CURVED LENSES AND RELATED METHODS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The application claims priority to U.S. Provisional Application Serial No. 61/475,871 titled "Apparatus and Method for Shaping Light Polarizers," which was filed on April 15, 2011 and is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The invention relates to the field of polarized eyewear, and, more particularly, to curved polarized lenses and eyewear having curved polarized lenses.

BACKGROUND

[0003] Light polarizing lenses such as those incorporated into sunglasses or other eyewear are preferably shaped to comply with fashion trends, to minimize the amount of light that can disturb the wearer's peripheral vision and to minimize the appearance of reflections. Unfortunately, there are currently very few techniques that can transform planar polarizing lens blank materials into a curved lens. The techniques that exist may suffer from one or more of the following drawbacks: some may produce lenses with optical power, production is not adapted for efficient automation, some involve time consuming grinding processes, or the forming process damages the linear polarizer.

SUMMARY

[0004] In view of the foregoing, it is an object of the ~~invention~~embodiments disclosed herein to provide curved polarized lenses having substantially no optical power, which can be produced according to efficiently automated processes that impart minimal damage to the delicate linear polarizer material.

[0005] In oneAccording to a method aspect of the invention, there is provided a method of making a formed lens, the method comprising: obtaining is prepared from a lens blank comprising, in superposed relation,made of a linear polarizer layer laminated together with a plurality of polymeric layers, the linear polarizer layer having a polarization axis;. The lens blank is heateding and pressseding the lens blank between a convex member and a concave member at a first pressure;. The pressure rampeding the pressure sigmoidally from the first pressure to a higher pressure over a ramping time; and maintaining the higher pressure is maintained for a time sufficient to allow the lens blank to conform to the shape of the convex member and concave member.

[0006] In another method aspect of the invention, there is provided a method of making a formed lens, the method comprising: obtaining is prepared from a lens blank comprising, in superposed relation,made of a linear polarizer layer laminated together with a plurality of polymeric layers, the linear polarizer layer having a polarization axis;. The lens blank is heateding the lens blank to a forming temperature by pressing the lens blank at a first pressure between a convex member and a concave member, the convex member and concave member both being at the forming temperature;. The pressure is rampeding the pressure to a second pressure while heating at the forming temperature, wherein ramping from the first pressure to the second pressure is performed according to a sigmoidal pressure profile;. The second pressure is maintaineding the second pressure while heating at the forming temperature for allowing the lens blank to conform to the shape of the convex member and concave member;. The temperature is reduceding the temperature to a reduced temperature while maintaining the second pressure for allowing the lens blank to become a rigid lens having a convex side and a concave side; and. The rigid lens is then removeding the rigid lens from between the convex member and concave member.

[0007] In another method aspect of the invention, there is provided a method of making eyewear, the method comprising: (a) obtaining is prepared from a first lens and a second lens, the first lens and second lens comprising, in superposed relation, made of a linear polarizer layer laminated together with a plurality of polymeric layers, the linear polarizer layer having a polarization axis, t. The first lens and second lens beingare formed from lens blanks into a desired shape according to the following steps: (i) heating and pressing the lens blanks separately between a convex member and a concave member at a first pressure;, (ii) ramping the pressure sigmoidally to a higher

pressure over a ramping time;, and (iii) maintaining the higher pressure for a time sufficient to allow the lens blanks to conform to the shape of the convex member and concave member; and (b) placing the. ~~The formed~~ first lens and second lens~~es are then placed~~ into an eyeglass frame.

[0008] The following are preferred forming parameters that may optionally be used in methods of the ~~invention~~disclosure. Heating is preferably conducted at about 70°C to about 200°C. The first pressure is about 0.75 to about 2.5 MPa. The second pressure is about 1.5 to about 32 MPa. The ramping time is preferably about 5 to about 150 seconds.

[0009] In some embodiments, a method may comprise cooling the lens blank while maintaining the second pressure. Cooling may be conducted at about 20°C to about 90°C.

[0010] In some embodiments, a method may comprise, heating the lens blank to a temperature of between about 20°C to about 150°C prior to placing the lens blank between the convex member and concave member and pressing the lens blank at the first pressure.

[0011] In certain embodiments, at least one of the polymeric layers is an optical wave retarder having fast and slow axes and the fast retarder axis is aligned at an angle relative to the polarizer axis. The angle may be chosen to render the lens a linear polarizer, an elliptical polarizer, or a circular polarizer.

[0012] In embodiments in which the lens is a circular polarizer, an anti-reflective coating may be applied to the concave surface and convex surface of the formed lens. This advantageously allows the formed lens to have a parallel polarizer transmittance equal to or greater than 90% and a cross polarizer transmittance equal to or less than 0.5%.

[0013] In some embodiments, the shape of the convex member and concave member may be adjusted to produce a spherically, toroidally, or cylindrically shaped lens. A spherically shaped lens has a first radius of curvature and a

second radius of curvature perpendicular to the first radius of curvature, wherein the first radius of curvature and second radius of curvature are equal. A toroidally shaped lens has a first radius of curvature and a second radius of curvature perpendicular to the first radius of curvature, wherein the first radius of curvature and second radius of curvature are not equal. A cylindrically shaped lens has a first radius of curvature and a second radius of curvature perpendicular to the first radius of curvature, wherein the first radius of curvature is non-zero and second radius of curvature is zero.

[0014] In some embodiments, the shape of the convex member and concave member produces a lens having non-uniform thickness with a maximum thickness of the lens being located proximal to the center of the lens, which advantageously allows the lens to have substantially no optical power.

[0015] In another aspect, there is provided an ~~Embodiments of the invention also include~~ eyeglass lenses made according to the method as defined above ~~aspects of the invention~~.

[0016] These and other embodiments ~~objects, aspects,~~ and advantages of the present disclosure ~~invention~~ will be better appreciated in view of the drawings and following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** is a side elevation view of a preferred composite light polarizer sheet that can be used to form a lens in accordance with an embodiment of the invention;

[0018] FIG. **2** is a side elevation view of another preferred composite light polarizer sheet that can be used to form a lens in accordance with an embodiment of the invention;

[0019] FIG. **3** is a side elevation view of another preferred composite light polarizer sheet that can be used to form a lens in accordance with an embodiment of the invention;