for the inner surfaces of the pharmaceutical package to shed glass particulates or "delaminate" following exposure to pharmaceutical solutions.

[0005] In addition, use of glass in pharmaceutical packaging may also be limited by the mechanical performance of the glass. Specifically, the high processing speeds utilized in the manufacture and filling of glass pharmaceutical packages may result in mechanical damage on the surface of the package, such as abrasions, as the packages come into contact with processing equipment, handling equipment, and/or other packages. This mechanical damage significantly decreases the strength of the glass pharmaceutical package resulting in an increased likelihood that cracks will develop in the glass, potentially compromising the sterility of the pharmaceutical contained in the package or causing the complete failure of the package.

[0006] Accordingly, a need exists for alternative glass containers for use as pharmaceutical packages which exhibit a combination of at least two of improved resistance to delamination, increased strength, and/or damage tolerance.

SUMMARY

[0007] A glass container may include a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface. At least the inner surface of the body may have a delamination factor less than or equal to 10. A compressively stressed layer may extend from the outer surface of the body into the wall thickness. The compressively stressed layer may have a surface compressive stress greater than or equal to 150 MPa.

~~[0007a] In a first aspect, there is provided a glass container comprising:~~

~~a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein at least the inner surface of the body has a delamination factor less than or equal to 10; and~~

~~a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa.~~

may be positioned on the inner surface of the body such that a composition contained in the glass container contacts the barrier coating and not the inner surface of the body.

~~[0008a] In a second aspect, there is provided a glass container comprising:~~

~~a body having an inner surface, an outer surface and a wall thickness extending from the outer surface to the inner surface, wherein the body is formed from a glass composition which is free from constituent components which form species that volatilize significantly at temperatures corresponding to a viscosity in a range from about 200 poise to about 100 kilopoise; and~~

~~a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa.~~

[0009] A glass container may include a body having an inner surface, an outer surface and a wall thickness extending from the outer surface to the inner surface. The body may be formed from a glass composition which is free from constituent components which form species that volatilize significantly at temperatures corresponding to a viscosity in a range from about 200 poise to about 100 kilopoise. A compressively stressed layer may extend from the outer surface of the body into the wall thickness. The compressively stressed layer may have a surface compressive stress greater than or equal to 150 MPa.

[0009a] In ~~a third~~an aspect, there is provided a glass container comprising:

a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein the body is formed from a Type I, Class B glass according to ASTM Standard E438-92 and the body is formed under forming temperatures, forming speeds, or both, ~~processing conditions~~ which mitigate the vaporization of volatile species in the glass composition; and

a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa.

[0010] According to another embodiment, a glass container may include a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface. The body is formed from a Type I, Class B glass according to ASTM Standard E438-92 under processing conditions which mitigate the vaporization of volatile species in the glass composition. A compressively stressed layer may extend from the outer surface of the body into the wall thickness. The compressively stressed layer may have a surface compressive stress greater than or equal to 150 MPa.

[0010a] In another aspect, there is provided a glass container comprising:

a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein at least the inner surface of the body has a delamination factor less than or equal to 10 as measured by the glass container averaging less than 10 glass particles with a minimum length of about 50 μm and an aspect ratio of greater than about 50 per trial following accelerated delamination testing, wherein the body comprises laminated glass and the laminated glass comprises:

a core layer having a core coefficient of thermal expansion CTE_{core}; and

at least one cladding layer fused to the core layer and having a second coefficient of thermal expansion CTE_{clad}, wherein CTE_{core} is not equal to CTE_{clad}, wherein the at least one cladding layer forms the inner surface of the body and has a delamination factor of less than or equal to 10 after the laminated glass is formed into the glass container; and

a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa;

wherein:

the glass body has an interior region extending from 10 nm below the interior surface of the glass body and into the thickness of the glass body;

the interior region has a thickness of at least about 100 nm; and

the interior region has a persistent layer homogeneity such that an extrema in a layer concentration of each constituent component in the interior region is greater than

or equal to about 80% and less than or equal to about 120% of a concentration of a same constituent component at a midpoint of the thickness of the glass body.

[0010b] In another aspect, there is provided A glass container comprising:

a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein at least the inner surface of the body has a delamination factor less than or equal to 10 as measured by the glass container averaging less than 10 glass particles with a minimum length of about 50 μm and an aspect ratio of greater than about 50 per trial following accelerated delamination testing, wherein the inner surface of the body is a barrier coating; and

a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa;

wherein:

the glass body has an interior region extending from 10 nm below the interior surface of the glass body and into the thickness of the glass body;

the interior region has a thickness of at least about 100 nm; and

the interior region has a persistent layer homogeneity such that an extrema in a layer concentration of each constituent component in the interior region is greater than or equal to about 80% and less than or equal to about 120% of a concentration of a same constituent component at a midpoint of the thickness of the glass body.

[0011] Additional features and advantages of the embodiments of the glass containers described herein will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0012] It is to be understood that both the foregoing general description and the following detailed description describe various embodiments and are intended to provide an overview or framework for understanding the nature and character of the claimed subject matter. The accompanying drawings are included to provide a further understanding of the various embodiments, and are incorporated into and constitute a

CLAIMS:

1. ~~A glass container comprising:~~

~~a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein at least the inner surface of the body has a delamination factor less than or equal to 10; and~~

~~a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa.~~

2. ~~A glass container comprising:~~

~~a body having an inner surface, an outer surface and a wall thickness extending from the outer surface to the inner surface, wherein the body is formed from a glass composition which is free from constituent components which form species that volatilize significantly at temperatures corresponding to a viscosity in a range from about 200 poise to about 100 kilopoise; and~~

~~a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa.~~

~~3~~1. A glass container comprising:

a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein the body is formed from a Type I, Class B glass according to ASTM Standard E438-92 and the body is formed under forming temperatures, forming speeds, or both, ~~processing conditions~~ which mitigate the vaporization of volatile species in the glass composition; and

a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa.

42. The glass container of claim 1 ~~any of claims 1 through 3~~, wherein the compressively stressed layer extends from the outer surface into the wall thickness to a depth of layer greater than or equal to about 25 μm.

53. The glass container of claim 1 ~~any of claims 1 through 3~~, wherein the body is thermally tempered and the compressively stressed layer extends from the outer surface into the wall thickness to a depth of layer of up to 22% of the wall thickness.

64. The glass container of any of claim 1 ~~any of claims 1 through 3~~, wherein the body comprises laminated glass and the laminated glass comprises:

a core layer having a core coefficient of thermal expansion CTE_{core}; and

at least one cladding layer fused to the core layer and having a second coefficient of thermal expansion CTE_{clad}, wherein CTE_{core} is not equal to CTE_{clad}, wherein the at least one cladding layer forms the inner surface of the body and has a delamination factor of less than or equal to 10 after the laminated glass is formed into the glass container.

75. The glass container of claim 1 ~~any of claims 1 through 3~~, wherein the body has an interior region extending from 10 nm below the interior surface of the glass body and into the thickness of the glass body ~~between the inner surface of the body and the outer surface of the body~~, the interior region having a persistent layer homogeneity such that an extrema in a layer concentration of each constituent component in the interior region is greater than or equal to about 80% and less than or equal to about 120% of a concentration of a same constituent component at a midpoint of the thickness of the glass body.

86. The glass container of claim 1 ~~any of claims 1 through 3~~, wherein the inner surface of the body has a persistent surface homogeneity such that the surface concentration of each of the constituent components in the surface region at a discrete point is greater than or equal to 70% and less than or equal to 130% of the same constituent components in the surface region at any second discrete point on the inner surface.

97. The glass container of claim 1 ~~any of claims 1 through 3~~, wherein the inner surface of the body is a barrier coating.

~~10~~8. The glass container of claim 1 ~~any of claims 1 through 3~~, wherein the body has either:

(a) at least a class S3 acid resistance or better according to DIN 12116;
at least a class A2 base resistance or better according to ISO 695; and
at least a type HgB2 hydrolytic resistance or better according to ISO 719; and
at least a type HgA2 hydrolytic resistance or better according to ISO 720;

or (b) a Type 1 chemical durability according to USP <660>.

9. The glass container of claim 3, wherein the body is formed under forming temperatures of less than 1350°C.

10. A glass container comprising:

a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein at least the inner surface of the body has a delamination factor less than or equal to 10 as measured by the glass container averaging less than 10 glass particles with a minimum length of about 50 μm and an aspect ratio of greater than about 50 per trial following accelerated delamination testing, wherein the body comprises laminated glass and the laminated glass comprises:

a core layer having a core coefficient of thermal expansion CTE_{core}; and

at least one cladding layer fused to the core layer and having a second coefficient of thermal expansion CTE_{clad}, wherein CTE_{core} is not equal to CTE_{clad}, wherein the at least one cladding layer forms the inner surface of the body and has a delamination factor of less than or equal to 10 after the laminated glass is formed into the glass container; and

a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa;

wherein:

the glass body has an interior region extending from 10 nm below the interior surface of the glass body and into the thickness of the glass body;

the interior region has a thickness of at least about 100 nm; and

the interior region has a persistent layer homogeneity such that an extrema in a layer concentration of each constituent component in the interior region is greater than

or equal to about 80% and less than or equal to about 120% of a concentration of a same constituent component at a midpoint of the thickness of the glass body.

11. A glass container comprising:

a body having an inner surface, an outer surface and a wall thickness extending between the outer surface and the inner surface, wherein at least the inner surface of the body has a delamination factor less than or equal to 10 as measured by the glass container averaging less than 10 glass particles with a minimum length of about 50 μm and an aspect ratio of greater than about 50 per trial following accelerated delamination testing, wherein the inner surface of the body is a barrier coating; and

a compressively stressed layer extending from the outer surface of the body into the wall thickness, the compressively stressed layer having a surface compressive stress greater than or equal to 150 MPa;

wherein:

the glass body has an interior region extending from 10 nm below the interior surface of the glass body and into the thickness of the glass body;

the interior region has a thickness of at least about 100 nm; and

the interior region has a persistent layer homogeneity such that an extrema in a layer concentration of each constituent component in the interior region is greater than or equal to about 80% and less than or equal to about 120% of a concentration of a same constituent component at a midpoint of the thickness of the glass body.