higher mobility than those based on amorphous-silicon based transistors (a-Si). This allows the manufacture of smaller and faster transistors, which ultimately produces brighter and faster displays. One problem with p-Si based transistors is that their manufacture requires higher process temperatures than those employed in the manufacture of a-Si transistors. These temperatures range from 450°C to 600°C compared to the 350°C peak temperatures employed in the manufacture of a-Si transistors.

[0006] The glass compositions used for display applications need to have good thermal and mechanical properties, and dimensional stability satisfying the processing and performance requirements. In addition, diffusion of meal ions into the thin film transistors may cause damages to the transistors. Such diffusion needs to be avoided.

[0007] Display technology, such as TV displays, is moving towards 8K technology. 8K refers to the horizontal resolution in the order of 8,000 pixels. For example, when an 8K TV has a screen with 7,680 horizontal and 4,320 vertical pixels, such a TV may have a total of approximately 33 million pixels. 8K technology offers an ultra-high resolution. With four times more pixels than a 4K TV, which has an ultra-high definition (UHD) resolution, 8K TVs show a sharper and more detailed picture quality.

SUMMARY

[0008] The present disclosure provides a glass composition, a product comprising such a glass composition, methods of making the glass composition and the product, and methods of using the glass composition and the product. Such a glass composition is an aluminoborosilicate glass, and includes oxides of alkaline earth metals and a low concentration of boron oxide and strontium oxide.

[0009] Such glass compositions may be substantially alkali-free. The glass compositions exhibit desirable physical and chemical properties, for example, high annealing point, high elastic modulus, low stress optical coefficient (SOC), low T(35kP) and T(200P), and desirable liquidus viscosity. The glass compositions are suitable for use as substrates for display applications such as in flat panel display devices with ultra-high resolution.

[0010] The present disclosure provides a glass or a glass composition.

[0011] In accordance with some examples, a glass or a glass composition provided herein comprises in mole percent on an oxide basis:

SiO_2: 66.17-74.31;

Al_2O_3: 11.72-13.86;

B_2O_3: 0.71-1.75;

MgO: 4.61-6.36;

CaO: 4.81-7.27;

SrO: 0.10-1.42; and

BaO: 2.38-4.00.

[0012] In accordance with some examples, a glass or a glass composition provided herein comprises in mole percent on an oxide basis:

SiO_2: 69.65-70.77;

Al_2O_3: 12.34-13.20;

B_2O_3: 0.75-1.67;

MgO: 4.85-6.06;

CaO: 5.06-6.92;

SrO: 0.11-1.35; and

BaO: 2.51-3.81.

[0013] The glass composition may include a tramp amount of oxides of alkali metals. In some examples, the glass composition or the glass is substantially alkali-free defined by a combined concentration of Li_2O, Na_2O, and K_2O less than 0.1 mol.%, for example, less than 0.09 mol.%, less than 0.08 mol.%, less than 0.07 mol.%, less than 0.06 mol.%, less than 0.05 mol.%, less than 0.04 mol.%, less than 0.03 mol.%, less than 0.02 %, less than 0.01 %, or 0%. In some examples, the glass composition has a combined concentration of Li_2O, Na_2O, and K_2O less than 0.06 mol.%.

[0013a] In one aspect, the present disclosure provides a glass comprising in mole percent on an oxide basis:

SiO_2: 66.17-74.31;

Al_2O_3: 11.72-13.86;

B_2O_3: 0.71-1.75;

MgO: 4.61-6.36;

CaO: 4.81-7.27;

SrO: 0.10-1.42; and

BaO: 2.38-4.00,

wherein the glass is substantially alkali-free defined by a combined concentration of Li_2O, Na_2O, and K_2O less than 0.1 mol.%.

[0014] In some examples, B_2O_3 is in a suitable range. For example, B_2O_3 is in a range of from 0.75 to 1.75 by mole percent, in a range of from 0.75 to 1.67 by mole percent, in a range of from 0.75 to 1.60 by mole percent, in a range of from 0.75 to 1.50 by mole percent, in a range of from 0.75 to 1.40 by mole percent, in a range of from 0.75 to 1.30 by mole percent, in a range of from 0.75 to 1.20 by mole percent, or in a range of from 0.75 to 1.00 by mole percent. In some examples, B_2O_3 is in a range of from 0.75 to 1.00 by mole percent.

[0015] In some examples, SrO is in a suitable range. For example, SrO is in a range of from 0.11 to 1.42 by mole percent, in a range of from 0.11 to 1.40 by mole percent, in a range of from 0.11 to 1.35 by mole percent, in a range of from 0.11 to 1.30 by mole percent, in a range of from 0.11 to 1.20 by mole percent, in a range of from 0.11 to 1.10 by mole percent, in a range of from 0.11 to 1.00 by mole percent, in a range of from 0.11 to 0.90 by mole percent, in a range of from 0.11 to 0.80 by mole percent, in a range of from 0.11 to

0.70 by mole percent, in a range of from 0.11 to 0.60 by mole percent, in a range of from 0.11 to 0.50 by mole percent, in a range of from 0.11 to 0.40 by mole percent, in a range of from 0.11 to 0.30 by mole percent, or in a range of from 0.11 to 0.20 by mole percent. In some examples, SrO is in a range of from 0.11 to 1.00 or 0.50 by mole percent.

[0016] In some examples, a ratio of RO/Al_2O_3 is in a range of from 1.13 to 1.31 and RO is the sum of the mole percents of MgO, CaO, SrO, and BaO. For example, the ratio of RO/Al_2O_3 is in a range of from 1.20 to 1.31 in some examples.

[0017] The glass may further comprise 0.01 mol.% to 0.4 mol.% of a chemical fining agent, which is selected from SnO_2, As_2O_3, Sb_2O_3, Fe_2O_3, CeO_2, MnO_2, F, Cl, Br, or any combination thereof. For example, the chemical fining agent comprises 0.08 mol.% to 0.14 mol.% of SnO_2 in some examples.

[0018] In some examples, the glass composition may include a tramp amount of Fe_2O_3, ZrO_2, or TiO_2. Each of Fe_2O_3, ZrO_2, and TiO_2 may be in a range of from 0 to 0.03 by mole percent. In some examples, each of Fe_2O_3, ZrO_2, and TiO_2 may be zero or less than 0.01 by mole percent.

[0019] The glass has high annealing point, for example, higher than 775°C. In some examples, the glass has an annealing point in a range from 790 °C to 810 °C, for example, in a range from 790 °C to 806 °C.

[0020] The glass also has high elastic modulus (Young's modulus). For example, in some examples, the glass has an elastic modulus in a range of from 83.30 GPa to 84.49 GPa.

[0021] The glass has a desirable low stress optical coefficient (SOC). For example, the glass provided in the present disclosure has a SOC in a range of from 26.70 to 30.59, for example, in a range of from 28.10 to 29.13 in some examples.

[0021a] In another aspect, the present disclosure provides a glass comprising in mole percent on an oxide basis:

SiO_2: 66.17-74.31;

Al_2O_3: 11.72-13.86;

B_2O_3: 0.75-1.20;

MgO: 4.61-6.36;

CaO: 4.81-7.27;

SrO: 0.11-0.5; and

BaO: 2.38-4.00,

wherein the glass is substantially alkali-free defined by a combined concentration of Li_2O, Na_2O, and K_2O less than 0.1 mol.%,

the glass has an elastic modulus in a range of from 83.30 GPa to 84.49 GPa, and

the glass has a stress optical coefficient (SOC) in a range of from 26.70 to 30.59.

[0022] The glass also has desirable low T(35 kP) and T(200 P) temperatures. For example, in some examples, the glass has a T(35 kP) in a range of from 1,280 ºC to 1,292 ºC, and a T(200 P) in a range of from 1,654 ºC to 1,666 ºC. T(35 kP) and T(200 P) represent a temperature when the glass has a viscosity of 35 kilopoise (kP) and 200 poise (P), respectively.

[0023] In accordance with some examples, a glass provided in the present disclosure is an aluminoborosilicate glass, and comprises in mole percent on an oxide basis:

SiO_2: 66.17-74.31;

Al_2O_3: 11.72-13.86;

B_2O_3: 0.75-1.20;

MgO: 4.61-6.36;

CaO: 4.81-7.27;

SrO: 0.11-0.5; and

BaO: 2.38-4.00,

[0024] The glass has an elastic modulus in a range of from 83.30 GPa to 84.49 GPa, and the glass has a stress optical coefficient (SOC) in a range of from 26.70 to 30.59.

[0025] In accordance with some examples, a glass provided in the present disclosure comprises in mole percent on an oxide basis:

SiO_2: 69.65-70.77;

Al_2O_3: 12.34-13.20;

B_2O_3: 0.75-1.20;

MgO: 4.85-6.06;

CaO: 5.06-6.92;

SrO: 0.11-0.5; and

BaO: 2.51-3.81.

[0026] The glass is substantially alkali-free. In some examples, the glass composition has a combined concentration of Li_2O, Na_2O, and K_2O less than 0.06 mol.%.

[0027] In some examples, B_2O_3 is in a range of from 0.75 to 1.20, for example, from 0.75 to 1.00, by mole percent. SrO is in a range of from 0.11 to 1.00, for example, from 0.11 to 0.50, by mole percent.

[0028] The glass has a ratio of RO/Al_2O_3 in a range of from 1.14 to 1.31, for example, from 1.20 to 1.31, and RO is the sum of the mole percents of MgO, CaO, SrO, and BaO.

[0029] The glass further comprises 0.08 mol.% to 0.14 mol.% of SnO_2 as a chemical fining agent. In some examples, the glass composition may include a tramp amount of Fe_2O_3, ZrO_2, or TiO_2. Each of Fe_2O_3, ZrO_2, and TiO_2 may be in a range of from 0 to 0.03 by mole percent. In some examples, each of Fe_2O_3, ZrO_2, and TiO_2 may be zero or less than 0.01 by mole percent.

[0030] The glass has an annealing point in a range from 790 ºC to 810 ºC, for example, in a range from 799 ºC to 806 ºC. The glass has an elastic modulus in a range of from 83.30 GPa to 84.49 GPa, and a stress optical coefficient (SOC) in a range of from 28.10 to 29.13.

[0031] In some examples, the glass has a T(35 kP) in a range of from 1,280 ºC to 1,292 ºC, and a T(200 P) in a range of from 1,654 ºC to 1,666 ºC.

[0032] The present disclosure provides an article comprising the glass or the glass composition described herein. For example, a substrate for liquid crystal display comprises the glass or the glass composition described here.

[0032a] In another aspect, the present disclosure provides an article comprising the glass as described herein.

[0032b] In another aspect, the present disclosure provides a substrate for liquid crystal display comprising the glass as described herein.

[0033] The present disclosure provides a device for flat panel display, which comprises at least one sheet comprising the glass as described herein. Such a device may further comprise polycrystalline silicon thin film transistors.

[0033a] In another aspect, the present disclosure provides a device for flat panel display comprising at least one sheet comprising the glass as described herein, and polycrystalline silicon thin film transistors.

[0034] A method for producing the glass or the glass composition as described herein is provided. Such a method comprises at least one step of mixing and melting raw materials in mole percent on an oxide basis so as to provide the oxides as described. Such a method may further comprise making a sheet comprising the glass composition through a downdraw sheet fabrication process or a fusion process.

[0034a] In another aspect, the present disclosure provides a method for producing the glass as described herein, comprising mixing and melting raw materials in mole percent on an oxide basis.

[0035] The glass compositions exhibit desirable physical properties and chemical properties. For example, the glass provided in the present disclosure has high annealing point (e.g., higher than 790°C), low stress optical coefficient (SOC), and desirable liquidus viscosity. Compared to a commercial product Corning LOTUS™ NXT Glass, the glass described herein has improved elastic modulus, and lower T(350 kP), T(35 kP), and/or T(200 P) temperatures. The glass can be made at lower cost. The glass compositions are suitable for use as substrates in flat panel display devices such as active matrix liquid crystal displays (AMLCDs) with ultra-high resolution, for example, in the 8K display technology.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The present disclosure is best understood from the following detailed description when read in conjunction with the accompanying drawings. It is emphasized that, according to common practice, the various features of the drawings are not necessarily to scale. On the contrary, the dimensions of the various features are arbitrarily expanded or reduced for clarity. Like reference numerals denote like features throughout specification and drawings.

[0037] FIG. 1 shows the results of annealing point at different mole percentages of B_2O_3 in the glass compositions in accordance with some embodiments.

DETAILED DESCRIPTION

[0038] This description of the exemplary embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. In the description, relative terms such as “lower,” “upper,” “horizontal,”