

TOUGHENED GLASS BODY

The present invention relates to glass bodies of any shape, for example in the form of flat sheets or in three-dimensional form of greater thickness.

In numerous applications such glass bodies require particularly high strength, in particular a surface strength. Chemical or thermal treatments are considered for this purpose.

With thermal hardening of glass compressive stresses are frozen on the surface, while tensile stresses are frozen in the core due to the lower cooling rate. The width of the compressive stress zone is approximately $1/5$ of the thickness of the glass. Thermal hardening, however, is limited to sheets having a thickness > 3 mm.

By comparison to thermal hardening chemical hardening is based on the fact that compressive stresses in the glass surface transpire by modification to the composition of the surface area relative to the interior of the glass. In most cases this modification is accomplished by an alkali ion exchange at temperatures below the transformation temperature T_g . In the process the glass is treated in potassium nitrate smelting at approximately $50 - 150^\circ\text{C}$ below T_g for several hours. A compressive stress zone, whose depth is ca. $60 - 150\ \mu\text{m}$ results from the exchange of Na to K. This method also is restricted to thicker glass > 0.7 mm. Furthermore, it is essential that the glass is polished for optical or electronic applications after chemical hardening. This procedural step again increases production costs and in the case of thin glass (< 0.3 mm) leads to considerable losses due to breakages.

The abovementioned methods are accordingly not to be implemented for thin glass, as used in particular for displays or for data storage or for electronic applications.

With minimal glass thickness, in particular thicknesses < 1 mm, or due to the manufacturing process for three-dimensional glass bodies, previously known processes for toughening glass, such as thermal and chemical hardening, are ruled out because these processes are too time-consuming, or produce a surface which must be reprocessed using an expensive polishing procedure and which is not useful for optical, electrical, electronic and optoelectronic applications. In particular in applications where very thin glass (< 0.3 mm) is used, it is particularly important to increase the strength of the glass, since this otherwise breaks too easily. Furthermore, thermal hardening is possible only for glass-types having a

thermal expansion coefficient of $> 7 \text{ ppm/}^\circ\text{C}$. In the abovementioned applications especially glasses having a thermal expansion coefficient of $< 7 \text{ ppm/}^\circ\text{C}$ are used on account of the required thermal geometric stability.

The relatively minimal practical strength of glass as compared to its theoretical strength is caused in particular by damage to and defects in the glass surface. It is accordingly suggested to protect the surface by coating it. DE 36 15 227 A1 thus describes a process in which flat glass is coated with a scratch-proof splinter coating of a synthetic material, such that a synthetic powder is melted onto the still hot surface of the glass. But this method does not produce a surface quality adequate for glass substrates for use in displays or for data media.

US 5 476 692 describes a process for improving the stability of containers made of glass by using an organic resin which is manufactured by polymerisation on the glass. With this process the surface of the glass is certainly well protected and thus becomes more stable against external impact and pressure, but does not describe toughening of the glass by means of compressive or tensile stress being built up in the layer or in the glass.

US 5 455 087 also describes a process for toughening glass containers by polymerisation on the glass surface. Here, too, this increase in strength is achieved only by the protective mechanical effect and not, as described in the process according to the present invention, by means of mechanical prestressing of the polymer layer. Neither is there any mention made of the significance of tear-growth resistance of the polymers in the abovementioned documents.

The object of the invention is to equip a glass body of any type and shape with greater strength. In particular, high surface strength should be achieved with the lowest possible manufacturing expense and low manufacturing costs.

This task is solved by the characteristics of the independent claims.

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According to a first aspect of the present invention, there is provided a toughened glass body comprising a base body of glass and at least one first layer applied thereto, characterised in that the first layer is a layer of silicon resin, such that the layer is under tensile stress of the order of 100 to 1000 MPa.

According to a second aspect of the present invention, there is provided a toughened glass body comprising a base body of glass and at least one first layer applied thereto, characterised in that the first layer is a layer of a platinum-catalysed, addition-cross-linking silicon elastomer, such that the layer is under a tensile stress of the order of 100 to 1000 MPa.

According to a third aspect of the present invention, there is provided a toughened glass body comprising a base body of glass and at least one first layer applied thereto, characterised in that the applied first layer is an epoxy resin layer, such that the layer is under a tensile stress of the order of 100 to 1000 MPa.

According to a fourth aspect of the present invention, there is provided a toughened glass body comprising a base body of glass and at least one first layer applied thereto, characterised in that the applied first layer is a polymer mixture of polyacrylate and polyepoxy, such that the layer is under a tensile stress of the order of 100 to 1000 MPa.

According to a fifth aspect of the present invention, there is provided a toughened glass body comprising a base body of glass of thickness less than 0.3mm and at least one first layer applied thereto, characterised in that the applied first layer is a lacquer coating, such that the lacquer coating is a polyurethane lacquer or a lacquer system based on acrylate or a lacquer system based on epoxy and where the layer is under a tensile stress of the order of 200 to 1000 MPa.

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The invention is therefore based on a glass body which is composed of a base body and a layer applied thereto. At the same time provision is made for the applied layer to be under a defined compressive stress or under a defined tensile stress. The layer has either its own tension, which is already effective when applied to the glass surface, or it obtains this tension from further processing.

When a layer, which is under compressive stress, is applied the tensile stress applied

externally must first overcome this compressive stress before the glass breaks. If the applied layer, however, is under tensile stress, a compressive stress is created in the superficial region of the glass. When an external tensile stress is applied this too must first be overcome before the glass breaks.

In an embodiment, this defined mechanically prestressed layer may comprise organic, inorganic and organic/inorganic materials. Apart from the mechanical prestressing of the applied layer, with polymer layers the tear-growth resistance of the polymer may be important for increasing the mechanical stability of the polymer/glass compound. With the process according to one embodiment, the selected material, the type and method of coating, or appropriate subsequent treatment accordingly may guarantee that a defined mechanical layer stress is produced. Dip coating, centrifuging, laminating, spraying and vacuum treatment, such as sputtering, plasma polymerisation, or plasma-supported chemical precipitation from the vapour phase (PECVD) can be used as possible process for coating.

According to a sixth aspect of the invention, there is provided a process for manufacturing a glass body as defined above, characterised by a first layer comprising a silicon resin which is applied to the base body by centrifuging a silicon resin xylol solution and is dried.

According to a seventh aspect of the invention, there is provided a process for manufacturing a glass body as defined above, characterised by a first layer comprising a silicon resin which is applied to the base body by centrifuging a silicon resin xylol solution and dried, and a second layer which is applied to the dried first layer by centrifuging and is dried.

According to an eighth aspect of the invention, there is provided a process for manufacturing a glass body as defined above, characterised by a coating solution comprising vinyl siloxane, a cross-linker, a platinum catalyst and ethyl acetate which is applied to the base body by centrifuging and the centrifuged layer is hardened in an IR ray field.

According to a ninth aspect of the invention, there is provided a process for manufacturing a glass body as defined above, characterised by a first epoxy layer which is applied to the base body by centrifuging an epoxy resin and is hardened.

According to a tenth aspect of the invention, there is provided a process for manufacturing a glass body as defined above, characterised by a polymer mixture, comprising a polyacrylate and a polyepoxy, which is centrifuged on the base body, producing the first layer which is dried.

According to an eleventh aspect of the invention, there is provided a process for manufacturing a glass body as defined above, characterised by a first layer which is applied to the base body by centrifuging or spraying a polyurethane lacquer or a lacquer system based on acrylate or epoxy and is hardened.

According to a twelfth aspect of the invention, there is provided displays manufactured with glass bodies as defined above.

According to a thirteenth aspect of the invention, there is provided hard disks manufactured with glass bodies as defined above.

According to a fourteenth aspect of the invention, there is provided electrical circuit carriers manufactured with glass bodies as defined above.

All materials which can be produced using the process according to one embodiment may be considered as layer materials. Thermoplasts, duroplasts and elastomers can be used as organic polymers. Polymers such as for example polyvinyl alcohols, polyacrylates, polyarylates, polyesters, polysilicons and the like or also so-called ormocers and materials containing nanoparticles can be applied to the glass by the process according to the present invention, such that defined tensile or compressive stresses are adjusted. This may occur by the selection of the appropriate polymer with respect to molecular weight, degree of hydrolysis, purity, cross-linkable functional groups and by corresponding subsequent treatment can be carried out thermally or photochemically (e.g. UV hardening) or autocatalytically. The layer stress may hereby be produced by drying and cross-linking of the polymer. This process may also influence the tear-growth resistance (ASIM 0 264) of the polymer. In a preferred embodiment the range of tear-growth resistance can be 10 N/mm, and in a particularly preferred embodiment this may be in the range of 11 – 15 N/mm. Values over 10 N/mm mean so-called 'shear-proof' elastomers which have a clearly higher initial tearing resistance and tear-growth resistance than standard products.

In order to attain greater strength and high chemical endurance the glass substrate can be coated a number of times. A first layer may be applied which may be under a defined tensile or compressive stress. To render this mechanically prestressed layer more resistant to chemicals, for instance, a second layer can be applied which may give this protection

Adjusting a specific layer tension can be thus made possible with the sputter process by

appropriate choice of processing parameters. Materials such as metal oxides (e.g. aluminium oxide), metal nitrides (e.g. aluminium nitride), metal oxinitrides (e.g. $\text{Al}_x\text{O}_y\text{N}_z$), metal carbides, metal oxycarbides, metal carbonitrides, semiconductor oxides (e.g. silicon oxide), semiconductor nitrides (e.g. silicon nitride), semiconductor oxinitrides (e.g. SiO_xN_y), semiconductor carbides, semiconductor oxycarbides (e.g. SiO_xC_y), semiconductor carbonitrides (e.g. SiC_xN_y) or metals (e.g. chrome) or mixtures of these materials may be considered for this purpose. Plasma polymers can be produced from a plurality of organic and metallorganic volatile compounds. Plasma polymers also can be precipitated according to coating conditions with a defined tensile or compressive stress. With the plasma-supported sputter process and with plasma polymerisation the layer tension may be adjusted in particular by a bias stress which may lie on the glass to be coated. This bias stress on the substrate can be created by applying a direct voltage, a low-frequency voltage, a medium-frequency voltage or a high-frequency voltage on the substrate.

The vacuum arc process may be particularly well suited to creating layers with high mechanical strength from an economical standpoint.

The tensile or compressive stress of the applied layer can be of the order of 100 – 1000 MPa preferably 200 - 600 MPa and particularly preferably 300 - 500 MPa. The glass can be coated single-sided or double-sided. The thickness of the layer can be 0.05 – 50 μm , according to layer material. With plasma polymers and sputtered layers the layer thickness may preferably be of the order of 0.05 - 0.5 μm and particularly preferably 0.1 - 0.3 μm . With the polymer layers applied from the liquid phase the layer thickness can be of the order of 0.5 – 50 μm and in a particularly preferred embodiment 1 - 10 μm .

In a particularly preferred embodiment the coating may be applied directly after hot moulding, thus on the glass strip. This can result in an additional increase in the surface stability. This is because the glass may be provided with a protective layer immediately after manufacture, effectively preventing scratching or the appearance of corrosion on the surface of the glass.

Due to the mechanical stress in the layer material special significance may be given to adhesion of the layer material on the glass. If this adhesion between layer and glass is insufficient, the layer may detach from the glass on account of the layer stress, or may develop cracks. For adequate adhesion of the layer on the glass it may be effective to improve the adhesion of the layer by way of appropriately pretreating the glass. This can occur by means of corresponding cleaning of the glass surface using aqueous or organic solutions. Other known processes for improving the adhesive strength of glass coatings can be corona

pretreatment, flaming, plasma pretreatment in a vacuum, UV pretreatment, ozone pretreatment, UV/ozone pretreatment. Special adhesives such as for example silanole, hexamethyldisilazane, aminosilane or polydimethylphenyl siloxane may also be used to improve the adhesion of silicon polymers.

The surface strength of the glass can be raised from 580 MPa to 2350 MPa by means of double-sided flat coating of the glass with a layer which may be under tensile or compressive stress, which may be within the range of intrinsic stability.

If not only the surface of a flat glass substrate, but also the edges of a glass substrate may be provided with a layer, which can be under mechanical compressive or tensile stress, the surface and edge stability may accordingly increased. This may be particularly significant for thin glass substrates of < 0.3 mm, because in that case the edges cannot be ground using conventional edge processing methods.

Accordingly to the process in one embodiment, in particular thin glass with a thickness of less than 0.3 mm, preferably glass with thicknesses of the order of 0.03 – 0.2 mm, can now be hardened and can also be used for those applications in which otherwise only glass thicker than 0.3 mm is employed. If transparent and heat-resistant materials are used for hardening the glass according to the process, then these glasses can be utilised as substrates for producing displays such as LCDs or PLEDs, for example. In this way stable flexible displays can be manufactured using the process.

In a particularly advantageous embodiment these layers can fulfil other functions still in addition to their stability-reinforcing effect, according to the process according to the present invention. By way of example, they can also act as a diffusion barrier to easily moved alkali ions, or as reflecting layers for reflective displays.

If transparency of the glass substrate is not a requirement, then metallic layers can also be employed to produce layer stresses. Cr layers, and Ta layers in α -modification, which are precipitated at low processing pressures (< 4 μ bar) and a high separation efficiency, are particularly suitable.

With sputtering of Cr or Ta a tensile stress may be established in the metallic layer, which may essentially depend on the processing pressure during sputtering. The lower the processing pressure, the higher the tensile stress on account of the higher kinetic energy of the applied

layer molecules. In processing pressures $> 10 \mu\text{bar}$ the layer stress may become minimal. Furthermore, the sputter rate may decrease sharply due to less ion energy of the Ar^+ ions.

Another application of the process according to another embodiment may comprise the manufacture of data media made of glass, in particular so-called hard disks made of glass. To ensure the mechanical stability of these glass hard disks, they generally may undergo chemical hardening. This chemical hardening may have some disadvantages, however such as for example lengthy processing times and surface contamination. Subsequently, glass substrates for hard disks must be polished and washed following chemical hardening. The processes can also be highly time-intensive. Because of the process in the embodiment, these processes may no longer be required and glass hardened by the process can be employed to manufacture hard disks without any further preliminary treatment.

A further application of the process according yet another embodiment may comprise the manufacture of printed circuit boards, which may use a thin glass film with a thickness of $30 - 100 \mu\text{m}$, instead of glass fabric. A prestressed layer can be effected on the glass by means of coating with an epoxy resin and subsequent cure hardening may be by means of exposure or heat, thus increasing its surface stability. Next, a copper film can be laminated onto the glass treated thus and the electrical circuit carrier may be produced by structuring the copper and tipping with additional electrical components. The surface stability can be measured using a ring-on-ring method (ROR) with reference to DIN 52292 or draft DIN 52300. The measuring instrument may comprise two concentric steel rings, a support ring (radius 20 mm) and a load ring (radius 4 mm). A square sample (50 mm x 50 mm) can be placed between both load rings and the load on the glass defined by the upper load ring may be increased. An anisotropic state of stress may be created in the thin glass sample. The tests may be performed with a dynamic effect which may increase in linear fashion over time, in such a way that a power-controlled stress rate of 2 MPa/s can be given. The stress may be increased until such time as the glass shatters.

Non-linear power voltage connections may be considered for calculating breaking strains. The breaking strains can be given as an MPa unit and evaluated in accordance with DIN 55303-7. The values calculated from this estimation method may then be given as strength values of the tested glasses.

Various measuring methods may be available for determining layer stress in metallic or oxidic thin and thick layers. This measurement may be made relatively simply by bending a thin glass strip which can be coated using the process according to one embodiment. The mechanical

layer stress may be calculated from the basic mechanical data of the glass, its geometry, measured deformation and layer thickness. The process is described in the following references

E.I. Bromley, J.N. Randall, D.C. Flanders and R.W. Mountain,

"A Technique for the Determination of Stress in Thin Films"

J. Vac. Sci. Technol. B 1 (4), Oct.-Dec. 1983, pp. 1364-1366

and

H. Guckel, I. Randazzo and D.W. Burns

"A Simple Technique for the Determination of Mechanical Strain in Thin Films with Applications to Polysilicon", J. Appl. Phy. 57 (5), March 1985, pp. 1671-1675.

Embodiments

1. Coating with polyvinyl alcohol directly on the glass draw

Alkali-free borosilicate glass of glass type AF 37 by Schott 700 μm thick was coated with polyvinyl alcohol (Mowiol by Clariant; 10% dissolved in H_2O), during the glass drawing process (down-draw). The glass temperature was ca. 80°C when the polyvinyl alcohol (viscosity 1100 mPas) was sprayed on both sides (upper and underside) and dried at 180°C in a furnace for ca. 15 seconds, during the on-line process. The tensile stress was 0.6 GPa, the layer thickness 10 μm . The surface stability of the same glass without any coating was 512 MPa, while the glass with the abovementioned coating had intrinsic strength, measured with 2.350 MPa.

2. Coating of glass substrates with polyvinyl alcohol

Alkali-free borosilicate glass (D 263 by Schott Displayglas GmbH) measuring 100 x 100 mm and 0.4 mm thick was coated with polyvinyl alcohol (Mowiol by Clariant, 16% in H_2O) at room temperature by centrifugal process (2000 min^{-1} , viscosity 250 mPas) and dried at 180°C for 10 min. The layer thickness was 20 μm . With single-sided coating the surface stability was 706 MPa (with a tensile stress of 0.2 GPa) and with double-sided coating (dipping method) 924 MPa (tensile stress 0.26 GPa). The uncoated samples had a surface stability of 579 MPa.

3. Coating of glass substrates with a silicon elastomer

Alkali-free borosilicate glass (D 263 by Schott Displayglas GmbH, 100 x 100 mm) 0.2 mm thick was coated with a polydimethyl siloxane (Elastosil® by Wacker) by dipping (viscosity 70.000 mPas, draw rate 50 cm/min) and dried at 180°C for 10 min. The layer thickness was 40 µm, the tear-growth resistance of the polymer is 12 N/mm. The tensile strength was 0.14 GPa, while the surface stability was 722 MPa. The uncoated reference had a surface stability of 404 MPa.

4. Coating with a silicon resin

Alkali-free borosilicate glass (D 263 by Schott Displayglas GmbH, 100 x 100 mm) 0.1 mm thick was coated single-sided with an alkyl phenyl silicon resin Silres® (40% solution in xylol) by Wacker by centrifugal process (4000 min⁻¹, viscosity 60 mPas) and dried at 200°C for 15 min. The layer thickness of the samples was 8.7 µm. The tensile strength was 0.21 GPa and the surface stability 733 MPa, while the uncoated samples exhibited a surface stability of 426 MPa.

5. Coating with a SiC_xO_yH_z plasma polymer

Borosilicate glass (D 263 by Schott Displayglas GmbH, glass thickness 0.4 mm, format 200 x 200 mm) was coated with hexamethyldisiloxane (HMDSO) as monomer using a low-pressure plasma process. A parallel plate reactor was used for this, such that the lower electrode was connected to a high-frequency generator (1356 MHz). The applied HF output on the electrode was 300 Watt, while the bias voltage likewise applied to this electrode was -300 V. After 30 minutes the layer thickness was 0.6 µm. A SiC_xO_y layer was created which had a compressive stress of 0.3 GPa. The surface stability of the coated samples was 1420 MPa, while the uncoated samples had a surface stability of 579 MPa.

6. Coating with a SiC_xN_yH_z plasma polymer

Using high-frequency low-pressure plasma in a parallel plate reactor borosilicate glass (D 263 by Schott Displayglas GmbH, format 150 x 150 mm, 400 µm thick) was used to produce

a 0.42 μm thin $\text{SiC}_x\text{N}_y\text{H}_z$ layer of tetramethylsilane (TMS) and nitrogen. Precipitation lasted for 20 minutes. The pressure was 0.11 mbar. A flow of 5 sccm (Standard cubic centimetre per minute) TMS and 24 sccm nitrogen was set. The processing pressure was 0.2 mbar. The compressive stress of the plasma polymer layer was 0.6 GPa. The surface stability was 1120 MPa, while the uncoated samples had a surface stability of 579 MPa.

7. D 263 Glass / silicon resin / silicon elastomer compound

A glass film measuring 100 x 100 mm of glass type ID 263 (trade literature of Schott-Desag) is used as a glass substrate with a thickness of 100 μm , manufactured by the down-draw process. The strength of this glass substrate is ca. 470 MPa. The glass substrate is coated using a centrifugal process (5000 1/min) with a methylphenyl silicon resin (brand name Silres® by Wacker-Chemie GmbH, silicon resin / xylol solution mass ratio 1 : 3) and then dried at 220°C for 15 min in a circulating air oven. The layer thickness is 4.5 μm , the tensile strength 0.21 CPa and the surface stability ca. 980 MPa. Because silicon resins display minimal chemical resistance relative to ketones inter alia, a second layer is applied. The silicon resin-coated glass substrates are coated with a silicon polymer film based on polydimethyl siloxane (brand name Elastosil® by Wacker-Chemie GmbH, viscosity 70000 mPas) using a centrifugal process (5000 1/mm) and dried at 200°C for 20 min in a circulating air oven. The layer thickness is 45 μm . With the first coating the strength clearly increased, and the chemical resistance in particular relative to ketones was improved by the second coating.

8. Coating with an amorphous silicon nitride layer by means of plasma enhanced chemical vapour deposition (PECVD)

Substrate:	AF45 0.7 mm x 400 x 400 mm by Schott Displayglas
Plant:	PI/PE-CVC reactor horizontal configuration with plasma cage
Plasma excitation frequency:	13.56 MHz
Plasma output:	40W
Temperature:	$T \approx 300^\circ\text{C}$
Precursor gases:	SiH_4 65sccm, NH_3 , 280 sccm
Carrier gases:	N_2 800 sccm, H_2 178 sccm
Processing pressure:	890 μbar
Layer thickness:	$\sim 450\text{nm}$

Layer stress: $\sigma_0 \approx -345 \dots -380 \text{ MPa}$

Surface stability without coating: $\sigma_0 \approx 540 \text{ MPa}$

Surface stability with coating: $\sigma_{0S} \approx 950 \text{ MPa}$

9. Coating with a silicon oxide layer (SiO_x) by powdering (sputtering, PVD, Phys. Vapor Deposition)

Substrate: D263 0.4 x 400 x 400 mm³ by Schott Displayglas
 Plant: Vertical inline sputter plant with water-cooled magnetron cathode and HF plasma generation
 Source: 2 x linear water-cooled magnetron cathode 488 mm wide with intermediate cool zone
 Fully oxidised quartz glass target
 Plasma excitation frequency: 13.56 MHz
 Plasma output: 2500 W
 Substrate temperature: 250°C
 Carrier gases: Ar 40 sccm, Kr 5 sccm, O₂ x sccm
 Running speed: 0.1 m/min
 Processing pressure: 2.9 µbar
 Layer thickness: ~ 2850 nm

Layer stress: $\sigma_S \approx -180 \dots -250 \text{ MPa}$

Surface stability without coating: $\sigma_0 \approx 579 \text{ MPa}$

Surface stability with coating: $\sigma_{0S} \approx 722 \text{ MPa}$

10. Coating of glass substrates with aluminium oxide (AlO_x) by powdering (sputtering, AVD Phys. Vapor Deposition)

Substrate: D 263 0.4 x 400 x 400 mm³
 Plant: Vertical inline sputter plant with water-cooled magnetron cathode and HF plasma generation
 Source: 2 x linear water-cooled magnetron cathode 488 mm wide

Plasma excitation frequency: 13.56 MHz
 Plasma output: 2 x 2500 W
 Carrier gases: Ar 50 sccm, Kr 5 sccm, O₂ 5 sccm
 Substrate temperature: 250°C
 Running speed: 0.15 m/min
 Processing pressure: 3.2 µbar
 Layer thickness: ~ 280nm

Layer stress: $\sigma_s \approx -250 \dots -330$ MPa

Surface stability without coating: $\sigma_0 \approx 579$ MPa

Surface stability with coating: $\sigma_{0s} \approx 754$ Mpa

11. Application of Cr by sputtering in the magnetron field

Substrate: AF 45 0.7 with thickness of 400 mm glass strip width by Schott Displayglas
 Plant: Vertical inline sputter plant with water-cooled magnetron cathode and DC plasma generation
 Source: Linear magnetron cathode 488 mm wide
 Cr target
 Plasma excitation frequency: 13.56 MHz
 Plasma output: 4 kW
 Carrier gases: Ar 40 sccm
 Processing pressure: 2.6 µbar, pressure increase at plasma ignition to ~ 15 µbar
 Layer thickness: ~ 400 nm

Layer stress: $\sigma_s \approx -350 \dots -400$ MPa

Surface stability without coating: $\sigma_0 \approx 515$ MPa

Surface stability with coating: $\sigma_{0s} \approx 1520$ MPa

12. Coating of glass substrates with aluminium oxide (Al₂O₃) by vapour deposition in e-Beam process

Substrate: D 263 0.4 x 50 x 50 mm

Plant: Vacuum vaporisation plant with planet suspension
 Source: Balzers e-Beam on Al_2O_3 , source distance 450 mm
 Residual gas pressure: 10^{-5} mbar
 Layer thickness: ~ 300 nm

Layer stress: $\sigma_s \approx 225\ 255$ MPa (compressive stress)

Surface stability without coating: $\sigma_0 \approx 404$ MPa

Surface stability with coating: $\sigma_{0s} \approx 631$ MPa

13. Coating of glass substrates with silicon resins

Borosilicate glass containing alkali (D 263 T by Schott Displayglas GmbH, format 100 x 100 mm) 0.1 mm thick was dissolved with a polysiloxane Silres® containing methyl groups by Wacker in xylol (55% solution) and filtered. Next, a 5% solution of F 100 (Wacker) in xylol is added for faster cross-linking of the polysiloxane solution and stirred with a magnetic agitator. The glasses are coated with the polymer solution using a centrifugal process ($1000\ \text{min}^{-1}$) and dried at 230°C for 60 min in a circulating air oven. The layer thickness of the sample was $5.3\ \mu\text{m}$. The tensile strength was 0.19 GPa and the surface stability 814 MPa, while the uncoated samples had a surface stability of 426 MPa.

14. Coating of glass substrates with acrylate epoxy polymer mixture

Borosilicate glass containing alkali (D 263 by Schott Displayglas GmbH, format 100 x 100 mm) 0.1 mm thick was coated double-sided with a polymer mixture of polyacrylate and polyepoxy by Clariant (centrifugal process $800\ \text{min}^{-1}$) and dried at 230°C for 30 min in a circulating air oven. The layer thickness of the sample was $3.5\ \mu\text{m}$, the tensile strength 0.18 GPa and the surface stability 790 MPa, while the uncoated samples had a surface stability of 426 MPa.

15. Coating with polyurethane resin

15.1 2 K System

Borosilicate glass containing alkali (D 263 by Schott Displayglas GmbH, format 100 x 100 mm) 0.2 mm thick was coated with a polyurethane lacquer (Desmodur/Desmophen, Bayer)

in a spin-coat process. The viscosity of the resin system was adjusted with a non-polar solvent such that at 2000 rpm a layer thickness of 5 μm resulted. The system was cure hardened for 10 min at 120°C. The tensile strength was 0.17 GPa and the surface stability 683 MPa, while the uncoated samples had a surface stability of 404 MPa.

15.2 1 K System

Borosilicate glass containing alkali (D 263 by Schott Displayglas GmbH, format 300 x 400 mm) 0.2 mm thick was coated with 1 K PU lacquer Coetrans (Coelan) by a spraying process. The lacquer was diluted with MIBK to a solids content of 20%. The lacquer was applied using an air atomiser nozzle (air pressure 2 bar), with the layer thickness 20 μm . The coating cure hardens at room temperature within 1 hour by reacting with humidity. The samples had a tensile strength of 0.15 GPa and a surface stability of 679 MPa, while the uncoated samples had a surface stability of 404 MPa.

15.3 Coating with aqueous PU system

Borosilicate glass containing alkali (D 263 by Schott Displayglas GmbH, format 300 x 400 mm) 0.2 mm thick was coated with the aqueous lacquer system Hydroglasur (Diegel) by a spraying process. The spray pressure was 3 bar, the nozzle diameter 0.8 mm. According to requirements layers thicknesses between 5 and 15 μm were obtained, such that the tensile strength was 0.18 GPa and the surface stability was 752 MPa, while the uncoated samples had a surface stability of 404 MPa.

16. Coating with epoxy resin

Borosilicate glass containing alkali (D 263 by Schott Displayglas GmbH, format 100 x 100 mm) 0.2 mm thick was coated with 2 K epoxy Stycast 1269 A (Grace) in a spin-coat process (1500 s^{-1}) and hardened for 3 h at 120°. The layer thickness was 7.2 μm , the tensile strength 0.18 GPa and the surface stability 748 MPa (surface stability of the uncoated reference 404 MPa).

17. Coating with silicon elastomer (platinum-catalysed addition-cross-linked)

Borosilicate glass containing alkali (D 263 by Schott Displayglas GmbH, format 100 x 100 mm) 0.2 mm thick was coated with an addition-cross-linking silicon in a spin-coat process (1300 s^{-1}). The coating solution had the following ingredients:

10.0 g vinyl siloxane

0.4 g cross-linker

0.1 g platinum catalyst

5.0 g ethyl acetate

After centrifuging the coating was hardened under an IR ray field in 5 sec and a layer thickness of 97 μm was obtained. The tensile strength of the coated samples was 0.19 GPa and the surface stability 783 MPa, while the uncoated samples had a surface stability of 404 MPa.

18. Coating with UV-hardening systems

Alkali-free borosilicate glass (D 263 by Schott Displayglas GmbH, 100 x 100 mm) thickness 0.2 mm was coated with UV-hardening lacquer-systems in a spin-coat process (1300 s^{-1}). The lacquer systems were based on both acrylates and epoxies. These lacquer systems are hardened using a fusion lamp (lamp type H) and an output of 180 W/cm^2 , which was guided at a rate of 6 m/min over the coated samples. The thickness of the acrylate coating was 7.6 μm (tensile stress 0.2 GPa, surface stability 658 MPa). The surface stability of the uncoated reference had 404 MPa.

Claims (Amended):

1. A toughened glass body comprising
 - 1.1 a base body of glass and at least one first layer applied thereto, characterised in that
 - 1.2 the first layer is a layer of silicon resin, such that the layer is under tensile stress of the order of 100 to 1000 MPa.
2. A glass body as claimed in Claim 1, characterised in that the silicon resin of the first layer is an alkyl phenyl silicon resin or a methyl phenyl silicon resin or mixtures thereof.
3. Glass body as claimed in any one of Claims 1 to 2, characterised in that the base body comprises a second layer applied to the first layer and the second layer is a silicon polymer film.
4. A glass body as claimed in Claim 3, characterised in that the silicon polymer film comprise polydimethyl siloxane.
5. A toughened glass body comprising
 - 5.1 a base body of glass and at least one first layer applied thereto, characterised in that
 - 5.2 the first layer is a layer of a platinum-catalysed, addition-cross-linking silicon elastomer, such that the layer is under a tensile stress of the order of 100 to 1000 MPa.
6. A toughened glass body comprising
 - 6.1 a base body of glass and at least one first layer applied thereto, characterised in that
 - 6.2 the applied first layer is an epoxy resin layer, such that the layer is under a tensile stress of the order of 100 to 1000 MPa.
7. A toughened glass body comprising

7.1 a base body of glass and at least one first layer applied thereto, characterised in that

7.2 the applied first layer is a polymer mixture of polyacrylate and polyepoxy, such that the layer is under a tensile stress of the order of 100 to 1000 MPa.

8. A toughened glass body comprising

8.1 a base body of glass of thickness less than 0.3 mm and at least one first layer applied thereto, characterised in that

8.2 the applied first layer is a lacquer coating, such that the lacquer coating is a polyurethane lacquer or a lacquer system based on acrylate or a lacquer system based on epoxy and where the layer is under a tensile stress of the order of 200 to 1000 MPa.

9. A glass body as claimed in Claim 8, characterised in that lacquer system based on acrylate or the lacquer system based on epoxy is a UV-hardening lacquer system.

10. A glass body as claimed in any one of Claims 1 to 9, characterised in that the base body is designed as flat glass or a bent flat glass.

11. A glass body as claimed in Claim 10, characterised in that the thickness of the base body is of the order of 10 to 1500 μm .

12. A glass body as claimed in any one of Claims 1 to 11, characterised in that the base body is flexible and the thickness of the glass is of the order of 10 to 200 μm .

13. A process for manufacturing a glass body as claimed in either one of Claims 1 or 2, characterised by the following procedural steps:

13.1 a first layer comprising a silicon resin is applied to the base body by centrifuging a silicon resin xylol solution;

13.2 the applied first layer is dried.

14. A process for manufacturing a glass body as claimed in Claim 3,

characterised by the following procedural steps:

- 14.1 a first layer comprising a silicon resin is applied to the base body by centrifuging a silicon resin xylol solution;
- 14.2 the first layer comprising a silicon resin is dried;
- 14.3 a second layer is applied to the dried first layer by centrifuging;
- 14.4 the second layer is dried.

15. A process for manufacturing a glass body as claimed in Claim 5, characterised by the following procedural steps:

- 15.1 a coating solution comprising vinyl siloxane, a cross-linker, a platinum catalyst and ethyl acetate is applied to the base body by centrifuging;
- 15.2 the centrifuged layer is hardened in an IR ray field.

16. A process for manufacturing a glass body as claimed in Claim 6, characterised by the following procedural steps:

- 16.1 a first epoxy layer is applied to the base body by centrifuging an epoxy resin;
- 16.2 the first layer is hardened.

17. A process for manufacturing a glass body as claimed in Claim 7, characterised by the following procedural steps:

- 17.1 a polymer mixture, comprising a polyacrylate and a polyepoxy, is centrifuged on the base body, producing the first layer;
- 17.2 the first layer is dried.

18. A process for manufacturing a glass body as claimed in Claim 8, characterised by the following procedural steps:

- 18.1 a first layer is applied to the base body by centrifuging or spraying a polyurethane lacquer or a lacquer system based on acrylate or epoxy;
- 18.2 the first layer is hardened.

19. A process for manufacturing a glass body as claimed in Claim 18, characterised in that the lacquer systems based on acrylate and epoxy are hardened using UV radiation.

20. Displays manufactured with glass bodies as claimed in Claims 1 to 12.
21. Hard disks manufactured with glass bodies as claimed in Claims 1 to 12.
22. Electrical circuit carriers manufactured with glass bodies as claimed in Claims 1 to 12.
23. A glass body in the form of hardened flat glass as claimed in any one of Claims 1 to 12, characterised in that coating on at least one side fulfils further functional characteristics.
24. A glass body in the form of hardened flat glass as claimed in Claim 23, characterised in that the coating on at least one side serves as blooming coat.
25. A glass body in the form of hardened flat glass as claimed in Claim 23, characterised in that the coating on at least one side serves as reflecting or absorption layer.
26. A glass body in the form of hardened flat glass as claimed in Claim 23, characterised in that the coating on at least one side serves as diffusion barrier.
27. A glass body in the form of hardened flat glass as claimed in Claim 23, characterised in that the coating on at least one side serves as photo-sensitive layer.
28. A glass body in the form of hardened flat glass as claimed in Claim 23, characterised in that the coating on at least one side serves as polariser.
29. A glass body in the form of hardened flat glass as claimed in Claim 23, characterised in that the coating on at least one side serves as information storage.