along the contour within the workpiece, wherein a periodicity between adjacent defect lines is between 0.1 micron and 20 microns. Other embodiments include glass articles prepared by this method.

[0007] Laser forming the plurality of defect lines along the contour within the workpiece can facilitate separating the workpiece along a surface defined by the contour to form a separated surface. The induced absorption can produce an Ra surface roughness of the cut and separated edge of less than or equal to about 0.5 micron. The induced absorption can also produce particles on the separated surface with an average diameter of less than 3 microns.

[0008] The developed laser method can be tailored for manual or mechanical separation of the parts from the panel or full laser separation by thermal stressing the desired profile. The method involves the utilization of an ultra-short pulse laser and can be followed by a CO_2 laser to create thermal stress, sometimes coupled with high pressure air flow, for fully automated separation.

[0008a] In another embodiment, a glass article comprises alkaline earth boro-aluminosilicate glass composite including at least one edge having a plurality of defect lines extending at least 250 microns, the defect lines each having a diameter less than or equal to about 5 microns.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The foregoing will be apparent from the following more particular description of example embodiments, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the exemplary embodiments.

[0010] FIGS. 1A-1C are illustrations of a fault line (or perforated line) with equally spaced defect lines or damage tracks of modified glass.

[0011] FIGS. 2A and 2B are illustrations of positioning of the laser beam focal line, i.e., the processing of a material transparent for the laser wavelength due to the induced absorption along the focal line.

CLAIMS

WHAT CLAIMED IS:

1. A method of laser processing an alkaline earth boro-aluminosilicate glass composite workpiece, the method comprising:

focusing a pulsed laser beam into a laser beam focal line oriented along the beam propagation direction and directed into the alkaline earth boro-aluminosilicate glass composite workpiece, the laser beam focal line generating an induced absorption within the material, and the induced absorption producing a defect line along the laser beam focal line within the workpiece; and

translating the alkaline earth boro-aluminosilicate workpiece and the laser beam relative to each other along a contour, thereby laser forming a plurality of defect lines along the contour within the workpiece, wherein a periodicity between adjacent defect lines is between 0.1 micron and 20 microns.

2. A glass article prepared by the method of claim 1.

3. The method or article of claim 1 or 2, further comprising separating the workpiece along the contour.

4. The method or article of any preceding claim, wherein separating the workpiece along the contour includes directing a carbon dioxide (CO_2) laser beam into the workpiece along or near the contour to facilitate thermal stress induced separation of the workpiece along the contour.

5. The method or article of any preceding claim, wherein the workpiece comprises a stack of plural display glass composite substrates.

6. The method or article of any preceding claim, wherein the pulsed laser has laser power of 10W-150W and produces pulse bursts with at least 2 pulses per pulse burst.

7. The method or article of any preceding claim, wherein a burst repetition rate of the pulsed laser beam is in a range of between about 1 kHz and about 4 MHz.

8. The method or article of any preceding claim, wherein each pulse of the pulsed laser beam has an average laser burst energy measured at the workpiece greater than 40 microJoules per mm thickness of workpiece.

9. The method or article of any preceding claim, wherein the pulsed laser beam has a wavelength selected such that the workpiece is substantially transparent at this wavelength.

10. The method or article of any preceding claim, wherein the laser beam focal line has a length in a range of between about 0.1 mm and about 10 mm.

11. The method or article of any preceding claim, wherein the laser beam focal line has an average spot diameter in a range of between about 0.1 micron and about 5 microns.

12. The method or article of any preceding claim, wherein the induced absorption produces subsurface damage up to a depth less than or equal to about 100 microns within the workpiece.

13. The method or article of any preceding claim, wherein laser forming the plurality of defect lines along the contour within the workpiece facilitates separating the workpiece along a surface defined by the contour to form a separated surface, and wherein the induced absorption produces an Ra surface roughness of the cut and separated edge of less than or equal to about 0.5 micron.

14. The method or article of any preceding claim, wherein the workpiece has a thickness in a range of between about 0.01 mm and about 5 mm.

15. The method or article of any preceeding claim, wherein the alkaline earth boro-aluminosilicate glass composite workpiece is in the form of a glass sheet, and wherein focusing the pulsed laser beam and translating the workpiece and the laser beam relative to each other along the contour are performed with the glass sheet at an online draw.

16. The method or article claim 15, wherein focusing and translating are performed with the glass sheet at a temperature around an annealing temperature of the glass sheet.

17. The method or article of claim 15 or 16, wherein the glass sheet comprises at least two layers having at least two different respective annealing temperatures, and wherein focusing and translating are performed with the glass sheet at a temperature between the at least two different respective annealing temperatures.

18. The method or article of any of the claims 15-17, wherein the glass sheet comprises at least two layers, and wherein focusing and translating are performed with the glass sheet above an annealing temperature of the glass sheet.

19. The method or article of any of the claims 15-18, further comprising applying at least one of a heat source, a tensile stress, or a bending stress to the glass sheet in the region of the contour to facilitate separation of the glass sheet from the draw along the contour.

20. A glass article comprising alkaline earth boro-aluminosilicate glass composite including at least one edge having a plurality of defect lines extending at least 250 microns, the defect lines each having a diameter less than or equal to about 5 microns.

21. The glass article of claim 20 wherein a spacing of adjacent defect lines is between 0.1 micron and 20 microns.

22. The glass article of claim 20-21, wherein the at least one edge is a separated edge has an Ra surface roughness of less than or equal to about 0.5 micron.

23. The glass article of claim 20-22, wherein the edge has subsurface damage up to a depth less than or equal to about 100 microns.

24. The glass article of claim 20-23, having a thickness between about 10 microns and about 5 mm.

25. The method of claim 1-22, wherein the pulsed laser has laser power of 25 W-60 W, and produces pulse bursts with at least 2-25 pulses per burst and the periodicity between the defect lines is 2-10 microns, and the workpiece or the laser beam is translated relative to one another at a rate of at least 0.25 m/sec.

CLAIMS

1. A method of laser processing an alkaline earth boro-aluminosilicate glass composite workpiece, the method comprising:

focusing a pulsed laser beam into a laser beam focal line oriented along the beam propagation direction and directed into the alkaline earth boro-aluminosilicate glass composite workpiece, the laser beam focal line generating an induced absorption within the material, and the induced absorption producing a defect line along the laser beam focal line within the workpiece; and

translating the alkaline earth boro-aluminosilicate workpiece and the laser beam relative to each other along a contour, thereby laser forming a plurality of defect lines along the contour within the workpiece, wherein a periodicity between adjacent defect lines is between 0.1 micron and 20 microns.

2. A glass article prepared by the method of claim 1.

3. The method or article of claim 1 or 2, further comprising separating the workpiece along the contour.

4. The method or article of claims 1 or 2, wherein the workpiece comprises a stack of plural display glass composite substrates.

5. The method or article of of claims 1 or 2, wherein the pulsed laser has a laser power of 10W-150W and produces pulse bursts with at least 2 pulses per pulse burst.

6. The method or article of claims 1 or 2, wherein the laser beam focal line has a length in a range of between about 0.1 mm and about 10 mm.

7. The method or article of any preceeding claim, wherein the laser beam focal line has an average spot diameter in a range of between about 0.1 micron and about 5 microns.

8. The method or article of claims 1-2, wherein laser forming the plurality of defect lines along the contour within the workpiece facilitates separating the workpiece along a surface defined by the contour to form a separated surface, and wherein the induced absorption produces an Ra surface roughness of the cut and separated edge of less than or equal to about 0.5 micron.

9. The method or article of any claims 1-2, wherein the alkaline earth boro-aluminosilicate glass composite workpiece is in the form of a glass sheet, and wherein focusing the pulsed laser beam and translating the workpiece and the laser beam relative to each other along the contour are performed with the glass sheet at an online draw.

10. A glass article comprising alkaline earth boro-aluminosilicate glass composite including at least one edge having a plurality of defect lines extending at least 250 microns, the defect lines each having a diameter less than or equal to about 5 microns.