has progressed more slowly in recent two years compared to children using monofocal contact lenses. When primary school students wear DISC lenses for 8 hours every day, the progression of myopia is slowed by 60%. The DISC lens provides patients with clear vision through the design of alternating concentric rings with different optical powers, and at the same time, it enables patients to continuously receive positive defocus signals at various visual distances to inhibit eyeball elongation. Although DISC lens has a positive effect on myopia control, as a kind of contact lenses, it is essentially invasive. Due to eye health problems, a large number of primary and secondary school students cannot wear soft contact lenses. For example, they may have lens intolerance issues or safety concerns, which may limit their wearing time.

The spectacle lens that incorporates defocusing function is very attractive and acceptable to all patients, because it is essentially non-invasive as traditional spectacle lens, and easy to wear and very safe. At the same time, the spectacle lens can maximize the wearing time, so as to achieve the best myopia control. However, simply transferring the design concept of concentric ring of DISC lens to spectacle lens will cause many problems. In particular, concentric rings with different optical powers will occur obvious joints at the joint position, for contact lenses. These joints will not be easily observed in appearance due to the influence of tears. However, when the joint appears on the spectacle lens, the appearance will be very obvious, which will seriously affect the aesthetics and reduce the patient's willingness to wear it.

Summary

The present disclosure discloses a ring-focus spectacle lens for controlling myopia progression, and manufacturing method therefor. This ring-focus spectacle lens can provide clear vision for patients, and also has a plurality of annular defocusing zones to form an optical defocus effect. Since this ring-focus spectacle lens has no joint between concentric rings with different optical powers, this ring-focus spectacle lens is as aesthetic as an ordinary spectacle lens. This manufacturing method can use three anterior mold cores, a set of posterior mold cores and a planar posterior mold core to manufacture a series of ring-focus spectacle lenses with full degrees, thereby reducing the number of mold cores and the production cost. At the same time, this manufacturing method provides a semi-finished lens/lenses to manufacture a ring-focus spectacle lens with high myopia degree and high astigmatism degree. Since the market demand for

high myopia degree and high astigmatism degree is small, it is not cost-effective to use a separate mold core. Using this post-processing manner of semi-finished lenses not only greatly reduces the number of mold cores, but also reduces the inventory number of required lenses, thereby reducing the cost.

Some examples of the present disclosure disclose a ring-focus spectacle lens for controlling myopia progression, which comprises a convex front surface, a concave rear surface, a plurality of correction zones for imaging light on a retina, and a plurality of astigmatism zones for imaging light in front of the retina. The optical centers of the front surface and the rear surface are located on a same optical axis. The correction zones have a first refractive power, and the astigmatism zones have a second refractive power which is greater than the first refractive power. The correction zones and the astigmatism zones are arranged in a staggered way in the ring-focus spectacle lens, wherein the front surface comprises a free-form surface composed of a plurality of first curved surfaces and a plurality of second curved surfaces. The plurality of first curved surfaces have a same radius of curvature, and the plurality of second curved surfaces have a same or different radius of curvature. The radius of curvature of the first curved surfaces is greater than that of the second curved surfaces. The first curved surfaces and the second curved surfaces are joined in a staggered way in the free-form surface. The correction zone is defined at least by the first curved surfaces, and the astigmatism zone is defined at least by the second curved surfaces. And wherein the first curved surface and the adjacent second curved surface are joined in a tangent and continuous manner or a transitional curved surface manner. For the tangent and continuous manner, the first curved surface and the adjacent second curved surface are tangent and continuous, so that the endpoint of the first curved surface and the endpoint of the second curved surface coincide at the joint point, and the tangent of the first curved surface and the tangent of the second curved surface have the same slope at the joint point. The extension line of the connecting line connecting the center of the first curved surface and the center of the second curved surface passes through the joint point. For the transitional curved surface manner, a transition curved surface is provided between the first curved surface and the adjacent second curved surface. The starting point and the ending point of the transition curved surface are respectively joined with the ending point of the first curved surface and the starting point of adjacent second curved surface. Directions and values of curvatures of the first curved surface and the transition curved

surface are the same at the joint point of the first curved surface and the transition curved surface. Directions and values of curvatures of the second curved surface and the transition curved surface are the same at the joint point of the second curved surface and the transition curved surface, and the curvature on the transition curved surface changes continuously.

In one aspect, the present disclosure refers to a ring-focus spectacle lens for controlling myopia progression, the ring-focus spectacle lens comprising a convex front surface, a concave rear surface, a plurality of correction zones for imaging light on a retina, and a plurality of astigmatism zones for imaging light in front of the retina, optical centers of the front surface and the rear surface being located on a same optical axis, the correction zones having a first refractive power and the astigmatism zones having a second refractive power that is greater than the first refractive power, the correction zones and the astigmatism zones being arranged in a staggered way in the ring-focus spectacle lens, wherein the front surface comprises a free-form surface composed of a plurality of first curved surfaces and a plurality of second curved surfaces, the plurality of first curved surfaces having a same radius of curvature, the plurality of second curved surfaces having a same or different radius of curvature, the radius of curvature of the first curved surfaces being greater than the radius of curvature of the second curved surfaces, the first curved surfaces and the second curved surfaces being joined in a staggered way in the free-form surface, the correction zones being defined at least by the first curved surfaces, and the astigmatism zones being defined at least by the second curved surfaces; wherein a first curved surface and an adjacent second curved surface are joined in a tangent and continuous manner or a transitional curved surface manner, for the tangent and continuous manner, the first curved surface and the adjacent second curved surface are tangent and continuous, such that an endpoint of the first curved surface and an endpoint of the second curved surface coincide at the joint point, and a tangent of the first curved surface and a tangent of the second curved surface have a same slope at the joint point, and an extension line of a connecting line connecting a center of the first curved surface and a center of the second curved surface passes through the joint point, for the transitional curved surface manner, a transition curved surface is provided between the first curved surface and the adjacent second curved surface, a starting point and an ending point of the transition curved surface being respectively joined with an ending point of the first curved surface and a starting point

of the adjacent second curved surface, directions and values of curvatures of the first curved surface and the transition curved surface being same at a joint point of the first curved surface and the transition curved surface, and directions and values of curvatures of the second curved surface and the transition curved surface being the same at a joint point of the second curved surface and the transition curved surface, curvatures on the transition curved surface changing continuously.

According to some examples, from the center of the lens outward in the radial direction, when the diopter of a previous curved surface minus the diopter of a subsequent curved surface is less than or equal to a threshold, the previous curved surface and the subsequent curved surface are joined in the tangent and continuous manner. When the diopter of the previous curved surface minus the diopter of the subsequent curved surface is greater than a threshold, the previous curved surface and the subsequent curved surface are joined in the transitional curved surface manner.

According to some examples, the threshold is 3.5D.

According to some examples, all first curved surfaces and second curved surfaces adjacent to each other are joined in the tangent and continuous manner.

According to some examples, the free-form surface is formed by a generatrix revolving along the optical axis, and the generatrix is composed of a plurality of first curves and a plurality of second curves. Each first curve has a radius of curvature of the first curved surface and each second curve has a radius of curvature of the second curved surface. The first curves and the second curves are joined in a staggered way in the generatrix. The first curves revolve to form the first curved surface, and the second curves revolve to form the second curved surface.

According to some examples, the radius of curvatures of the plurality of second curved surfaces is constant or increases in the radial direction of the ring-focus spectacle lens.

According to some examples, the second refractive power is greater than the first refractive power by 0.5D to 5D.

According to some examples, when the first refractive power is between -2D and 0D, the correction zone bending of the front surface is 401-600 bends.

According to some examples, when the first refractive power is between -4D and -2D, the correction zone bending of the front surface is 201-400 bends.

According to some examples, when the first refractive power is between -6D and -4D, the correction zone bending of the front surface is 50-200 bends.

According to some examples, the rear surface is a spherical surface, an even aspheric surface or a biconical surface.

According to some examples, the plurality of correction zones include a correction central zone and a plurality of correction concentric rings, wherein the correction central zone is located at the center of a ring-focus spectacle lens, and the plurality of astigmatism zones comprise a plurality of astigmatism concentric rings, and the correction concentric rings and the astigmatism concentric rings are arranged in a staggered way.

According to some examples, the diameter of the correction central zone is 5-12 mm, the width of the correction concentric ring is 0.5-2 mm, and the width of the astigmatism concentric ring is 0.5-2 mm.

According to some examples, the plurality of astigmatism zones have 5-15 astigmatism concentric rings, and the plurality of correction zones include 5-15 correction concentric rings.

According to some examples, the central thickness of the ring-focus spectacle lens is 1-3mm, and the diameter of the ring-focus spectacle lens is 60-80 mm.

Some examples of the present disclosure disclose a method for manufacturing a series of the ring-focus spectacle lenses, the series of the ring-focus spectacle lenses include a first set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, a second set of ring-focus spectacle lenses with different myopia

degree and astigmatism degree, a third set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, and a fourth set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, wherein the myopia degree of the first set of ring-focus spectacle lenses is smaller than that of the second set of ring-focus spectacle lenses, the myopia degree of the second set of ring-focus spectacle lenses is smaller than that of the third set of ring-focus spectacle lenses, and the myopia degree of the third set of ring-focus spectacle lenses is smaller than that of the fourth set of ring-focus spectacle lenses, the method comprises the following steps:

providing a first anterior mold core for generating a front surface with a first correction zone bending;

providing a second anterior mold core for generating a front surface with a second correction zone bending, wherein the first correction zone bending is greater than the second correction zone bending;

providing a third anterior mold core for generating a front surface with a third correction zone bending, wherein the second correction zone bending is greater than the third correction zone bending;

providing a set of posterior mold cores for generating rear surfaces with different radius of curvature, the set of posterior mold cores comprising a plurality of posterior mold cores, each posterior mold core being used for generating rear surfaces with corresponding radius of curvature;

providing a planar posterior mold core for generating a planar rear surface;

using the first anterior mold core and the set of posterior mold cores to generate the first set of ring-focus spectacle lenses;

using the second anterior mold core and the set of posterior mold cores to generate the second set of ring-focus spectacle lenses;

using the third anterior mold core and the set of posterior mold cores to generate the third set of ring-focus spectacle lenses;

using the third anterior mold core and the planar posterior mold core to generate a semi-finished lens; and

processing the rear surface of the semi-finished lens to generate the fourth set of ring-focus spectacle lenses.

In another aspect, the present disclosure refers to a method for manufacturing a series of ring-focus spectacle lenses according to claim 1, the series of the ring-focus spectacle

lenses comprising a first set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, a second set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, a third set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, and a fourth set of ring-focus spectacle lenses with different myopia degree and astigmatism degree, the myopia degree of the first set of ring-focus spectacle lenses being smaller than that of the second set of ring-focus spectacle lenses, the myopia degree of the second set of ring-focus spectacle lenses being smaller than that of the third set of ring-focus spectacle lenses, and the myopia degree of the third set of ring-focus spectacle lenses being smaller than that of the fourth set of ring-focus spectacle lenses, the method comprising, providing a first anterior mold core for generating a front surface with a first correction zone bending, providing a second anterior mold core for generating a front surface with a second correction zone bending, wherein the first correction zone bending is greater than the second correction zone bending, providing a third anterior mold core for generating a front surface with a third correction zone bending, wherein the second correction zone bending is greater than the third correction zone bending, providing a set of posterior mold cores for generating a rear surface with different radius of curvature, the set of posterior mold cores comprising a plurality of posterior mold cores, each posterior mold core being used for generating a rear surface with a respective radius of curvature, providing a planar posterior mold core for generating a planar rear surface, using the first anterior mold core and the set of posterior mold cores to generate the first set of ring-focus spectacle lenses, using the second anterior mold core and the set of posterior mold cores to generate the second set of ring-focus spectacle lenses, using the third anterior mold core and the set of posterior mold cores to generate the third set of ring-focus spectacle lenses, using the third anterior mold core and the planar posterior mold core to generate a semi-finished lens, and processing the rear surface of the semi-finished lens to generate the fourth set of ring-focus spectacle lenses.

According to some examples, wherein the first set of ring-focus spectacle lenses have ring-focus spectacle lenses with a first refractive power of -2D to 0D, the second

set of ring-focus spectacle lenses have ring-focus spectacle lenses with a first refractive power of -4D to -2D, the third set of ring-focus spectacle lenses have ring-focus spectacle lenses with a first refractive power of -6D to -4D, and the fourth set of ring-focus spectacle lenses have ring-focus spectacle lenses with a first refractive power of less than -6D or an astigmatism degree less than -2D.

According to some examples, the first correction zone bending is 401-600 bends, the second correction zone bending is 201-400 bends, and the third correction zone bending is 50-200 bends.

According to some examples, the set of posterior mold cores have 80 to 120 posterior mold cores.

According to some examples, the central thickness of the semi-finished lens is 2-20 mm.

Description of the drawings

Fig. 1 is a schematic structural diagram of a ring-focus spectacle lens according to embodiments of the present invention;

Fig. 2 is an optical effect diagram of a ring-focus spectacle lens according to embodiments of the present invention;

Fig. 3 is a schematic diagram of a generatrix of a free-form surface according to embodiments of the present invention;

Fig. 4 is a distribution diagram of a correction zone and an astigmatism zone according to embodiments of the present invention;

Fig. 5a and Fig. 5b illustrate a method of joining different curved surfaces;

Fig. 6 is a flowchart of a method for manufacturing a series of ring-focus spectacle lenses according to embodiments of the present invention;