(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 January 2025 (02.01.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/003699 A1

(51) International Patent Classification:
C03C 3/087 (2006.01) *C03C 19/00* (2006.01)
B24C 1/00 (2006.01) *C09K 3/14* (2006.01)
C03C 12/00 (2006.01)

(21) International Application Number:
PCT/GB2024/051685

(22) International Filing Date:
28 June 2024 (28.06.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2309915.3 29 June 2023 (29.06.2023) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

(54) Title: METHOD FOR AFFECTING GLASS STRENGTH

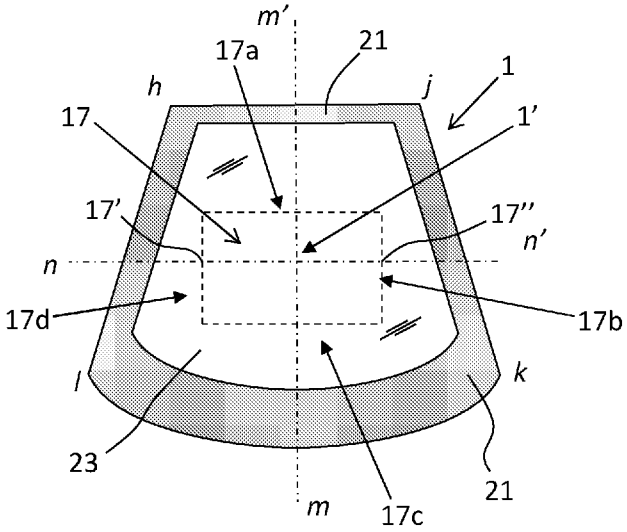


Fig. 2

(57) Abstract: A method for reducing the strength of a first sheet of glass is described. A portion of a first major surface of the first sheet of glass is treated with a first powder to reduce the strength of the first sheet of glass. The first powder comprises particles comprising an aluminosilicate glass. Glass sheets treated using such a method may be used to make a laminated glazing, wherein the first glass sheet is laminated to a sheet of glazing material using an interlayer structure comprising at least one sheet of adhesive interlayer material. The strength of the first sheet of glass may be reduced prior to, or after, being laminated to the sheet of glazing material.

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[Continued on next page]

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

METHOD FOR AFFECTING GLASS STRENGTH

The present invention relates to a method of reducing the strength of a sheet of glass and to a method of making a laminated glazing including the sheet of glass that has had the strength thereof reduced. Such a laminated glazing may be used as a window in an automobile, in particular as a vehicle windscreen.

Conventional laminated glazings for automotive windscreens comprise two plies of soda-lime-silicate glass joined by a sheet of polyvinyl butyral (PVB). Typically, each glass sheet is 2.1mm thick and the PVB sheet is typically 0.76mm thick.

As is known in the art, a laminated automotive windscreen provides the driver of the vehicle with improved safety benefits. However, vehicle manufacturers are also addressing vehicle safety in the event of a forward collision with a pedestrian.

In the event of a collision with a pedestrian, the pedestrian's head may impact the vehicle windscreen thereby causing further injury to the pedestrian.

WO2013181505A1 describes a glass laminate including at least one chemically strengthened glass sheet with a thickness not exceeding 2.0 mm and a polymer interlayer between the glass sheets. Flaws are created in the surface of one of the glass sheets in order to weaken the glass laminate upon an impact event on a first side of the laminate, while retaining the strength of the laminate upon impact on the opposing second side of the laminate.

EP2062862A1 describes a sheet glass laminate structure produced by laminating at least three sheet glasses each having a thickness of less than 1 mm through an intermediate layer between two adjacent sheet glasses.

WO2019245819A1 describes a glass laminate construction with controlled breakage for pedestrian safety.

WO202115654A1 describes a laminated glass for a vehicle that has been subjected to a strength levelling process which may include using a powder that has an average particle diameter of 10 nm to 100 μm.

It is well known in the art to polish materials such a glass to improve the optical quality thereof.

The use of cerium oxide (or ceria) has been used for many years in polishing glass surfaces, see for example US2,383,500.

US2,597,182 describes smoothing glass blanks using a smoothing technique which is employed between grinding and polishing steps. A mixture of rouge and pumice is used as the abrasive. Such grinding, smoothing and polishing processes were widely used before the development of the float process.

US2012/0094578A1 describes heterocoagulate composite structures having a plurality of first particles (typically nanoparticles) on the surface of a second particle (typically a microparticle) for use in polishing compositions for both removing stains and polishing glass. The first particles contain cerium oxide and the second particle contains silicon oxide, aluminium oxide and/or zirconium oxide. In a heterocoagulate, the first particles are maintained on the surface of the second particle by electrostatic forces.

WO2003/091351A2 describes an unexpanded perlite ore polishing composition. The composition comprises a base material having grains of unexpanded perlite ore of a selected distribution of particle sizes which undergo fracturing of the grains as a function of an abrasive force applied to the base material. The selected distribution of particle sizes includes a significant volume of grains of unexpanded perlite ore having a (d90) particle size in a range of about 101 to about 229 μm. The base material is responsive to an abrasive force being applied thereto during polishing resulting in continued fracturing of the grains of unexpanded perlite ore to yield a final polishing composition having a sufficiently low level of abrasiveness under said abrasive force making it suitable for use in polishing. Compositions for polishing acrylic dentures and CRT tube surfaces using the unexpanded perlite ore polishing composition and methods for polishing the same are also described.

Unexpanded perlite ore polishing compositions and use thereof is also described in US2003/0203337A1 and US2003/0224702A1.

The perlite ore polishing compositions described in WO2003/091351A2, US2003/0203337A1 and US2003/0224702A1 have an initial selected particle size distribution that varies with use because there is a continued fracturing of the grains of unexpanded perlite during polishing under an abrasive force.

The present invention aims to provide a method for reducing the strength of a sheet of glass that may be used in the making of a laminated glazing for a vehicle windscreen, such that the vehicle windscreen has a lower risk of causing serious pedestrian injuries in case the vehicle collides with a pedestrian.

Accordingly, from a first aspect the present invention provides a method for reducing the strength of a first sheet of glass, the first glass sheet having a first major surface and a second opposing major surface; the method comprising a treatment step, the treatment step comprising treating a portion

of the first major surface of the first sheet of glass with a first powder to reduce the strength of the first sheet of glass; wherein the first powder comprises particles comprising an aluminosilicate glass.

Preferably the aluminosilicate glass comprises pumicite. Pumicite is an aluminosilicate glass because the composition comprises silica (SiO_2) and alumina (Al_2O_3).

Preferably the aluminosilicate glass comprises basalt. Basalt is an aluminosilicate glass because the composition comprises silica (SiO_2) and alumina (Al_2O_3). Other crushed igneous rock may also be used to form the first powder.

Preferably the aluminosilicate glass has a composition comprising (by weight) 40-75% SiO_2, 5-20% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-15% Fe_2O_3, and 0-20% CaO.

Preferably the aluminosilicate glass has a composition comprising (by weight) 55-75% SiO_2, 5-15% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-10% Fe_2O_3, and 0-10% CaO.

Preferably the aluminosilicate glass has a composition comprising (by weight) 70-75% SiO_2, 10-15% Al_2O_3, 2-7% Na_2O, 2-7% K_2O, 0.5-3.5% Fe_2O_3.

Preferably the aluminosilicate glass has a composition comprising (by weight) 71-75% SiO_2, 10-14% Al_2O_3, 2-6% Na_2O, 2-6% K_2O, 0.5-2.5% Fe_2O_3 and 0-1% CaO.

The aluminosilicate glass may contain other impurities such as manganese oxide and/or titania. Preferably the impurities are less than about 5% by weight.

The first powder comprises particles having a particle size distribution, the particle size distribution having: a mean particle diameter; and a median particle diameter.

Preferably the first powder comprises particles having a particle size distribution, the particle size distribution having: a mean particle diameter between 1 μm and 250 μm; and/or a median particle diameter of greater than 5 μm.

Without being bound by theory, it is thought that when a major surface of a sheet of glass is treated with a powder containing particles, the particles cause at least one microcrack in the major surface of the sheet of glass that was treated with the powder. When a strength test measurement is carried out with the test load being applied towards the major surface of the sheet of glass that was treated with the powder, the strength of the glass sheet is reduced compared to when no treatment with the powder is made to the major surface of the sheet of glass. Glass strength may be determined using a standard technique, such as described in ISO 1288-5 (2016).

The mean particle diameter may be determined using a particle size analyser such as a Beckman Coulter LS 13 320 Particle Size Analyzer.

The median particle diameter of the particle size distribution is often referred to in the art as D50 or Dv(50) and is the size point below which 50% of the material is contained. D50 may be determined using a particle size analyser such as a Beckman Coulter LS 13 320 Particle Size Analyzer.

Preferably the median particle diameter of the particle size distribution of the first powder is not more than 100 μm.

By controlling the particle distribution of the first powder in this way, the number of small particles can be reduced thereby reducing the amount of dusting that may be produced during the treatment step. For a treatment step prior to laminating the first glass sheet to a second sheet of glazing material such as a second sheet of glass, the avoidance of dust is advantageous because any dust introduced into the laminate may remain following a lamination process and may be visible in the final laminated glazing.

Preferably the mean particle diameter of the particle size distribution is at least *mp1* μm, wherein *mp1* is 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45 or 50.

Preferably the mean particle diameter of the particle size distribution is at most *mp2* μm, wherein *mp2* is 200, 150 or 100.

Preferably the mean particle diameter of the particle size distribution is in the range *mp1* μm to *mp2* μm, wherein *mp1* is 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45 or 50 and *mp2* is 200, 150 or 100.

Preferably the median particle diameter of the particle size distribution is not more than 90 μm.

Preferably the median particle diameter of the particle size distribution is not more than 80 μm.

Preferably the median particle diameter of the particle size distribution is not more than 70 μm.

Preferably the median particle diameter of the particle size distribution is at least 10 μm.

Preferably the median particle diameter of the particle size distribution is at least 15 μm, more preferably at least 20 μm, even more preferably at least 25 μm, even more preferably at least 30 μm.

Preferably the median particle diameter of the particle size distribution is in the range *md1* μm to *md2* μm, wherein *md1* is 5, 10, 15, 20, 25 or 30 and *md2* is 100, 90, 80 , 70, 60 or 50.

It is preferred that the treatment process may suitably reduce the strength of the treated glass sheet whilst avoiding visually observable scratches on the glass major surface.

The particles in the particle distribution have a lower diameter and an upper diameter.

The upper diameter may be defined as the particle diameter in the particle size distribution up to and including which 90% of the total volume of material in the sample being used to determine the

particle size distribution is contained. The upper diameter may be referred to as D90 or Dv(90). For example, if the D90 is 200 μm, this means that 90% of the sample has a size of 200 μm or smaller. D90 may be determined using a particle size analyser such as a Beckman Coulter LS 13 320 Particle Size Analyzer.

The lower diameter may be defined as the particle diameter below which 10% of the material used to determine the particle distribution is contained. When defined in this way, the lower diameter may be referred to as D10 and may be determined using a particle size analyser such as a Beckman Coulter LS 13 320 Particle Size Analyzer.

The parameters D10, D50 and D90 have been used in size distribution measurements by laser diffraction for many years and are well known to a person skilled in the art.

Preferably the particle size distribution has a D10 greater than 1 μm and preferably not more than 20 μm, more preferably not more than 15 μm, even more preferably not more than 10 μm.

Preferably the particle size distribution has a D90 greater than 50 μm.

Preferably the particle size distribution has a D90 greater than *Dw* μm, wherein *Dw* is 60, 70, 80, 90, 100, 125 or 150.

Preferably the particle size distribution has a D90 less than *Dx* μm, where *Dx* is 500, or 400, or 300, or 200.

The particle size distribution has a span defined as (D90 – D10)/D50 and gives an indication of how far D10 and D90 are apart, normalised with the midpoint.

Preferably the first powder has a particle size distribution with a span defined as (D90 - D10)/D50 of between 0.5 and 15.

Preferably the span is between 1 and 15, more preferably between 1 and 10, even more preferably between *m* and *n*, wherein *m* is 1.5, or 2, or 2.5 and *n* is 3, or 4, or 5, or 6, or 7, or 8, or 9.

It has also been found that the parameter D90 – D10 may provide a useful indicator for the suitability of a particular powder for use in the present invention.

Preferably D90 – D10 is at least 30 μm, more preferably D90 – D10 is at least *Da* μm, wherein *Da* is 40, 50, 60, 70, 80, 90 or 100.

Preferably D90 – D10 is at most 400 μm, more preferably D90 – D10 is at most *Db* μm, wherein *Db* is 350, 300, 250 or 200.

Preferably the particle size distribution has a mode particle diameter of at least 50 μm, more preferably at least 75 μm, even more preferably at least 100 μm, even more preferably at least 125 μm.

Preferably the particle size distribution has a mode particle diameter at most 300 μm, more preferably at most 250 μm, even more preferably at most 200 μm.

During the treatment step, the first powder is preferably rubbed onto the first major surface of the first sheet of glass using a pressing force. Preferably the pressing force is less than about 0.01MPa applied to an area 1-2cm^2. Preferably the pressing force does not cause the particles to fracture.

The pressing force used is sufficient to reduce the strength of the treated first sheet of glass to a desired level, either when used alone or as a pane of a laminated glazing incorporating such a treated sheet of glass. The effect on the strength of the treated first sheet of glass may be assessed using strength measurements known in the art, for example as defined in ISO 1288-5 (2016).

The powder used during the treatment step comprises particles that have a hardness value sufficient to mark the glass surface, either with a scratch, crack or microcrack. Hardness may be measured using a standard method, such as used to determine a Vickers hardness, and may be the hardness of a sheet of material having the same, or substantially the same, composition as the composition of the first powder. A suitable Vickers hardness test is described in ASTM C1327-08. For example, the hardness may be determined by making a hardness measurement of a unitary mass that is subsequent ground to form the first powder. Float glass such as soda-lime-silica glass typically has a Vickers Hardness between 5.2 GPa and 5.8 GPa. It is preferred to use particles that have a Vickers Hardness less than 10 GPa. Particles that have a much greater hardness than the glass being treated have a tendency to cause too many and/or too deep marks i.e. scratches, which may affect the optical properties to the treated glass sheet. It is preferred that the hardness of the particles of the first powder is about 1.1 – 2, or 1.5 - 2 times the hardness of the first sheet of glass.

In some embodiments the first power is applied to the first major surface of the first sheet of glass using a powder applicator.

When a powder applicator is used, the first powder may be applied to the first major surface of the first sheet of glass then rubbed with the powder applicator; and/or the first powder may be applied to the powder applicator and the powder applicator with the first powder thereon rubbed onto the first major surface of the first sheet of glass.

In some embodiments the first powder is applied to the first major surface of the first sheet of glass by a powder applicator comprising at least one of a cloth, a brush, a blade and a roller.

When a cloth is used, the first powder may be applied to the first major surface of the first sheet of glass and then rubbed with the cloth; and/or the first powder may be applied to the cloth and the cloth with the first powder thereon rubbed onto the first major surface of the first sheet of glass.

When a brush is used, the first powder may be applied to the first major surface of the first sheet of glass and then rubbed with the brush; and/or the first powder may be applied to the brush and the brush with the first powder thereon rubbed onto the first major surface of the first sheet of glass.

When a blade is used, the first powder may be applied to the first major surface of the first sheet of glass and then rubbed with the blade; and/or the first powder may be applied to the blade and the blade with the powder thereon rubbed onto the first major surface of the first sheet of glass.

When a roller is used, the first powder may be applied to the first major surface of the first sheet of glass and then rubbed with the roller; and/or the first powder may be applied to the roller and the roller with the first powder thereon rubbed onto the first major surface of the first sheet of glass.

Preferably the blade comprises an elastomeric material.

When a brush is used, preferably the brush comprises a plurality of bristles.

When a brush is used, preferably treatment step uses a rotary brush. It is preferred that the rotary brush during the treatment step has an axis of rotation transverse to the first major surface of the first sheet of glass when being treated.

Preferably the rotary brush has a rotational speed of less than 1000rpm relative to the first major surface of the first sheet of glass when being treated, more preferably between 50 and 500 rpm relative to the first major surface of the first sheet of glass when being treated, even more preferably between 100 and 300 rpm relative to the first major surface of the first sheet of glass when being treated.

When a brush is used, the duration of the treatment step may depend on the size of the brushes, the number of bristles per unit area for the or each brush and the speed of the brush relative to the first major surface of the first sheet of glass when being treated. For example, similar results may be obtained using a brush at a rotational speed S_1 relative to the first major surface of the first sheet of glass when being treated for a duration T_1 and a brush at a rotational speed of $\frac{1}{2}S_1$ for a duration of $2T_1$.

It is advantageous if the bristles of the brush comprise a synthetic material, preferably nylon (e.g. nylon 612 or nylon 66) or polyester. However, other types of bristles may also be useful in the treatment step.

It will be readily apparent that the nature of the bristle can be changed such that each bristle incorporates an amount of particles, in particular abrasive particles. Examples of such bristles are

disclosed in US4,507,361 and US5,226,929. Methods for making bristles having an abrasive filler are known, for example being described in US3,522,342.

Preferably the bristles of the brush will have a diameter in the range 0.1 to 1 mm, preferably 0.2 to 0.8 mm and more preferably 0.2 to 0.6 mm. Preferably, the length of the bristles of the brush will be in the range 5 to 50 mm, more preferably 10 to 45 mm and most preferably 20 to 40 mm.

In some embodiments the first powder is directed toward the first major surface of the sheet of glass using a fluid carrier.

Preferably the fluid carrier comprises a gas, more preferably nitrogen or air.

Preferably the fluid carrier comprises a liquid, more preferably water.

Preferably the fluid carrier is in the form of a jet.

When the fluid is a liquid, preferably the fluid is in the form of a jet or droplets.

Preferably the fluid carrier strikes the first major surface of the sheet of glass with a velocity, wherein the velocity of the fluid carrier is preferably less than 200 m/s, more preferably between 1 m/s and 100 m/s. The velocity of the fluid is selected to achieve the desired strength reduction of the first sheet of glass.

In some embodiments a liquid is used during the treatment step when the first major surface of the first sheet of glass is treated with the first powder.

Preferably the liquid comprises water.

Preferably the first powder is dispersed in the liquid.

The liquid with the first powder dispersed therein may be a slurry.

In some embodiments the second major surface of the first sheet of glass is treated with a second powder, the second powder having a composition and comprising particles having a particle size distribution.

The second major surface of the first sheet of glass is preferably treated during the treatment step, although the second major surface of the first sheet of glass may be treated before, after and/or at the same time as when the first major surface of the first sheet of glass is treated with the first powder.

Preferably the particle size distribution of the second powder is the same as the particle size distribution of the first powder.

Preferably the composition of the second powder is the same as a composition of the first powder.

Preferably the second powder is the same as the first powder.

In some embodiments first sheet of glass is a pane of a laminated glazing, the laminated glazing comprising the first sheet of glass joined to a sheet of glazing material by an interlayer structure comprising at least one sheet of adhesive interlayer material, the pane of the laminated glazing having an exposed major surface, and wherein the exposed major surface comprises the first major surface of the first sheet of glass.

The exposed major surface of the laminated glazing does not face the interlayer structure.

Using conventional nomenclature, the exposed major surface of the laminated glazing is surface one or surface four of the laminated glazing.

Preferably the sheet of glazing material is a sheet of glass or a sheet of plastic.

Preferably the sheet of glazing material has a thickness between 1mm and 5mm, more preferably between 1.3mm and 3mm.

Preferably the sheet of glazing material is a sheet of chemically strengthened glass having a thickness between 0.4mm and 1.3mm.

Preferably the sheet of glazing material is thinner than the first sheet of glass.

Preferably the laminated glazing is a vehicle window, in particular an automobile windscreen.

Preferably the sheet of glazing material is a sheet of glass that has been produced using a float process, and a first major surface of the sheet of glazing material is the tin side and a second opposing major surface of the sheet of glazing material is the air side.

Preferably the sheet of glazing material is a sheet of glass that has been produced using a float process, and a first major surface of the sheet of glazing material is the air side and a second major surface of the sheet of glazing material is the tin side.

Preferably the sheet of glazing material is a soda-lime-silicate glass having a composition comprising (by weight), SiO_2 69 – 74 %; Al_2O_3 0 – 3 %; Na_2O 10 – 16 %; K_2O 0 – 5 %; MgO 0 – 6 %; CaO 5 – 14 %; SO3 0 – 2 %.

In embodiments where the first sheet of glass is a pane of a laminated glazing, the laminated glazing comprising the first sheet of glass joined to a sheet of glazing material by an interlayer structure comprising at least one sheet of adhesive interlayer material, the pane of the laminated glazing having

an exposed major surface, and wherein the exposed major surface comprises the first major surface of the first sheet of glass, preferably the laminated glazing is a vehicle window, in particular an automobile windscreen.

Preferably the laminated glazing achieves a Head Injury Criteria (HIC) value of less than 700, more preferably less than 650, even more preferably less than 600. Head Injury Criteria (HIC) is often referred to as Head Impact Criteria (HIC).

Preferably the HIC value is measured according to EURO-NCAP Vulnerable Road User Testing Protocol Version 9.0.2 at grid position A, 12, *a,* wherein *a* is between -4 and +4, preferably between -3 and +3, more preferably between -2 and +2; and an impact velocity of 40km/h.

Preferably a head form used to determine the HIC value is as described in UN Regulation No. 127 (E/ECE/324/Rev.2/Add. 126/Rev.2).

In some embodiments the first sheet of glass has been produced using a float process, and wherein the first major surface of the first sheet of glass is the tin side and the second major surface of the first sheet of glass is the air side.

In some embodiments the first sheet of glass has been produced using a float process, and wherein the first major surface of the first sheet of glass is the air side and the second major surface of the first sheet of glass is the tin side.

In preferred embodiments the treatment step does not comprise a grinding step. In such embodiments it is preferred that the first sheet of glass has been made using a float process, rolling process or a down drawing process. As is known in the art, glass sheets produced by a float process has fired polished surfaces having good optical quality and parallel major surfaces not requiring subsequent grinding and/or re-polishing. The treatment step in such embodiments is not used to improve the optical quality of the as formed first sheet of glass, although as is readily apparent, if the portion of the first sheet of glass prior to the treatment step is soiled, the first treatment step will also clean any dirt on the portion of the first major surface of the first sheet of glass. It is therefore preferred to clean the first major surface of the first sheet of glass prior to carrying out the treatment step.

In some embodiments the treatment step includes at least a first cleaning step. The first cleaning step can take place before the portion of the first major surface of the first sheet of glass is treated with the powder or after the portion of the first major surface of the first sheet of glass is treated with the powder. The portion of the first major surface of the first sheet of glass that is treated with the powder may be cleaned before and after being treated with the powder.

Cleaning may be carried out using known cleaning means, including fluids and/or contact materials such as cloths, brushes and sponges.

Preferably the first cleaning step is used to remove dirt or the like from the first major surface of the first sheet of glass without reducing the strength of the first sheet of glass.

In some embodiments prior to the treatment step the particles have a first particle size distribution, and following the treatment step the particles have a second size distribution, wherein the first particle size distribution is the same, or substantially the same, as the second particle size distribution.

In such embodiments it is preferred that the particles do not fracture when used to treat the first portion of the first major surface of the first sheet of glass, or that any fracturing of the particles used to treat the first portion of the first major surface of the first sheet of glass is such that the D90 of the particles in the powder is only reduced by between 5 and 50%. For example, the first particle size distribution may have a D90 of 500μm, and the second particle size distribution may have a D90 of between about 250μm and 475μm.

Other embodiments of the first aspect of the present invention have other preferable features.

Preferably the first powder is free, or substantially free, of ceria. When the first powder is free, or substantially free, of ceria, the first powder does not contain any deliberate additions of ceria particles.

Preferably the first powder is free, or substantially free, of rouge. When the first powder is free, or substantially free, of rouge, the first powder does not contain any deliberate additions of rouge particles.

Preferably the first powder consists essentially of a powdered aluminosilicate glass.

Preferably the particles consist essentially of an aluminosilicate glass.

Preferably the first powder is a powdered aluminate silicate glass comprising a plurality of particles.

Preferably the first powder has a composition comprising (by weight) 40-75% SiO_2, 5-20% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-15% Fe_2O_3, and 0-20% CaO.

Preferably the first powder has a composition comprising (by weight) 65-75% SiO_2, 5-15% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-10% Fe_2O_3, and 0-10% CaO.

Preferably the first powder has a composition comprising (by weight) 55-75% SiO_2, 5-15% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-10% Fe_2O_3, and 0-10% CaO.

Preferably the first powder has a composition comprising (by weight) 70-75% SiO_2, 10-15% Al_2O_3, 2-7% Na_2O, 2-7% K_2O, 0.5-3.5% Fe_2O_3.

Preferably the first powder has a composition comprising (by weight) 71-75% SiO_2, 10-14% Al_2O_3, 2-6% Na_2O, 2-6% K_2O, 0.5-2.5% Fe_2O_3 and 0-1% CaO.

Preferably the particles of the first powder do not have a heterocoagulate structure.

Preferably the first powder does not comprise unexpanded perlite.

Preferably the aluminosilicate glass is not a perlite.

Preferably prior to the treatment step the portion of the first major surface of the first sheet of glass has a first visible light transmittance, and after the treatment step the portion of the first major surface of the first sheet of glass has a second visible light transmittance, wherein the second visible transmittance is at least 70%. Visible light transmittance may be measured in terms of a recognised standard such as BS EN410 (2011).

Preferably the first major surface of the first sheet of glass is treated with the first powder whilst the first sheet of glass is flat, and thereafter, the first sheet of glass is shaped using a shaping process such that after being shaped, the first sheet of glass has a radius of curvature in at least one direction of between 500mm and 10000mm, preferably between 1000mm and 8000mm.

Preferably the first major surface of the first sheet of glass is treated with the first powder after the first sheet of glass has been shaped using a shaping process such that after the shaping process the first sheet of glass has a radius of curvature in at least one direction of between 500mm and 10000mm, preferably between 1000mm and 8000mm.

Preferably the first major surface of the first sheet of glass is treated with the first powder before being shaped and also after being shaped.

Preferably the portion of the first major surface of the first sheet of glass that is treated with the first powder during the treatment step has an area less than the area of the first major surface of the first sheet of glass.

Preferably the area of the portion of the first major surface of the first sheet of glass that is treated with the first powder during the treatment step is between 10% and 80% of the area of the first major surface of the first sheet of glass.

Preferably the portion of the first major surface of the first sheet of glass that is treated with the powder during the treatment step extends to at least one peripheral edge of the first major surface of the first sheet of glass.

Preferably the first sheet of glass has a thickness between 1mm and 5mm, more preferably between 1.3mm and 3mm.

Preferably the first major surface of the first sheet of glass is a convex surface.

Preferably the first major surface has on at least a portion thereof an optically transparent coating that reflects and/or absorbs infrared radiation.

Preferably the first major surface of the first sheet of glass is convex.

Preferably the first sheet of glass is a sheet of soda-lime-silicate glass, in particular a sheet of float glass.

Preferably the first sheet of glass is made using a float process. Other methods of making sheet glass may also be used, such as rolling and down drawing.

Soda-lime-silicate glass is often referred to as soda-lime-silica glass, or simply a sheet "soda-lime" glass.

Preferably the first sheet of glass is a soda-lime-silicate glass having a composition comprising (by weight), SiO_2 69 – 74 %; Al_2O_3 0 – 3 %; Na_2O 10 – 16 %; K_2O 0 – 5 %; MgO 0 – 6 %; CaO 5 – 14 %; SO3 0 – 2 %; and Fe_2O_3 0.005 - 2 %.

Preferably the first sheet of glass is not chemically strengthened. A sheet of glass may be classified as not being chemically strengthened when the sheet of glass has not been subject to an ion exchange process or has been subject to an ion exchange process following which the depth of layer is between 0 μm and *Dxo* μm, where *Dxo* is 1, or 2, or 3, or 4, or 5.

Preferably the first sheet of glass is a sheet of alkali aluminosilicate glass that preferably comprises at least about 6wt% (percent by weight) aluminium oxide (Al_2O_3) and/or is preferably chemically strengthened.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rz less than 20μm. As is known to a person skilled in the art, Rz is the maximum height of the profile and is the sum of the largest profile peak height and the largest profile valley depth within a sampling length. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Ra less than 5 μm, preferably less than 4 μm, or

3 μm, or 2 μm, or 1 μm. Ra is the arithmetical mean deviation of the profile within a sampling length. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rmax being at least 10 μm and/or preferably having Rmax at most 25 μm. Rmax is the largest single roughness depth within a sampling length. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rv being at most 20 μm. Rv is the maximum profile valley depth (Rv) within a sampling length. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rz less than about 8μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Ra in the range of 0.3 μm to 2 μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rmax being at least 1 μm and/or preferably having Rmax at most 10 μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or

0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rv being at most 4 μm, preferably at most 3 μm and/or preferably with Rv being at least 0.5 μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rz at most 10μm, and preferably with Rz at most 40μm or preferably with Rz at most 35 μm or more preferably with Rz at most 30 μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Ra in the range of 0.1 μm to 8 μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments the portion of the first major surface of the first sheet of glass has an initial roughness prior to being treated with the first powder, and a final roughness following treatment with the first powder, wherein the treated portion of the first major surface of the first sheet of glass comprises a region having a surface roughness with Rmax being at most 20 μm. The sample length may be less than 5cm, preferably between 0.5cm and 4cm, or 0.5cm and 3cm, or 0.5cm and 2cm, or 0.5cm and 1cm. The sample length may be greater or equal to 1cm.

In some embodiments, following treatment with the first powder the first sheet of glass has an increased haze of less than about 5%. Haze measurements may be made using a BYK Hazegard Plus in transmission mode, or a spectrometer such as a Perkin-Elmer Lambda 1050.

The present invention provides from a second aspect a method of making a laminated glazing comprising the steps: (i) providing a first glass sheet having a first major surface and a second opposing major surface; (ii) reducing the strength of the first sheet of glass using a method according to the first

aspect of the present invention; and (iii) laminating the first glass sheet to a sheet of glazing material using an interlayer structure comprising at least one sheet of adhesive interlayer material; wherein the first major surface of the first sheet of glass faces the interlayer structure or wherein the second major surface of the first sheet of glass faces the interlayer structure.

As is conventional in the art, surface one of a laminated glazing is an outermost surface of the laminated glazing and surface four of the laminated glazing is an inner facing surface being defined in relation to a vehicle or building interior in which the laminated glazing is installed. The inner facing surface of the laminated glazing faces the interior of the vehicle or building in which the laminated glazing is installed. The outermost surface (often referred to as the outer surface) faces the exterior of the vehicle or building in which the laminated glazing is installed.

Preferably after step (ii) and before step (iii) the first sheet of glass is washed to remove any powder therefrom that may otherwise end up in the final laminated glazing.

Preferably step (ii) takes place before step (iii) and following step (iii) the first major surface of the first sheet of glass faces the interlayer structure. In such embodiments it is preferred that the first major surface of the first sheet of glass is surface two or surface three of the laminated glazing.

Preferably the second major surface of the first sheet of glass is treated with a second powder having a composition and comprising particles having a particle size distribution, wherein the second major surface of the first sheet of glass is treated before or after step (iii).

Preferably step (ii) takes place before step (iii) and wherein following step (iii) the second major surface of the first sheet of glass faces the interlayer structure.

Embodiments where step (ii) takes place before step (iii) and wherein following step (iii) the second major surface of the first sheet of glass faces the interlayer structure have other preferable features.

Preferably the first major surface of the first sheet of glass is surface one or surface four of the laminated glazing.

Preferably before step (iii) the second major surface of the first sheet of glass is treated with a second powder having a composition and comprising particles having a particle size distribution.

Preferably the second major surface of the first sheet of glass is treated with the second powder during step (ii).

Preferably the first sheet of glass has thickness between 1mm and 5mm, more preferably between 1.3mm and 3mm.

Preferably the sheet of glazing material has a thickness between 1mm and 5mm, more preferably between 1.3mm and 3mm.

Preferably the sheet of glazing material is thinner than the first sheet of glass.

Preferably sheet of glazing material is a second sheet of glass that has had the strength thereof reduced using a method according to the first aspect of the present invention.

Preferably the laminated glazing is a window for an opening of a vehicle.

Preferably the laminated glazing is a vehicle windscreen.

Preferably the laminated glazing is curved in at least one direction. Preferably the radius of curvature in the at least one direction is between 500mm and 20000mm, more preferably between 1000mm and 8000mm.

Preferably the at least one sheet of adhesive interlayer material comprises polyvinyl butyral (PVB), acoustic modified PVB, a copolymer of ethylene such as ethylene vinyl acetate (EVA), polyurethane (PU), poly vinyl chloride (PVC), a copolymer of ethylene and methacrylic acid (EMA) or Uvekol (a liquid curable resin).

Preferably the at least one sheet of adhesive interlayer material is a sheet of polyvinyl butyral (PVB), EVA, PVC, EMA, polyurethane, acoustic modified PVB or Uvekol (a liquid curable resin).

Preferably the at least one sheet of adhesive interlayer material has a thickness between 0.3mm and 2.3mm, more preferably between 0.3mm and 1.6mm, most preferably between 0.3 and 0.8mm.

Preferably the interlayer structure comprises 2, or 3, or 4, or 5, or 6, or 7, or 8, or 9, or 10, or more, sheets of adhesive interlayer material. Each sheet of adhesive interlayer material may be the same type i.e. all PVB and may all have the same thickness.

Preferably the interlayer structure comprises at least one sheet of polyester, more preferably at least one sheet of polyethylene terephthalate (PET), and preferably the at least one sheet of polyester carries on at least one major surface thereof an optically transparent coating that reflects and/or absorbs infrared radiation.

Preferably the first sheet of glass is a sheet of soda-lime-silicate glass, in particular a sheet of float glass.

Preferably the sheet of glazing material is a sheet of soda-lime-silicate glass, in particular a sheet of float glass.

Preferably the first sheet of glass is not chemically strengthened. A sheet of glass may be classified as not being chemically strengthened when the sheet of glass has not been subject to an ion exchange process or has been subject to an ion exchange process following which the depth of layer is between 0 μm and *Dxo* μm, where *Dxo* is 1, or 2, or 3, or 4, or 5.

In some embodiments the laminated glazing achieves a Head Injury Criteria (HIC) value of less than 700, more preferably less than 650, even more preferably less than 600. Head Injury Criteria (HIC) is often referred to as Head Impact Criteria (HIC).

Preferably the HIC value is measured according to EURO-NCAP Vulnerable Road User Testing Protocol Version 9.0.2 at grid position A, 12, *a,* wherein *a* is between -4 and +4, preferably between -3 and +3, more preferably between -2 and +2; and an impact velocity of 40km/h.

A head form used to determine the HIC value may be as described in UN Regulation No. 127 (E/ECE/324/Rev.2/Add. 126/Rev.2) Annex 4.

In some embodiments the sheet of glazing material is a sheet of alkali aluminosilicate glass.

Preferably the sheet of alkali aluminosilicate glass comprises at least about 6wt% (percent by weight) aluminium oxide (Al_2O_3).

In some embodiments the sheet of glazing material is a sheet of chemically strengthened glass, wherein preferably the sheet of glazing material has a thickness less than 1.2mm, more preferably between 0.3mm and 1mm, even more preferably between 0.4mm and 0.9mm.

In some embodiments the sheet of glazing material is a second sheet of glass that has had the strength thereof reduced using a method according to the first aspect of the present invention.

Preferably the treated surface of the second sheet of glass faces the interlayer structure.

In some embodiments the first sheet of glass has been produced using a float process, and the first major surface of the first sheet of glass is the tin side and the second major surface of the first sheet of glass is the air side.

In some embodiments the first sheet of glass has been produced using a float process, and the first major surface of the first sheet of glass is the air side and the second major surface of the first sheet of glass is the tin side.

In some embodiments the sheet of glazing material is a sheet of glass that has been produced using a float process, and a first major surface of the sheet of glazing material is the tin side and a second opposing major surface of the sheet of glazing material is the air side.

In some embodiments the sheet of glazing material is a sheet of glass that has been produced using a float process, and a first major surface of the sheet of glazing material is the air side and a second major surface of the sheet of glazing material is the tin side.

The present invention will now be described with reference to the following figures (not to scale) in which:

Figure 1 is a cross-sectional view of a laminated glazing made in accordance with the present invention;

Figure 2 is a plan-view of a laminated glazing made in accordance with the present invention;

Figure 3 is a graph showing the details of the particle distribution used to treat glass sheets to reduce the strength thereof; and

Figure 4 is the view from inside a vehicle that has a windscreen in made in accordance with the present invention.

Figure 1 shows a cross-sectional view of a curved laminated glazing made in accordance with the present invention.

The laminated glazing 1 has a first sheet 3 of soda-lime-silicate glass having a composition such as clear float glass and may include colouring agents such as iron oxide to provide the laminated glazing with some form of solar control. The first sheet 3 has a thickness of 2.1mm although the thickness may be in the range 1.4mm to 2.5mm or in the range 1.6mm to 2.3mm.

A typical soda-lime-silicate glass composition is (by weight), SiO_2 69 – 74 %; Al_2O_3 0 – 3 %; Na_2O 10 – 16 %; K_2O 0 – 5 %; MgO 0 – 6 %; CaO 5 – 14 %; SO3 0 – 2 %; Fe_2O_3 0.005 - 2 %. The glass composition may also contain other additives, for example, refining aids, which would normally be present in an amount of up to 2 %. The soda-lime-silica glass composition may contain other colouring agents such as Co_3O_4, NiO and Se to impart to the glass a desired colour when viewed in transmitted light. The transmitted glass colour may be measured in terms of a recognised standard such as BS EN410 (2011).

The laminated glazing 1 also has a second sheet 7 of soda-lime-silicate glass having a thickness of 2.1mm, but the second sheet may have a thickness may be in the range 1.4mm to 2.5mm and is preferably not as thick as the first sheet 3.

In this example the first sheet of glass 3 is an outer sheet (or outer pane) and the second sheet of glass 7 is an inner sheet (or an inner pane). As is known in the art, the outer sheet faces the exterior of the vehicle in which the laminated glazing 1 is, or is to be, installed, and the inner sheet faces the interior of the vehicle in which the laminated glass is, or is to be, installed.

The first sheet 3 is joined to the second sheet 7 by an adhesive interlayer structure 5. The adhesive interlayer structure 5 in this example is a 0.76mm thick sheet of PVB. The adhesive interlayer structure 5 may have a thickness between 0.3mm and 1.8mm.

Other suitable adhesive interlayers include PVC, EVA, EMA and polyurethane. The interlayer structure 5 may comprise two or more sheets of adhesive interlayer material. The adhesive interlayer material may contain heat absorbing and/or heat reflecting particles such as indium tin oxide (ITO). There may be a carrier sheet such as polyethylene terephthalate (PET) in between two sheets of adhesive interlayer material, and the carrier sheet may have a coating on a major surface thereof. Such a coating may be infrared radiation reflective and may comprise one, or two, or three, or more layers comprising silver.

The laminated glazing 1 is curved in one or more directions. The radius of curvature in one of the one or more directions is between 1000mm and 8000mm.

When the laminated glazing is curved in two directions, suitably each direction of curvature is orthogonal to the other. Suitably the radius of curvature in one or both directions of curvature is between 1000mm and 8000mm.

The first sheet 3 has a convex first major surface 9 and an opposing concave second major surface 11. The second sheet 7 has a convex third major surface 13 and an opposing concave fourth major surface 15. The concave surface 11 of the first sheet 3 is in contact with the adhesive interlayer 5 and the convex surface 13 of the second sheet 7 is in contact with the adhesive interlayer 5. Using conventional nomenclature, the convex major surface 9 of the first sheet 3 is “surface one” (or S1) of the laminated glazing 1, the concave major surface 11 of first sheet 3 is “surface two” (or S2) of the laminated glazing 1, the convex major surface 13 of second sheet 7 is “surface three” (or S3) of the laminated glazing 1 and the concave major surface 15 of second sheet 7 is “surface four” (or S4) of the laminated glazing 1.

In this example there is a treated central region 17 on surface four (the concave fourth major surface 15 of the second sheet 7 of soda-lime-silicate glass) that has been treated with a powder according to the present invention. In the cross-section view of figure 1, the treated central region 17 extends between lateral edges 17’, 17’’. In this embodiment, only the treated central region 17 was treated with a powder in accordance with the present invention. In other embodiments, at least one of surface one, surface two, surface three and surface four has been treated with a powder according to the present invention.

Either or both of the first sheet 3 and the second sheet 7 may be formed by a float process.

Figure 2 is a schematic plan-view of the laminated glazing 1 in the direction of arrow 10 of figure 1.

In figure 2, the periphery of the laminated glazing is typical of a vehicle windscreen. Figure 1 is a cross-sectional view along plane including line *n-n*'.

In this example an obscuration band 21 is on the concave fourth major surface 15 of the second sheet 7. The obscuration band 21 is optically opaque and was applied to the glass in a conventional manner prior to the second sheet 7 being shaped. The obscuration band 21 is a coating that was screen printed onto the glass surface and is fused onto the glass surface by heating.

Inboard of the obscuration band 21 the laminated glazing 1 has a through vision region 23. In the art, the allowable light transmission of a vehicle windscreen is usually set by legislation such as ECE R43. In this example, the through vision region exhibits a total visible light transmittance (Illuminant A, two-degree observer) of 70% or more as measured at normal incidence. Visible light transmittance may be measured in terms of a recognised standard such as BS EN410 (2011).

In a central region of the through vision region 23 is located the treated central region 17. In figure 2, the treated central region 17 is shown as a dotted line, but in the laminated glazing 1 it is not possible by the unaided eye to determine the location of the treated central region 17.

In this example the treated region 17 is a rectangular region having a first side 17a, a second side 17, a third side 17c and a fourth side 17d. The area of the treated central region 17 is about 40% of the area of the through vision region but may be 10% - 80% of the area of the through vision region 23.

The laminated glazing 1 in plan view has corners *h*, *j*, *k* and *l* such that the laminated glazing has an upper edge *h-j*, a lower edge *k-l*, a right edge *j-k* and a left edge *l-h* when viewed in the direction of arrow 10. The treated central region 17 is located inside the area bounded by the corners *h*, *j*, *k* and *l*.

In this example the central treated region 17 has a rectangular shape but the treated central region may have other shapes, such as square, oval, circular or irregular. The side 17a may be parallel with the upper edge *h-j* of the laminated glazing. The side 17b may be parallel with the right edge *j-k* of the laminated glazing. The side 17c may be parallel with the lower edge *k-l* of the laminated glazing. The side 17d may be parallel with the left edge *l-h* of the laminated glazing. For example, the sides 17a, 17b and 17d may be as shown in figure 2, but the side 17c may be curved and substantially parallel to the lower edge *k-l* of the laminated glazing.

It is preferred that the treated central region has sides that are uniformly spaced from the edges of the obscuration band, although not essential.

In some embodiments the treated region may extend from one side of the obscuration band, for example at a lower edge, and extend into the through vision region.

Back to the embodiment shown, the treated central region 17 is a portion of the concave fourth major surface 15 of second sheet of glass 7 has been treated with a powder according to the present invention to reduce the strength of the laminated glazing 1.

When the laminated glazing 1 is installed as a windscreen in a vehicle, in the event of a pedestrian being involved in a collision with the vehicle, the reduction in strength of the windscreen (due to the reduced strength of the second sheet of glass 7) upon an impact with the convex first major surface 9 reduces the seriousness of injury, for in particular head injury, to the pedestrian.

In this example the laminated windscreen 1 was made in a conventional manner, whereby the first and second sheets of glass 3, 7 were shaped using a suitable shaping process such as a press bending process or a gravity sag bending process. The first and second sheets of glass 3, 7 may be shaped separately or together at the same time, wherein the first and second sheets of glass 3, 7 are shaped as a pair. This may be carried out with the second sheet of glass 7 on the first sheet of glass 3. Alternatively, the first sheet of glass 3 may be on the second sheet of glass 7 and the order thereof is alternated prior to lamination. The shaped glass sheets were then joined together via the sheet of PVB 5 using a conventional lamination process. Following lamination, the windscreen 1 was washed with de-ionised water, and following washing the exposed surfaces thereof had pristine surfaces.

The laminated glazing 1 was then supported about the periphery with the concave fourth major surface 15 facing upwards.

To treat the concave fourth major surface 15, 2 g of a suitable powder was applied to the centre 1' of the concave fourth major surface 15 and spread uniformly by rubbing over an area to define the central treated region i.e. the rectangular region 17 having sides 17a, 17b, 17c and 17d. In this example, the treated region had dimensions of about 80 cm × 50 cm.

According to "Glass Processing Days, 13-15 Sept 1997, pages 40-44, the surface roughness of float glass has $Rz < 0.1\mu m$. It is preferred that following treatment with the powder, the surface roughness of the region treated with the powder $< 1\ \mu m$, preferably $< 0.5\ \mu m$. It was not possible with the unaided eye to determine where the powder had been rubbed on the concave fourth major surface 15.

In this example the powder was a commercially available pumicite powder having a chemical composition shown in Table 1.

Oxide	% by weight
SiO_2	73.1
Al_2O_3	12.1
Na_2O	4.5
K_2O	4.4
Fe_2O_3	1.5
CaO	0.3
Mn_3O_4	0.1
TiO_2	0.1
Other	3.9

Table 1.

The powder had a particle size distribution determined using a commercially available particle size analyser such as a Beckman Coulter LS 13 320 Particle Size Analyzer and is shown in figure 3. In figure 3 line 60 is the line for the 'Differential Volume (%)' represents the number of percentage of particles within a certain diameter size range. The line 62 is the line for the 'Cumulative > Volume (%)' and represents the percentage of particles having a diameter greater than the specified particle diameter. For example, about 76% of the particles have a particle diameter greater than 10 μm.

The powder had a mean particle diameter of 62 μm, a median particle diameter (D50) of 33 μm, a mode particle diameter of 154 μm, a D10 particle diameter of 4.2 μm and a D90 particle diameter of 169 μm. The span of the particle distribution of the powder was 4.99. The values of mean particle diameter, median particle diameter, mode particle diameter, D10 particle diameter and D90 particle diameter were determined from measurements made on a sample of the powder using a Beckman Coulter LS 13 320 particle size analyser. That is, a Beckman Coulter LS 13 320 particle size analyser was used to determine the particle size distribution of a sample of the powder to determine the various characteristics discussed above.

The powder had 75% of the sample with a particle size less than about 101 μm and 50% of the sample had a particle size less than about 33 μm.

The powder includes particles that are suitably hard to damage the surface of the sheet of glass being treated. Such particles may be referred to as abrasive particle. The powder used in the examples described herein has a particle size distribution that does not produce excessive dusting during the treatment step and has sufficient large particles such that the treatment step can be carried out in a sufficiently short time without imparting unduly large scratches that may reduce the glass optical quality.

Optical quality may include measurement of haze and/or a method as described in WO2004/083835A1 or US5,694,479.

The powder used during the treatment step may be collected after the treatment step and the particle size distribution thereof determined using a suitable particle size analyser such as Beckman Coulter LS 13 320 particle size analyser.

A series of tests were carried out in order to determine the effect on the strength of a sheet of glass when treating a portion of a major surface thereof with the power described above. The tests were carried out on a number of sheets of soda-lime-silica glass that were formed by a float process.

The glass sheets used for the assessment were monolithic and each had a nominal thickness of 4mm. Each glass sheet was a sheet of annealed clear float glass, which was cut and edge-worked to produce ten sets of 240 mm × 240 mm samples, see Table 2. By clear float glass, it is meant a glass having a composition as defined in BS EN 572-1 and BS EN 572-2 (2012).

As is known in the art, glass that is produced by a float process has a "tin side" that was in contact with molten tin during forming, and an "air side" opposite the tin side. It is well known in the art that the tin side has a lower strength due to the tin side being in contact with conveyor rolls when being transported from the float bath through the annealing lehr to subsequently be cut into sheets.

As discussed in '*Acta Materiala* vol. 59, no. 4, pages 1790-1799 (2011)', a population of sub-critical cracks are formed that affects the glass strength when measured from the air side or the tin side, the tin side strength measurement showing a lower strength.

In the tests carried out on the ten sets of 240 mm × 240 mm samples, the strength was measured by applying a load from the air side or the tin side, thereby testing the strength of the opposite surface.

With reference to Table 2, Sample sets A1 and A2 were a control set to determine the baseline strength of the clear float glass sheets, measured either from the air side or the tin side.

Sample sets B1 and B2 were annealed glass sheets (as in sample sets A1 and A2) which were treated with the powder and then the strength measurements made from either the tin side or the air side.

Sample sets C1 and C2 were similar to sample sets B1 and B2 except that after being treated with the test powder, the samples were then heat treated by ramping up the glass temperature from ambient conditions (about 20 °C) to about 650 °C, followed by suitable air cooling to ambient conditions to simulate a thermal profile experienced by a sheet of glass during a glass shaping process, such as a gravity sag bending process or a press bending process.

Sample sets D1 and D2 were previously annealed glass sheets that are subsequently heat treated as discussed above in relation to sample sets C1 and C2.

Sample sets F1 and F2 were as sample sets D1 and D2, but after the suitable air-cooling step to ambient conditions the samples in the sample sets were treated with the powder in the same way as sample sets B1, B2 and C1, C2.

Sample sets C1 and C2 were prepared to evaluate the effect on the strength of the glass sheets when treatment with the powder was carried out before the heat treatment step, whereas sample sets F1 and F2 were prepared to evaluate the effect on the strength of the glass sheets then treatment with the powder was carried out after the heat treatment step.

Samples that were treated with the powder were prepared as follows. For each sheet of glass in a particular sample set that was treated with the powder, 1g of the powder was placed onto the centre of the major surface to be treated. The powder was evenly spread over a circular area having a diameter of about 100mm centred at the centre of the sheet of glass. A pressing force of about 0.5N was used to apply the powder to the major surface of the sheet of glass, starting at the centre of the sheet of glass moving in a spiral direction outwards to the perimeter of the 100mm circular area and back to the centre to uniformly spread the powder over the entire circular area. Each spiral pass from the centre of the circular area to the perimeter of the circular area took 10 seconds and was performed using a rubber tool having a contact area with the glass surface of about 1 cm^2.

Samples that had been heat treated were measured using a GASP surface stress measurement device such as that commercially available from Strainoptics (www.strainoptics.com) and Ayrox (ww.ayrox.com). The GASP surface stress measurements indicated surface compressive stresses of about 14 MPa to 17MPa. That is, the heat treated samples had an increase in the surface compressive stress of about 14 MPa to 17MPa compared to the annealed glass samples.

The surface damage caused by treating either the tin side or the air side (sometimes referred to as the non-tin side) of each glass sheet was not visible to the unaided eye. Damage could be seen using a microscope and using an Olympus SZX-12 optical microscope with a x1.6 objective at setting 40 scratches could be seen. Some of the observed scratches may have already been present in the surface of the glass sheet before being treated with the powder. The observed scratches were greater than 100μm long (typically less than 1000μm long) and less than 5μm wide.

Some of the sheets of glass that were treated with the powder were measured for haze using a BYK Hazegard Plus in transmission mode, and a Lambda 1050 spectrometer in total/diffuse transmission & reflection mode. The results were compared to a control sample that had not been treated with the powder. It was found that there were no discernible differences between the control sample and the glass sheets that had been treated with the powder, the difference being within the measurement error. It is possible for a sheet of glass that has been treated with the powder to have an increase in haze and preferably the increase in haze is less than 5% of the control sample.

Strength measurements were made using an Instron 5985 Materials Testing System fitted with an ISO 1288-5 R60 ring-on-ring test arrangement. In each case, the sample was tested to failure at a stressing rate of 2MPa/s and the maximum load and failure location noted. The number of tests carried out for each sample set are provided in Table 2.

In Table 2, the "Characteristic Strength" provides a measure of the location of the Weibull distribution and the "Weibull Modulus" is a measure of the variability of the Weibull data.

As can be seen from Table 2, the strength of the sample set A1 (141.8 MPa) is higher than the strength of the sample set A2 (100.7 MPa) illustrating the difference in glass strength between the air side and the tin side of a sheet of glass made using a float process. As discussed above, the tin side is in contact with conveyor rollers after the glass sheet has been formed which introduce sub-critical cracks into the tin side of the float glass sheet thereby reducing glass strength.

As the results in Table 2 show, when applying the powder to the annealed glass sheet (sample sets B1 and B2), the air side glass strength is reduced by about 50% and the tin side strength by about 30%. The lower reduction in strength on the tin side may be due to the tin side already having a lower initial strength.

Annealed samples that were subsequently heat treated (sample sets D1 and D2) show that the strength of the glass increases by about 50-60MPa (compared to sample sets A1 and A2).

When the annealed glass sheet is heat treated glass and then treated with the powder (sample sets F1 and F2), there is a strength reduction compared to the annealed glass sheets that were heat treated but not treated with the powder (sample sets D1 and D2). The Weibull Modulus also increases.

The strength of the sample sets F1 and F2 is not reduced to the same extent as the corresponding sample sets B1 and B2, and this may be because the initial strength of sample sets F1 and F2 before treatment with the powder was higher. The strength of the sample sets F1 and F2 is about 15MPa higher than the corresponding sample sets B1 and B2.

The effect of treating the glass sheets with the powder, and heat treating the powder treated glass sheets (sample sets C1 and C2) is to reduce the strength of the glass sheets compared to heat treating the annealed glass sheets with no intermediate treatment step with the powder (sample sets D1 and D2) to a level comparable to that of the annealed glass sheets (sample sets A1 and A2) but with a slightly narrower strength distribution (the Weibull Modulus has increased).

In order to assess the effect of using a glass sheet treated with the powder, vehicle windscreens were made where at least one of the glass sheets of the vehicle windscreen was treated with the previously described powder.

Sample Set	Description	Side Treated with the Powder	Side Load Applied for Strength Measurement	Number of Tests	Characteristic Strength (MPa)	Weibull Modulus
A1	Annealed – Comparative	N/A	Tin	25	141.8	2.91
A2	Annealed – Comparative	N/A	Air	25	100.7	5.11
B1	Annealed then Treated with powder	Air	Tin	25	77.2	12.17
B2	Annealed then Treated with powder	Tin	Air	25	71	11.08
C1	Annealed, Treated with powder – then heat treated	Air	Tin	24	140.2	7.62
C2	Annealed, Treated with powder – then heat treated	Tin	Air	24	140	9.34
D1	Annealed, then Heat treated – Comparative	N/A	Tin	25	190.6	2.88
D2	Annealed then Heat treated – Comparative	N/A	Air	25	162.5	4.35
F1	Annealed, Heat treated – then Treated with powder	Air	Tin	25	93.7	12.28
F2	Annealed, Heat treated – then Treated with powder	Tin	Air	25	85.5	12.49

Table 2.

Vehicle windscreens were constructed having the constructions as shown in Table 3. Each vehicle windscreen consisted of a pair of initially press bent glass sheets of clear soda-lime-silica glass having a thickness of 2.1mm laminated together using a sheet of PVB having a thickness of 0.76mm. Conventional lamination conditions were used, and the same lamination conditions were used to prepare each vehicle windscreen. Treatment with the powder was carried out on the bent glass sheets prior to lamination. In connection with the sample sets shown in Table 2, this corresponds to how samples in sample sets F1 or F2 were treated prior to the strength measurements being made.

Sample Set	Sample configuration	Number of Tests	Powder Treatment
W1 (Comparative)	2.1mm / 0.76mm PVB / 2.1mm	5	None
W2	2.1mm / 0.76mm PVB / 2.1mm	5	Surface two, after being shaped
W3	2.1mm / 0.76mm PVB / 2.1mm	5	Surface two and Surface four, both after being shaped
W4	2.1mm / 0.76mm PVB / 2.1mm	5	Surface four, after being shaped

Table 3.

The vehicle windscreens were made by first bending the glass sheets that were to be the inner and outer panes. As is conventional in the art, the glass sheet that was to be the outer pane is the sheet of glass of the vehicle windscreen that faces the exterior of the vehicle in which the vehicle windscreen is installed (or is intended to be installed); and the inner pane is the sheet of glass of the vehicle windscreen that faces the interior of the vehicle in which the vehicle windscreen is installed (or is intended to be installed). With reference to figure 1, the outer pane of the laminated glazing 1 corresponds to the first sheet of glass 3 and the inner pane of the laminated glazing 1 corresponds to the second sheet of glass 7.

Back to the examples in Table 3, each glass sheet was bent (often referred to as “shaped”) separately using a conventional press bending process such as described in EP0398759A2 or WO2004/085324A1. The bent glass sheets were then laminated together using a sheet of PVB having a thickness of 0.76mm to make the samples in Table 3.

Samples in sample set W1 are comparative, where neither of the inner or outer panes were treated with the powder.

The glass sheets used to make each sample in sample set W2 were shaped using the same bending process as used to shape the glass sheets for samples in sample set W1, but prior to assembling the individual bent glass sheets to make the final windscreen, the surface of the outer pane that would

be facing the sheet of PVB in the final laminated windscreen (conventionally referred to as surface two) was treated with the previously described powder. No other glass surface was treated with the powder.

The glass sheets used to make each sample in sample set W3 were shaped using the same bending process as used to shape the glass sheets for samples in sample set W1, but prior to assembling the individual bent glass sheets to make the final windscreen, the surface of the outer pane that would be facing the sheet of PVB in the final laminated windscreen (conventionally referred to as surface two) was treated with the previously described powder (as in sample set W2). However, in addition the surface of the inner pane that would not be facing the sheet of PVB in the final laminated windscreen (conventionally referred to as surface for) was also treated with the previously described powder.

The glass sheets used to make each sample in sample set W4 were shaped using the same bending process as used to shape the glass sheets for samples in sample set W1, but prior to assembling the individual bent glass sheets to make the final windscreen, the surface of the inner pane that would not be facing the sheet of PVB in the final laminated windscreen (conventionally referred to as surface four) was treated with the previously described powder. No other glass surface was treated with the powder.

In the aforementioned examples, surface one was a convex surface and surface two was a concave surface, surface three was a convex surface and surface four was a concave surface.

Treatment with the powder consisted of applying 1g of the powder to a portion of the surface of the bent glass sheet that would be a test impact location for a HIC test. The 1g of test powder was uniformly spread over a square area of dimensions 50 mm x 50 mm using a pressing force of about 0.5N using a rubber tool. Linear, parallel application of the test powder was used to cover the square area in about 5 seconds and a total treatment time of about 60 seconds. The square forming the treated region was centred at the desired impact location for the HIC test.

Following treatment with the test powder, the glass sheet was washed with water to remove any test powder from the glass sheet that may otherwise end up in the final laminated glazing.

The particle size distribution of the powder may also help assist removal of the powder from the glass sheet following treatment. Both surfaces of the glass sheet may be cleaned, even if only one surface of the glass sheet is treated with the powder.

In the aforementioned samples in sample sets W1, W2, W3 and W4, surface one and surface three was the tin side of the respective glass sheets used for the outer and inner plies. Due to the similar strength of the heat treated sheets, see sample sets F1 and F2 (and Table 2), similar results would be expected if surface one was the tin side and surface three was the air side; or if surface one was the air

side and surface three was the tin side; or if surface one was the air side and surface three was the air side.

In order to determine a HIC value for the windscreens, a HIC test was carried out using the procedure described in EURO-NCAP Vulnerable Road User Testing Protocol Version 9.0.2 at grid position A, 12, +2 and an impact velocity of 40km/h. The head form used to determine the HIC value was as described in UN Regulation No. 127 (E/ECE/324/Rev.2/Add. 126/Rev.2) Annex 4.

With reference to the sample sets B1, B2 and F1, F2 in Table 2, the increased Weibull Modulus indicates the strength distribution is less variable after the glass sheets have been treated with the powder. Without being bound by theory, this is may help reduce the overall HIC value for the vehicle windscreens treated with the powder because there are less likely to be regions of the glass sheet surface with higher than average strength.

The HIC values for the vehicle windscreens in sample sets W1, W2, W3 and W4 are shown in Table 4 below.

Sample Set	Surface(s) treated with the powder	HIC Values
W1	None	830 – 890; average 850
W2	Surface two	290 – 880; average 700
W3	Surface two and Surface four	220 – 240; average 230
W4	Surface four	250 – 750; average 460

Table 4.

For a vehicle windscreen it may be desirable to have a HIC value below 700, preferably below 650. Sample sets W3 and W4 have an average HIC value below 700. For the sample set W3, the HIC value was consistently less than 700 with little variability in the HIC values for the vehicle windscreens in this sample set.

It is expected to obtain similar behaviour by treating a different size area of surface two and/or surface four. For example, the treated region may be less than 80% of the area of the respective major surface of the glass sheet and/or the treated region may be more than 10% of the area of the respective major surface of the glass sheet. Having a greater percentage of surface two and/or surface four treated with the powder increases the area of the vehicle windscreen that has reduced strength (and so a reduced HIC value), thereby helping to reduce the potential for injury to a pedestrian whose head may strike different parts of the vehicle windscreen.

Figure 4 shows a vehicle that includes a windscreen 100 made in accordance with the present invention. The windscreen 100 is essentially as previously described with refence to figures 1 and 2.

The windscreen 100 has a through vision region defined by upper edge D-G; right hand edge F-G; lower edge E-F and left-hand edge D-E. Inboard of the upper, right hand, lower and left-hand edges is a treated region 104. The treated region is defined by upper edge D'-G'; right hand edge F'-G'; lower edge E'-F' and left-hand edge D'-E'. Inboard of the treated region surface 4 of the windscreen has been treated with powder of the type described above. The treated region 104 is not discernible to the naked eye and forms part of the through vision region 102. Outboard of the treated region 104, surface 4 of the windscreen has not been treated with powder.

The treated region 104 is about 75% of the entire see through region 102.

In this example surface two has also been treated with powder, which may be the same powder as used to treated surface four.

It is also within the scope of the present invention to treat surface one and/or surface three of the windscreen 100. The area of each major surface that is treated may be the same or different.

Any combination of surface one, surface two, surface three and surface four may be treated.

By including a sheet of glass that has been treated with powder in the windscreen 100, the strength of the sheet of glass is reduced, which also reduces the strength of the windscreen 100. If a pedestrian hits the windscreen 100, thereby making contact with surface one of the windscreen, the windscreen is able to break more easily because of the treatment with the powder. Treatment of the sheet of glass may be before the sheet of glass is laminated to another sheet of glazing material, in particular a sheet of glass, to make the laminated glazing. Alternatively, or as well as, the sheet of glass may be treated with the powder after having been laminated to a sheet of glazing material, such as a sheet of glass, although this is only possible for exposed surfaces of the windscreen.

CLAIMS

1. A method for reducing the strength of a first sheet of glass, the first glass sheet having a first major surface and a second opposing major surface;

the method comprising:

a treatment step,

the treatment step comprising treating a portion of the first major surface of the first sheet of glass with a first powder to reduce the strength of the first sheet of glass;

wherein the first powder comprises particles comprising an aluminosilicate glass.

2. A method according to claim 1, wherein the aluminosilicate glass comprises pumicite or basalt.

3. A method according to claim 1 or claim 2, wherein the aluminosilicate glass has a composition comprising (by weight) 40-75% SiO_2, 5-20% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-15% Fe_2O_3, and 0-20% CaO.

4. A method according to any of the preceding claims, wherein the aluminosilicate glass has a composition comprising (by weight) 55-75% SiO_2, 5-15% Al_2O_3, 0-10% Na_2O, 0-10% K_2O, 0-10% Fe_2O_3, and 0-10% CaO.

5. A method according to any of the preceding claims, wherein the aluminosilicate glass has a composition comprising (by weight) 70-75% SiO_2, 10-15% Al_2O_3, 2-7% Na_2O, 2-7% K_2O, 0.5-3.5% Fe_2O_3.

6. A method according to any of the preceding claims, wherein the aluminosilicate glass has a composition comprising (by weight) 71-75% SiO_2, 10-14% Al_2O_3, 2-6% Na_2O, 2-6% K_2O, 0.5-2.5% Fe_2O_3 and 0-1% CaO.

7. A method according to any of the preceding claims, wherein the particles have a particle size distribution, the particle size distribution having:

a mean particle diameter between 1 μm and 250 μm; and

a median particle diameter of greater than 5 μm.

8. A method according to claim 7, wherein the median particle diameter of the particle size distribution of the first powder is not more than 100 μm

9. A method according to claim 7 or claim 8, wherein the particle size distribution of the first powder has a at least one of: a D10 greater than 1 μm, a D10 not more than 20 μm; a D90 greater than 50 μm; a span defined as (D90 – D10)/D50 of between 0.5 and 15; a D90 – D10 of at least 30 μm; and a D90 – D10 of at most 400 μm.

10. A method according to any of the preceding claims, wherein the particles have a Vickers Hardness greater than 5.2 GPa, preferably greater than 5.6 GPa, more preferably greater than 5.8GPa, even more preferably greater than 6 GPa.

11. A method according to any of the preceding claims, wherein the first powder is applied to the first major surface of the first sheet of glass using a powder applicator, preferably wherein the powder applicator comprises at least one of a cloth, a brush, a blade and a roller.

12. A method according to any of the preceding claims, wherein during the treatment step the first powder is directed toward the first major surface of the first sheet of glass using a fluid carrier, preferably wherein the fluid comprises a gas such as nitrogen or air; or a liquid such as water.

13. A method according to any of the preceding claims, wherein a liquid is used during the treatment step when the first sheet of glass is treated with the first powder.

14. A method according to any of the preceding claims, wherein the second major surface of the first sheet of glass is treated with a second powder, the second powder having a composition and comprising particles having a particle size distribution, preferably wherein the particle size distribution of the second powder is the same as the particle size distribution of the first powder

and/or wherein the composition of the second powder is the same as a composition of the first powder.

15. A method according to any of the preceding claims, wherein the first sheet of glass is a soda-lime-silicate glass having a composition comprising (by weight), SiO_2 69 – 74 %; Al_2O_3 0 – 3 %; Na_2O 10 – 16 %; K_2O 0 – 5 %; MgO 0 – 6 %; CaO 5 – 14 %; SO3 0 – 2 %; and Fe_2O_3 0.005 - 2 %; and/or wherein the first sheet of glass has a thickness between 1mm and 5mm.

16. A method according to any of the preceding claims, wherein the first sheet of glass has been produced using a float process, and wherein the first major surface of the first sheet of glass is the tin side and the second major surface of the first sheet of glass is the air side.

17. A method according to any of the preceding claims, wherein the first sheet of glass is a pane of a laminated glazing, the laminated glazing comprising the first sheet of glass joined to a sheet of glazing material by an interlayer structure comprising at least one sheet of adhesive interlayer material, the pane of the laminated glazing having an exposed major surface, and wherein the exposed major surface comprises the first major surface of the first sheet of glass, preferably wherein the exposed major surface of the pane of the laminated glazing is surface one or surface four of the laminated glazing.

18. A method of making a laminated glazing comprising the steps:

(i) providing a first glass sheet having a first major surface and a second opposing major surface;

(ii) reducing the strength of the first sheet of glass using a method according to any of the claims 1 to 16; and

(iii) laminating the first glass sheet to a sheet of glazing material using an interlayer structure comprising at least one sheet of adhesive interlayer material;

wherein the first major surface of the first sheet of glass faces the interlayer structure or wherein the second major surface of the first sheet of glass faces the interlayer structure.

19. A method according to claim 18, wherein step (ii) takes place before step (iii) and wherein following step (iii) the first major surface of the first sheet of glass faces the interlayer structure.

20. A method according to claim 19, wherein the first major surface of the first sheet of glass is surface two or surface three of the laminated glazing.

21. A method according to any of the claims 18 to 20, wherein the second major surface of the first sheet of glass is treated with a second powder having a composition and comprising particles having a particle size distribution, wherein the second major surface of the first sheet of glass is treated before or after step (iii).

22. A method according to claim 18, wherein step (ii) takes place before step (iii) and wherein following step (iii) the second major surface of the first sheet of glass faces the interlayer structure.

23. A method according to claim 22, wherein the first major surface of the first sheet of glass is surface one or surface four of the laminated glazing.

24. A method according to claim 22 or claim 23, wherein before step (iii) the second major surface of the first sheet of glass is treated with a second powder having a composition and comprising particles having a particle size distribution.

25. A method according to claim 21 or claim 24, wherein the second major surface of the first sheet of glass is treated with the second powder during step (ii).

26. A method according to any of the claims 18 to 25, wherein the laminated glazing is a vehicle windscreen.

27. A method according to claim 26, wherein the vehicle windscreen has a HIC value less than 700, preferably less than 650.

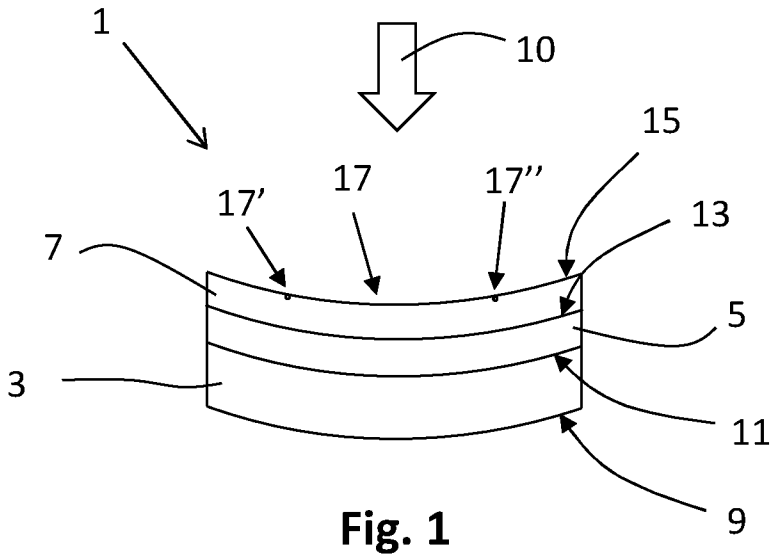

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Fig. 1

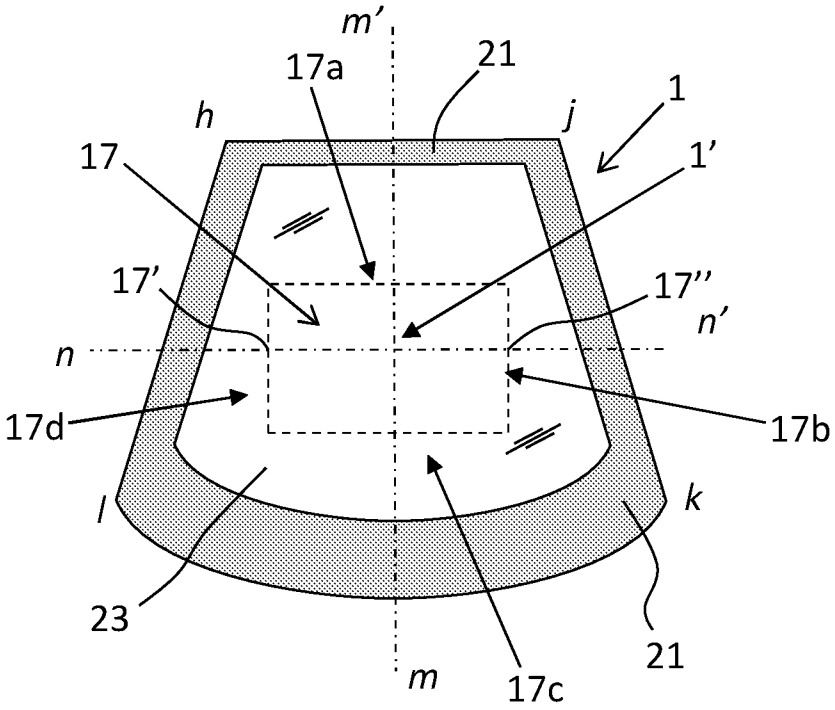

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Fig. 2

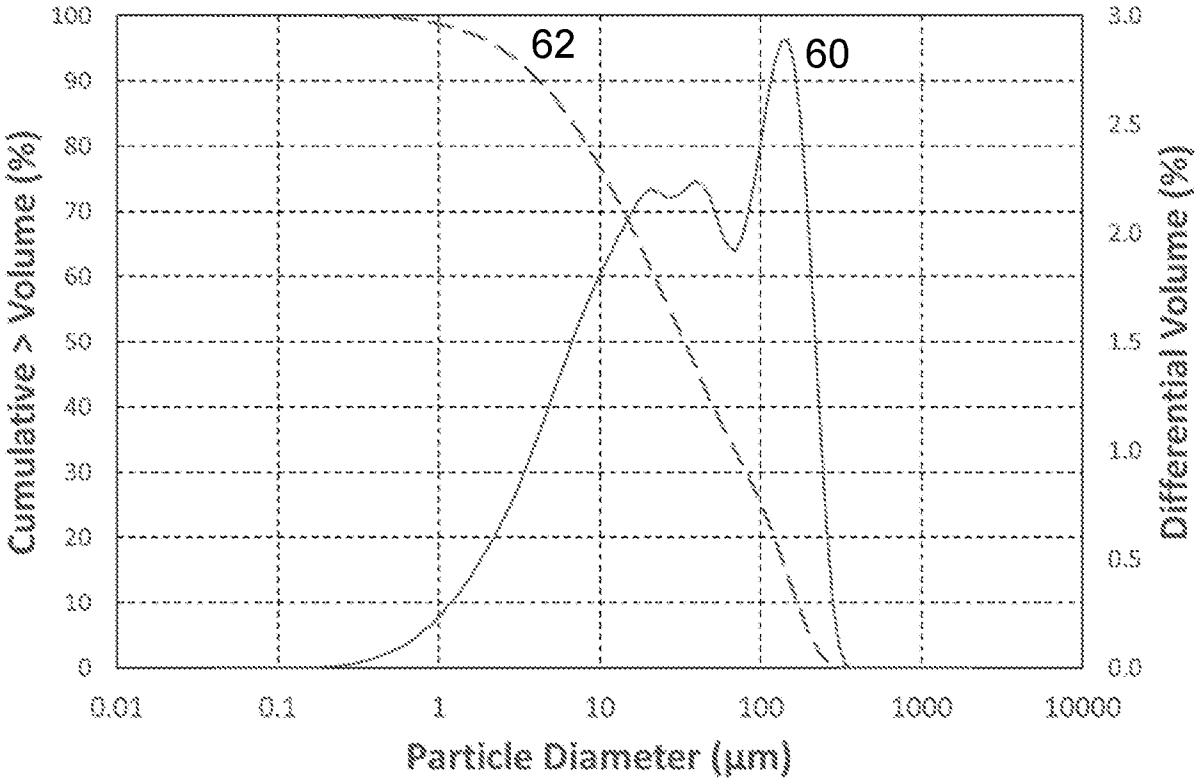

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Differential Volume (%)
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2.0
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1.0
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0.0
0.01
0.1
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1000
10000

Fig. 3

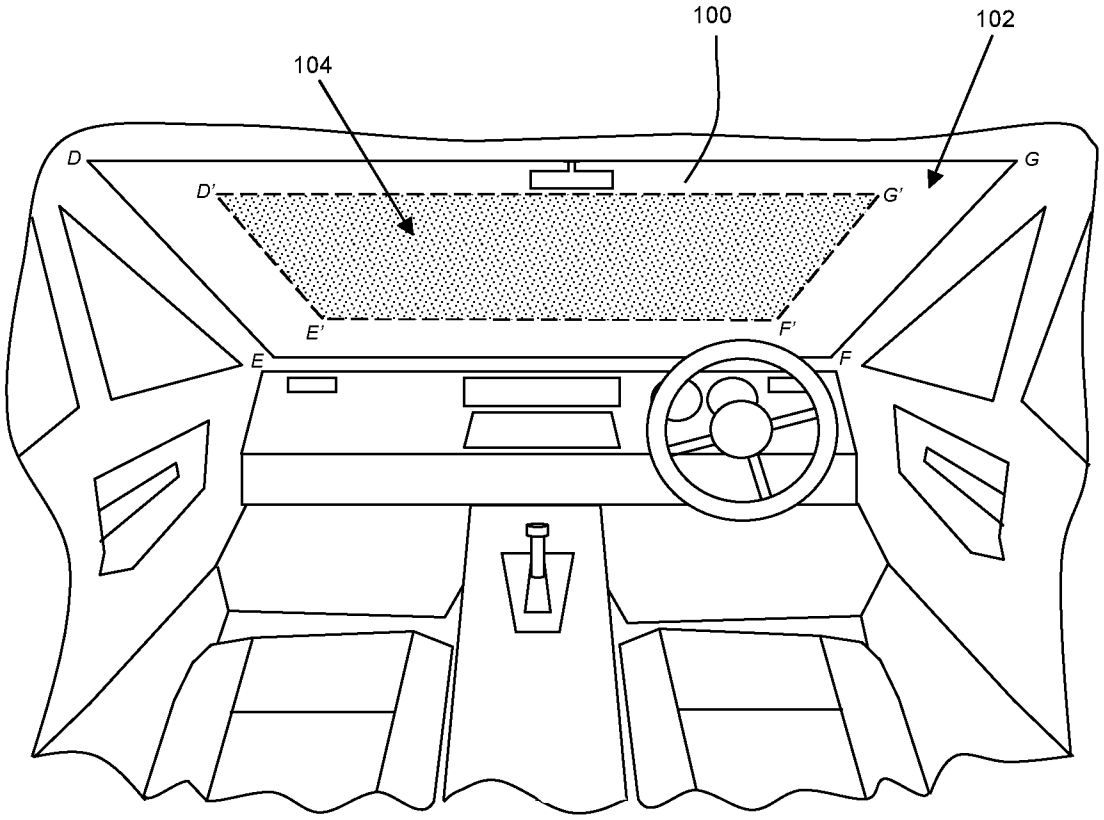

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Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2024/051685

A. CLASSIFICATION OF SUBJECT MATTER

INV. C03C3/087 B24C1/00 C03C12/00 C03C19/00 C09K3/14
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C03C B24C F16D C09K C09G

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2022/224912 A1 (AGC INC [JP]) 27 October 2022 (2022-10-27) paragraphs [0002] - [0070]; claims; figures	1-27
Y	US 2003/203337 A1 (ROULSTON JOHN S [US] ET AL) 30 October 2003 (2003-10-30) paragraphs [0080] - [0105]; claims; figures; examples	1-27
Y	US 2003/224702 A1 (ROULSTON JOHN S [US] ET AL) 4 December 2003 (2003-12-04) paragraphs [0186] - [0224]; figures; examples	1-27
Y	US 2 597 182 A (RICKNER GEORGE E ET AL) 20 May 1952 (1952-05-20) the whole document	1-27

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 October 2024	04/11/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Wrba, Jürgen

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2024/051685

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 4328018 A1	28-02-2024
		JP WO2022224912 A1	27-10-2022
		US 2024042737 A1	08-02-2024
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