A New Generation of Eyeglasses Pioneered Through Liquid Crystal Lens Technology

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ABSTRACT

Regardless of our age, we always want to live life looking forward. However, all of us will face worsening eyesight as we age. TouchFocus® *a new generation of eyeglasses can change the optical power polarization independently by controlling the alignment of liquid crystal molecules in the lens allowing for clear near and far vision.*

1 INTRODUCTION

In recent years, awareness of healthy life expectancy has increased, and seniors are said to be younger physically and mentally, but visual deterioration is an issue that cannot be avoided by anyone. The lens of the eye is a tissue that has a great power to refract light together with the cornea, and when trying to see a nearby object, the refractive power is adjusted by increasing the thickness of the lens by the muscles around the lens. This accommodation ability gradually weakens with the loss of elasticity of the crystalline lens with aging, presbyopia, which is a symptom that becomes difficult to see when looking at nearby things from the age of 40, so-called presbyopia, you will become aware of it.

However, due to the characteristics of conventional progressive lens, it is sometimes necessary to lower the line of sight or shift the glasses. Through wearing glasses and the gesture of seeing things, it was supposed to be recognized that people are getting older through wearing glasses and looking at things.

We have developed with the concept of providing a clear visual field with a natural line of sight at all distances, distant, intermediate and near, using liquid crystal lens technology.

2 WHAT IS TouchFocus®

Fig.1 shows the configuration of TouchFocus®. The lens is a progressive lens that incorporates an electronic liquid crystal lens that can electrically turn the refractive power ON and OFF, and the electronic circuit that drives the electronic liquid crystal lens is built into the eyeglass frame temple on the right side. The electric power supplied to the electronic circuit is supplied from a small and lightweight battery located in the eyeglass frame temple tip on the right side (the part that touches the ear). By touching the chevron-shaped touch sensor (capacitance sensor) on the right side of the temple for about 1 second, electricity flows through the conducting wire in the frame and the transparent conductive film in the progressive lens, driving the electronic liquid crystal lens. The electronic circuit is equipped with an accelerometer to reduce power consumption by monitoring the posture and usage of the glasses. The small and lightweight battery is removable, and can be used repeatedly by charging with a dedicated USB charger. (Touch Focus® is a registered trademark of Mitsui Chemicals, Inc.)

3 ELECTRONIC LIQUID CRYSTAL LENS

Fig.2 shows the diagram of the TouchFocus® electronic liquid crystal lens. The lens is composed of 9 layers in which a cholesteric liquid crystal is enclosed through a transparent electrode thin film (ITO), a transparent insulating thin film (SiO_2), and an alignment layer, and utilizes the diffraction phenomenon of light. The fine diffractive structure is engraved on MR-10™, which is a high refractive index lens material, and has a shape in which a saw-tooth shape is periodically changed into concentric circles. The height of the diffractive structure is about 3～4 μm. The transparent electrode thin film trims a part of the ITO thin film in order to connect the end faces to drive the electronic liquid crystal lens and reduce power consumption. The alignment layer is formed by photo-alignment. [1,2,3]

Next, the operation principle of the electronic liquid crystal lens will be described. The electronic liquid crystal lens is a kind of liquid crystal lens using the anisotropy of the refractive index of liquid crystal molecules. [4]

In the normal state (OFF state) when no voltage is applied to the liquid crystal molecules, the cholesteric liquid crystal becomes a horizontal molecular alignment by the action of the alignment film, as shown on the left in Fig.3. In this state, the effective refractive index of the liquid crystal and the refractive index of the lens material (MR-10™) both match with 1.67, so that the refractive power of the electronic liquid crystal lens does not occur. That is, the diffractive structure does not work. On the other hand, in the ON state when a voltage is applied, as shown in the right figure of Fig.3, the liquid crystal molecules change to a vertical homeotropic alignment, and the effective refractive index of the liquid crystal changes from 1.67 to 1.53. For this reason, a difference in refractive index occurs between the lens material (MR-10™) and the liquid crystal, and the lens action is exhibited.

4 ISSUE WITH CONVENTIONAL PROGRESSIVE

Conventional progressive lens for presbyopia has a field of view of different powers for all distances, intermediate and near, packed in one spectacle lens. Therefore, the change of the power in the lens becomes large, which causes a large "distortion/blurring of the vision" peculiar to the progressive lens. Common complaints about progressive lens include "I am not used to using the line of sight/difficult to use", "It is difficult to focus", "I am worried about where the lens looks distorted", etc. Many people give up. There are also voices such as "I can't see a certain distance neatly" and "I can't sense the distance at my feet." In addition, there are many opinions that "I don't feel the degree is right" and "I feel the degree is right but it is hard to focus". [5]

Fig.4 shows the additional power distribution (maximum additional power: 2.5 Dptr) in a progressive lens for presbyopia, the upper part of the lens is an area used for distance vision, and the lower part of the lens is an area used for near vision. When looking at one's feet with a progressive lens, the user sees the feet at an intermediate distance through the near vision area, which causes the feet to be blurred and the sense of distance to be unrecognizable. Here, if the additional power is defined as 0.5 Dptr ∼ 2.0 Dptr as the intermediate distance region, it is understood that the intermediate distance region is narrow because it is sandwiched between the far distance region and the near distance region.

Fig.5 shows the distribution of the astigmatism component of a conventional progressive lens. Similar to Fig.4, the maximum additional power is 2.5 Dptr. The upper part of the lens is the far vision region and the lower part is the near vision region. It can be seen that a large astigmatism component is generated because the power is continuously changed. This astigmatism component became a cause of feeling the blur. Especially, when the pupil of the eye is opened in the dark environment, it is affected by this astigmatism component, and it becomes a cause in which the character cannot be discriminated in spite of the focus.

5 DISCUSSION

TouchFocus® can be configured only in the distant and intermediate regions by adopting an electronic liquid crystal lens. Since it is possible to reduce the additional power of the progressive lens, it is possible to reduce astigmatism and distortion that are inevitably generated due to the change of the additional power.

Fig.6 show the additional power distribution that can be realized when the TouchFocus® is OFF. Fig.7 show the astigmatism component distribution that can be realized when the TouchFocus® is OFF. The maximum additional power is 2.5Dptr (when TouchFocus® is ON), which is the same as in Fig.4 and Fig.5. In Fig.7 it can be seen that the amount of astigmatism generated is smaller than that of the conventional progressive lens. Therefore, it is possible to realize a comfortable view with less distortion and blurring of the view. For example, it is possible to realize a distant field of view that makes driving comfortable and a wide intermediate field of view that allows comfortable operation of a laptop computer. In addition, since there is no near dioptric power under the progressive lens, there is little distortion of the feet even when getting on and off stairs, and light walking is possible.

As mentioned above, TouchFocus® has a progressive lens design that realizes a wide intermediate distance field of view with reduced astigmatism and distortion that are characteristic of progressive lens.

The additional power distribution and the astigmatism component distribution when TouchFocus® is ON are shown in Fig.8 and Fig.9, respectively (Maximum additional power: 2.5 Dptr). In the additional power distribution of Fig.8, the active area of the electronic liquid crystal lens is shown as a solid line area. The generated power distribution of the electronic liquid crystal lens is uniform. Further, it can be seen that there is a near distance area in the wide intermediate distance area, and the position is higher than the conventional progressive lens, and the area is also wide. In the distribution of astigmatism components in Fig.9, the operating range of the electronic liquid crystal lens is shown by the dashed line area. The distribution of the astigmatism component is the same as OFF state.

Therefore, the near vision can be realized with a natural viewing angle with reduced the aberration of the progressive lens. For example, you can enjoy reading with a natural line of sight when reading a small letter in a dark place or looking at a smartphone without lowering your line of sight or shifting your glasses. [6]

6 CONCLUSION

In this way, TouchFocus® is superior to conventional progressive lens for presbyopia because of its electronic liquid crystal lens. We will continue to contribute to the improvement of QOL (Quality of Life) of the seniors.

REFERENCES

[1] Motor Fan illustrated, vol.151 (SAN-EI CORPORATION, Tokyo, 2019) p.88.-91.
[2] Koji Okano et al.: Liquid Crystal and Applications (Baifukan, Tokyo, 1985) p.56.
[3] Kunihiro Ichimura: Optical alignment of liquid crystals (Yoneda Pub., Tokyo, 2007) p.142.-143.
[4] S. Sato: Jan. J. Appl. Phys., 18 (1979) p.1679.
[5] Glasses DB (Gankyo Pub., Tokyo, 2019) p.227.-228.
[6] Akihiro Muramatsu et al.: Journal of Ophthalmology, vol.22-2 (2019) p.2.-4.

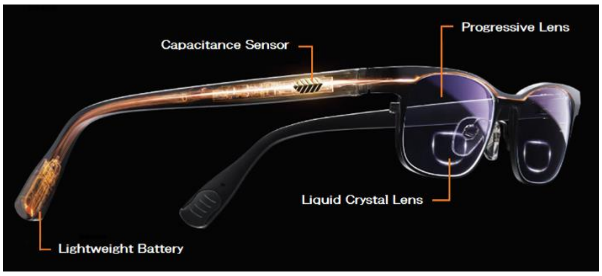

Fig.1 Configuration of TouchFocus®

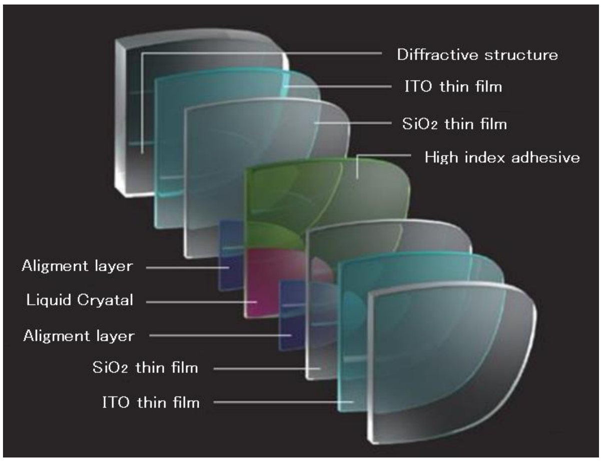

Fig.2 Diagram of electronic liquid crystal lens

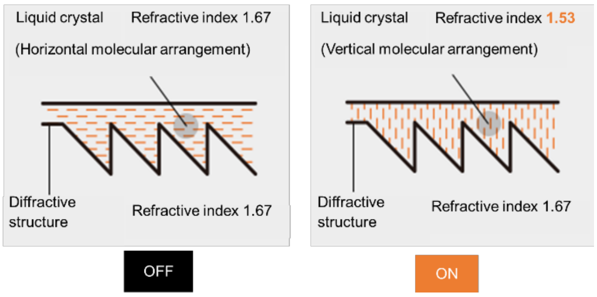

Fig.3 Operation principle of liquid crystal lens

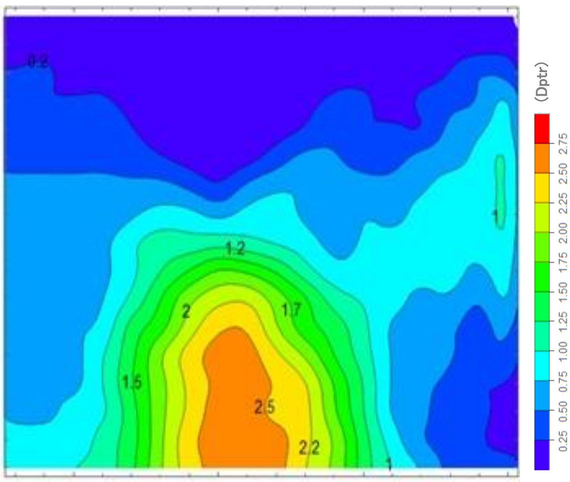

Fig.4 Additional power map of conventional lens

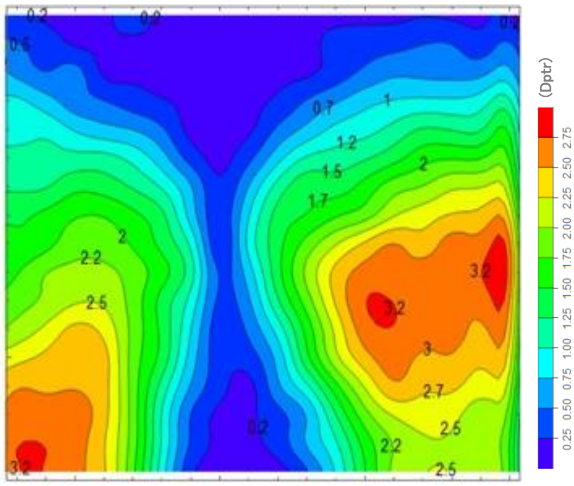

Fig.5 Astigmatism of conventional lens

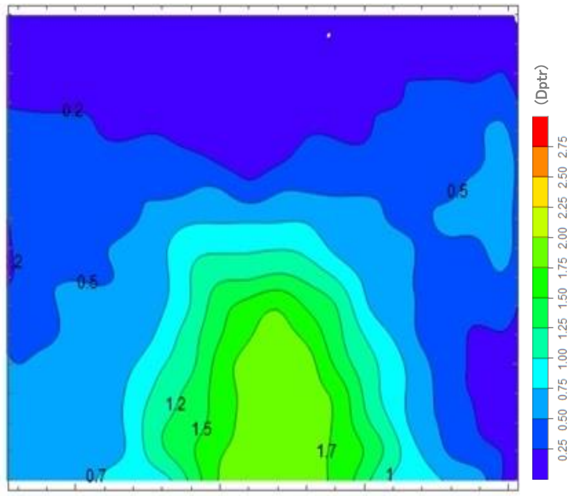

Fig.6 Additional power map of TouchFocus® at OFF

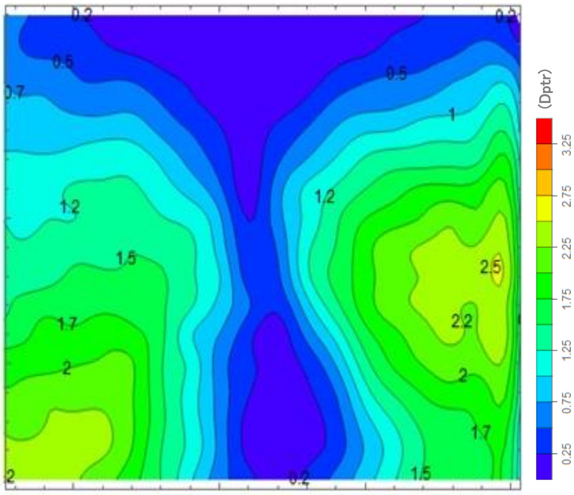

Fig.7 Astigmatism of TouchFocus® at OFF

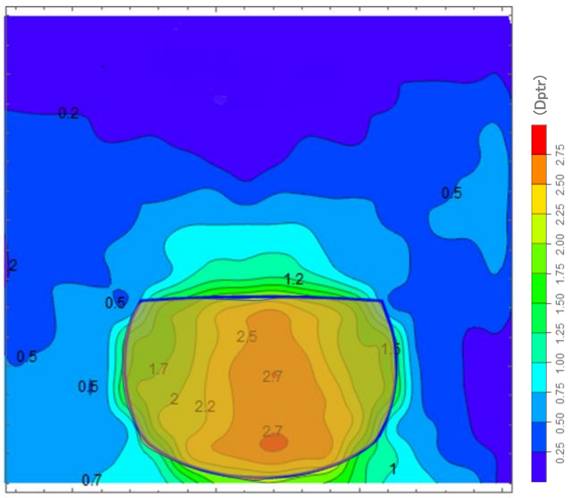

Fig.8 Additional power map of TouchFocus® at ON

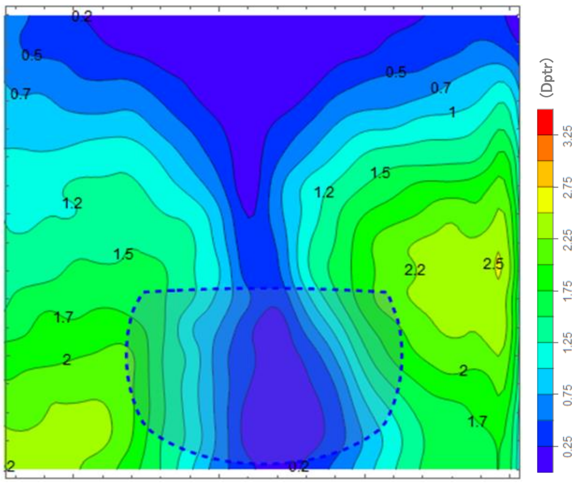

Fig.9 Astigmatism of TouchFocus® at ON