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Lens Carrier and Waveguide Subframe for Near-eye Device

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ABSTRACT

This disclosure describes a lens stack (lens module) for a near-eye device that includes a lens carrier and waveguide subframe. The lens carrier and waveguide subframe fully or partially encircles and houses the waveguide and enables precision placement of the waveguide in-coupling grating with respect to controlled datums that interface with display modules. The lens carrier is made of a high strength material and provides structural support to the waveguide. The material is opaque and helps to minimize stray light in the display system by reducing edge glow from waveguide. The lens carrier and waveguide subframe additionally provide a locating surface for the WS and ES lenses. Utilization of the lens carrier and waveguide subframe leads to better drop impact strength. Optical tooling and coating processes are simplified. Further, the design enables a larger choice of materials for both the lens carrier and the ophthalmic lenses. Additional features and functionality can be added to the lens carrier and waveguide subframe to support other smart glass features. The design also supports assembly via additional mechanical datums or fiducials to the carrier for holding/location the module during manufacturing and alignment/testing

KEYWORDS

- Smart glasses
- Near-eye Device
- Heads-up display (HUD)
- Augmented reality (AR)
- Virtual reality (VR)
- Drop test
- Hard coat processing
- Waveguide
- Stray light control

BACKGROUND

Augmented reality (AR) and virtual reality (VR) devices, sometimes referred to as near-eye display devices or smart glasses, typically include a combiner lens that includes a world side (WS) ophthalmic lens, an optical waveguide, and an eye side (ES) ophthalmic lens arranged in a stack. The optical waveguide includes gratings that guide light rays into the eye to create virtual images while the WS and ES lenses are utilized to enable the wearer to view the environment. In some designs, curvatures of the lens surfaces of the WS and ES lenses can be selected to achieve a specified prescription. The lens stack also includes a mechanical structure to provide support for the lenses and waveguide.

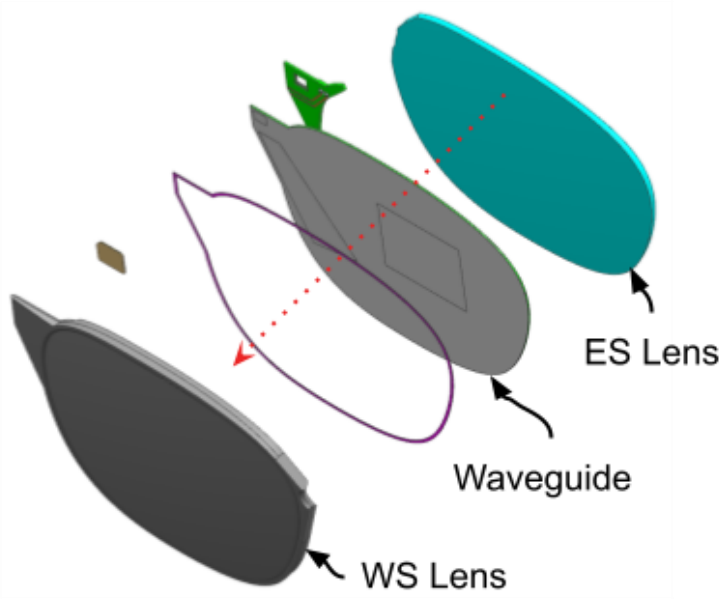

Fig. 1: Lens stack for a near-eye device

Fig. 1 illustrates an example lens stack for a near-eye device. As shown in Fig. 1, the combiner lens includes a WS lens with mechanical features molded into the lens itself. Alternatively, the ES lens can have mechanical features instead. This design can lead to poor drop test results as well as other cosmetic issues. Hard coating the lens with mechanical features

can create pooling and fileting of the hard coating material in the lens. The material choices are constrained to optical grade transparent substrates as the ophthalmic lens function is combined with the mechanical datuming functions. Besides, hard coating the lens can cause varying coating thickness which produces unwanted rainbow and ripple effects.

DESCRIPTION

This disclosure describes a lens stack (lens module) for a near-eye device that includes a lens carrier and waveguide subframe. The lens carrier and waveguide subframe is a precision mechanical component that fully or partially encircles and houses the waveguide. This enables precision placement of the waveguide in-coupling grating with respect to controlled datums that interface with display modules.

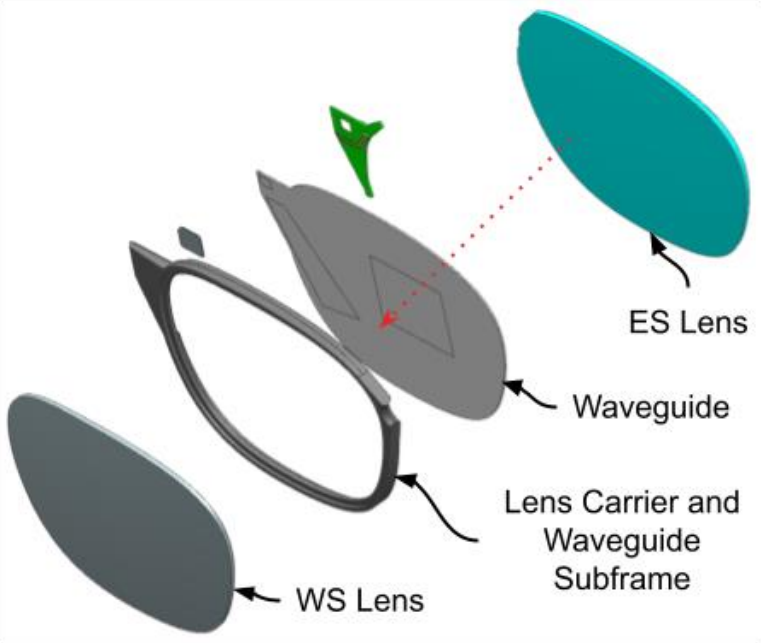

Fig. 2: Lens stack that includes a separate lens carrier and waveguide subframe

Fig. 2 illustrates an example lens stack that includes a lens carrier and waveguide subframe, per techniques of this disclosure. As depicted in Fig. 2, the lens stack includes a lens

carrier and waveguide subframe that is made of a high strength material. The lens carrier and waveguide subframe is utilized to house the waveguide and provides structural support to the waveguide. The lens carrier and waveguide subframe additionally provides a locating surface for the WS and ES lenses. While Fig. 2 depicts the lens carrier and waveguide subframe placed adjacent to the WS lens in the lens stack, it can alternatively be placed adjacent to the ES lens in some designs.

Utilization of the lens carrier and waveguide subframe leads to improved drop impact strength and greater wear and tear resistance. Optical tooling and coating processes are simplified. Further, the design enables a larger choice of material for both the lens carrier (e.g., high performance engineered resins) and the ophthalmic lenses, which can be cast using any of multiple ophthalmic materials rather than being limited to injection molded materials.

The stiffer material used in fabricating the lens carrier and waveguide subframe improves the overall structure of the lens assembly. Hard coat processing is improved and is similar to the process used for normal ophthalmic lenses. Decoupling the carrier from the WS or ES lens allows for the optical center of the WS lens to be adjusted as necessary to accommodate wearer needs.

Simplifying the WS lens that fits into the lens carrier (by decoupling mechanical datums and features) enables use of various lens materials and configurations including tinted lenses, mirrored lenses, photochromic, electrochromic, and/or polarized lenses. These lens configurations can be accommodated using the same lens carrier and waveguide subframe. Additional features and functionality can be added to the lens carrier and waveguide subframe to support other smart glass features, e.g., antenna, LED indicators, tooling marks/features to locate and hold components, etc.

CONCLUSION

This disclosure describes a lens stack (lens module) for a near-eye device that includes a lens carrier and waveguide subframe. The lens carrier and waveguide subframe fully or partially encircles and houses the waveguide and enables precision placement of the waveguide in-coupling grating with respect to controlled datums that interface with display modules. The lens carrier is made of a high strength material and provides structural support to the waveguide. The material is opaque and helps to minimize stray light in the display system by reducing edge glow from waveguide. The lens carrier and waveguide subframe additionally provide a locating surface for the WS and ES lenses. Utilization of the lens carrier and waveguide subframe leads to better drop impact strength. Optical tooling and coating processes are simplified. Further, the design enables a larger choice of materials for both the lens carrier and the ophthalmic lenses. Additional features and functionality can be added to the lens carrier and waveguide subframe to support other smart glass features. The design also supports assembly via additional mechanical datums or fiducials to the carrier for holding/location the module during manufacturing and alignment/testing

REFERENCES

1. "Eyeglass Lens" http://www.madehow.com/Volume-1/Eyeglass-Lens.html, accessed September 9, 2022
2. "Eyeglass frame materials: Metal, plastic and unusual" https://www.allaboutvision.com/eyeglasses/eyeglass_frame_materials.htm, accessed September 9, 2022