating on the glass;

wherein the coated glass comprises a polymer having silicon, oxygen and carbon in the backbone, and wherein the coating on the glass has a refractive index of 1.22 to 1.7, a pencil hardness of 6H or more preferably 8H or more, and an oil contact angle of 30 degrees or more.

In another aspect, there is provided a method for making a coated glass, comprising:

providing glass to be coated;

coating the glass with a liquid phase coating;

baking and/or UV hardening the coating on the glass;

wherein the coated glass comprises a polymer having silicon, oxygen and carbon in the backbone, and wherein the coating on the glass has a refractive index of 1.22 to 1.7, a pencil hardness of 7H or more, a water contact angle of 65 degrees or more, and an oil contact angle of 20 degrees or more.

The present disclosure also provides a method, which can be combined with the previous, for making a coated glass, comprising:

- providing glass to be coated;
- coating the glass with a liquid phase coating;
- baking and/or UV hardening the coating on the glass;

wherein the coating to be deposited by liquid phase coating is formed by combining:

- a first monomer having the chemical formula $R^{11}{}_xR^{12}{}_ySiC_3H_6R^{13}$, wherein R^{11} is an alkoxy, acetoxy or chloro group and where x is 2 or 3, and wherein R^{12} is an alkyl group where y is 0 or 1, and wherein R^{13} is an epoxy, acrylate, methacrylate, (substituted) phenyl or isocyanate group;
- a second monomer having the chemical formula $R^{14a}R^{15b}SiC_2H_4(CF)_n$, wherein R^{14} is an alkoxy, acetoxy or chloro group and where a is 2 or 3, and wherein R^{15} is an alkyl group where b is 0 or 1, and wherein n is an integer from 3 to 25; and
- a third monomer having the chemical formula $R^{16c}R^{17d}SiC_2H_4SiR^{18e}R^{19f}$, wherein R^{16} is a an alkoxy, acetoxy or chloro group and wherein c = 2 or 3, wherein R^{17} is an alkyl group or H and wherein d = 0 or 1, wherein R^{18} is an alkoxy, acetoxy or chloro group and wherein e = 2 or 3, and wherein R^{19} is an alkyl group or H and wherein f = 0 or 1.

In another aspect, there is provided a method for making a coated glass, comprising:

providing glass to be coated;

coating the glass with a liquid phase coating;

baking and/or UV hardening the coating on the glass;

wherein the coating to be deposited by liquid phase coating is formed by combining:

a first monomer having the chemical formula $R^{11}{}_xR^{12}{}_ySiC_3H_6R^{13}$, wherein R^{11} is an alkoxy, acetoxy or chloro group and where x is 2 or 3, and wherein R^{12} is an alkyl group where y is 0 or 1, and wherein R^{13} is an epoxy, acrylate, methacrylate, phenyl or isocyanate group;

a second monomer having the chemical formula $R^{414a}R^{515b}SiC_2H_4(CF)_n$, wherein R^{14} is an alkoxy, acetoxy or chloro group and where a is 2 or 3, and wherein R^{15} is an alkyl group where b is 0 or 1, and wherein n is an integer from 3 to 25; and

a third monomer having the chemical formula $R^{16c}R^{17d}SiC_2H_4SiR^{18e}R^{919f}$ wherein R^{16} is a an alkoxy, acetoxy or chloro group and wherein c = 2 or 3, wherein R^{17} is an alkyl group or H and wherein d = 0 or 1, wherein R^{18} is an alkoxy, acetoxy or chloro

group and wherein e = 2 or 3, and wherein R^{19} is an alkyl group or H and wherein f = 0 or 1.

Formula $R^{16c}R^{17d}SiC_2H_4SiR^{18e}R^{19f}$ represents a subformula for compounds included in general formula VI mentioned above.

The present disclosure provides a method of increasing the anti-reflectivity, hardness and oleophobicity of a display, a computer or personal communication device having a touch sensitive screen, comprising:

- polymerizing a plurality of monomers that comprise silicon, oxygen and carbon so as to form a carbosiloxane polymer with a molecular weight of at least 2000;
- depositing the carbosiloxane polymer with a liquid phase process at atmospheric pressure on a glass substrate;
  wherein after hardening the polymer on the glass substrate, the carbosiloxane polymer has a hardness of at least 6H, a refractive index of from 1.22 to 1.46, and an oil contact angle of at least 30 degrees;
- further providing a central processing unit (CPU), a display, a touch sensor layer, and a housing so as to form a the computer or personal communication device with a touch sensitive screen;

wherein the properties of antireflectivity reduces surface reflection with over 15 %, preferably 20 % or more compared to the same glass substrate without the carbosiloxane polymer layer.

In another aspect, there is provided a method of increasing the hardness and oleophobicity of a computer or personal communication device having a touch sensitive screen, comprising:

polymerizing a plurality of monomers that comprise silicon, oxygen and carbon so as to form a carbosiloxane polymer with a molecular weight of at least 2000;

depositing the carbosiloxane polymer with a liquid phase process at atmospheric pressure on a glass substrate;

wherein after hardening the polymer on the glass substrate, the carbosiloxane polymer has a hardness of at least 7H, a refractive index of from 1.22 to 1.46, a water contact angle of at least 65 degrees, and an oil contact angle of at least 20 degrees;

further providing a CPU, a display, a touch sensor layer, and a housing so as to form a the computer or personal communication device with a touch sensitive screen;

wherein the amount of sunlight reflected from the glass substrate is at least 1.5% less due to the carbosiloxane polymer layer as compared to the same glass substrate without the carbosiloxane polymer layer.

The present disclosure provides computer or personal communication device, comprising a housing; a central processing unit (CPU); and a display; wherein the display comprises; an array of optical elements; a touch sensor; and a glass cover having a coating that is durable antireflective and oleophobic; wherein the coating is a polymer comprising silicon, carbon, oxygen and fluorine, and wherein the atom% of silicon is from 10 to 30, the atomic% of carbon is from 10 to 60, the atomic% of oxygen is from 10 to 60, and the atomic% of fluorine is from 0.1 to 10.

In another aspect, there is provided a computer or personal communication device, comprising:

a housing;

a central processing unit (CPU);

and a display;

wherein the display comprises;

an array of optical elements;

a touch sensor; and

a glass cover having a coating that is antireflective and oleophobic;

wherein the coating is a polymer comprising silicon, carbon, oxygen and optionally fluorine, and wherein the atom% of silicon is from 10 to 30, the atomic% of carbon is from 10 to 60, the atomic% of oxygen is from 10 to 60, and the atomic% of fluorine is from 0.1 to 10.

In another aspect, there is provided a product having at least a portion comprising glass, the glass having an antireflective and oleophobic coating thereon, wherein the coating is a polymer having silicon, oxygen, carbon and fluorine, and wherein the atom% of silicon is from 10 to 30, the atom% of carbon is from 10 to 60, the atom% of oxygen is from 10 to 60, and the atom% of fluorine is from 1 to 40.

In another aspect, there is provided a display comprising:

an array of optical elements;

a touch sensor; and

a glass cover having a coating, wherein the coating is a polymer comprising silicon, carbon, oxygen and fluorine, and wherein the atom% of silicon is from 10 to 30, the atomic% of carbon is from 10 to 60, the atomic% of oxygen is from 10 to 60, and the atomic% of fluorine is from 0.1 to 10.

In another aspect, there is provided a composition of a hybrid organic-inorganic material having an inorganic portion comprising silicon, oxygen and carbon, and further comprising an organic portion with organic groups connected to the inorganic portion,

said material comprising polymers obtained from polymerization of monomers according to

formula I

$$R^1_aSiX_{4-a} \qquad I$$

or formula II

$$R^2_bSiX_{4-b} \qquad II$$

wherein R^1 and R^2 are independently selected from the group consisting of hydrogen, linear and branched alkyl and cycloalkyl, alkenyl, alkynyl, (alk)acrylate, epoxy, allyl, vinyl and alkoxy and aryl having 1 to 6 rings; each X represents independently a hydrolysable group or a hydrocarbon residue; and
a and b is an integer 1 to 3;

or formula III

$$R^3_cSiX_{4-c} \qquad III$$

wherein R^3 stands for hydrogen, alkyl or cycloalkyl which optionally carries one or several substituents, such as halo (e.g. fluoro), or alkoxy;
each X represents independently a hydrolysable group or a hydrocarbon residue having the same meaning as above; and
c is an integer 1 to 3,

or combinations thereof,

together with monomers of formula VI:

$$(R^6)_3Si\text{-}Y\text{-}Si(R^7)_3, \qquad VI$$

wherein R^6 and R^7 are independently selected from hydrogen and a group consisting of linear or branched alkyl, cycloalkyl, alkenyl, alkynyl,

(alk)acrylate, epoxy, allyl, vinyl, alkoxy and aryl having 1 to 6 rings, and wherein the group is substituted or unsubstitued; and

Y is a linking group selected from unsubstituted and substituted bivalent aliphatic and aromatic groups, such as alkylene, arylene, -O-alkylene-O-; -O-arylene-O-; alkylene-O-alkylene, arylene-O-arylene; alkylene-$Z^1C(=O)Z^2$-alkylene, arylene-$Z^1C(=O)Z^2$-arylene and -O-alkylene-$Z^1(=O)Z^2$-alkylene-O-; –O-arylene-$Z^1(=O)Z^2$-arylene-O-, wherein Z^1 and Z^2 are each selected from a direct bond or -O-.

In another aspect, there is provided the use of a composition as defined above in a device as defined above, on a glass substrate as defined above, a display as defined above, a method as defined above, a device as defined above, or a product as defined above.

In another aspect, there is provided the use of a composition of a hybrid organic-inorganic material having an inorganic portion comprising silicon, oxygen and carbon, and further comprising an organic portion with organic groups connected to the inorganic portion, said material comprising polymers obtained from polymerization of monomers according to formula VI:

$$(R^6)_3Si\text{-}Y\text{-}Si(R^7)_3, \qquad VI$$

wherein R^6 and R^7 are independently selected from hydrogen and a group consisting of linear or branched alkyl, cycloalkyl, alkenyl, alkynyl, (alk)acrylate, epoxy, allyl, vinyl, alkoxy and aryl having 1 to 6 rings, and wherein the group is substituted or unsubstitued; and

Y is a linking group selected from unsubstituted and substituted bivalent aliphatic and aromatic groups, such as alkylene, arylene, -O-alkylene-O-; -O-arylene-O-; alkylene-O-alkylene, arylene-O-arylene; alkylene-$Z^1C(=O)Z^2$-alkylene, arylene-$Z^1C(=O)Z^2$-arylene and -O-alkylene-$Z^1(=O)Z^2$-alkylene-O-; –O-arylene-$Z^1(=O)Z^2$-arylene-O-, wherein Z^1 and Z^2 are each selected from a direct bond or -O-,

in a device as defined above, on a glass substrate as defined above, a display as defined above, a method as defined above, a device as defined above, or a product as defined above.

More specifically, the computer device according to the present disclosure is characterized by what is stated in the characterizing part of original claim 1.

The glass substrate having an antireflective and oleophobic hard coating is characterized by what is stated in the charactering part of original claim 10.

The display with a touch sensitive screen is characterized by what is stated in the characterizing part of original claim 22.

The methods for making coated glass is characterized by what is stated in the characterizing parts of original claims 38 and 43.

The method of increasing the hardness and oleophobicity of a computer or personal communication device having a touch sensitive screen is characterized by what is stated in the characterizing part of original claim 53.

The computer or personal communication device, with a display having a glass cover and exhibiting a coating that is antireflective and oleophobic is characterized by what is stated in the characterizing part of original claim 62.

The compositions are characterized by what is stated in the characterizing part of original claim 80.

Considerable advantages are obtained by the disclosure. Thus, the disclosure provides material compositions that are thermally curable and/or optionally irradiation curable. The material compositions can be cured at relatively low processing temperatures e.g. at a temperature of max 375 °C or even at temperature of 100 °C.

The patterning of the films can be performed via direct lithographic patterning, conventional lithographic masking and etching procedure, imprinting and embossing, but are not limited to these.

The material composition suitable to be used with different glass types. These include thick glass and thin glass and also chemically tempered and thermally tempered glass. The material compositions can also be used on various substrates, such as metal and of polymer materials, in particular thermoplastic films and sheets.

In case of chemically tempered glass it is highly advantageous to have a coating composition of the present kind which can be cured at temperature of 350 °C or preferable at temperature below 250 °C or below 200 °C. The same low temperature requirement applies in case of the chemically tempered glass as well when the coating is applied after thermal tempering of the glass.

The present disclosure provides in addition to anti-smudge and easy-to-clean properties and antireflective properties also increased mechanical stability for thin and thick glass substrate surfaces. The highly mechanically stabile coating material protects the glass substrate from external damage.

Due to the chemically and physically homogenous nature of the coating, the mechanical durability and long-term stability of the anti-smudge and easy-to-clean properties and antireflective properties is achieved and sustained.

The present disclosure provides a glass substrate having an antireflective and mechanical durability and long-term stability of the anti-smudge and easy-to-clean properties, wherein the coating is a polymer having silicon, oxygen, carbon in the backbone, and wherein the coating has a refractive index of 1.22 to 1.55, a pencil hardness of 8H or more, water contact angle of 70 degrees or more and an oil contact angle of 30 degrees or more. Furthermore, specifically the coating has durability properties where the water contact angle is retained above 65 degrees after 5000 cycles of steel-wool (0000-type) taber abrasion test (measured before and after the test).

Furthermore, specifically the coating has durability properties where the water contact angle is retained above 65 degrees after 200 000 cycles of cheesecloth/cotton cloth taber abrasion test.

The present disclosure also provides a glass substrate having an antireflective and mechanical durability and long-term stability of the anti-smudge and easy-to-clean properties, wherein the coating is a polymer having silicon, oxygen, carbon and fluorine in the backbone, and wherein the coating has a refractive index of 1.22 to 1.5, a pencil hardness of 8H or more, water contact angle of 90 degrees or more and preferably 100 degrees or more and an oil contact angle of 35 degrees or more preferably 45 degrees or more. Furthermore, specifically the coating has durability properties where the water contact angle is retained above 90 degrees or preferably over 100 degrees after 5000 cycles of steel-wool (0000-type) taber abrasion test (measured before and after the test). Furthermore, specifically the coating has durability properties where the water contact angle is retained above 90 or preferably over 100 degrees after 200 000 cycles of cheesecloth/cotton cloth taber abrasion test.