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A Method for Adding Ophthalmic Prescription to Augmented Reality Heads-Up Displays

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Abstract

A method for adding ophthalmic prescription to a heads-up display is described. The method incorporates Chiolite layers on opposing sides of a lightguide to generate an optical path from an input coupler to an output coupler. The Chiolite has an index of refraction that is less than the material forming the lightguide so that light may propagate within the lightguide under total internal reflection principles. The method further includes placement of a customized prescription lens surface on an eye-facing side of the lightguide, where one Chiolite layer is between the lightguide and the prescription.

Background

Head mounted display (HMD) technology has been evolving over the years, and various permutations have been developed and marketed. However, the HMD and the included optics were developed without providing prescription lens options for wearers that need prescription lenses. As such, an HMD that includes one or more prescription lenses is desirable. Further, the HMD with prescription lens may desirably take a traditional eyeglass form factor that provides a less obvious platform, which may increase adoption by the general population.

Description

An example HMD, as shown in Figure 1, includes two see-through eyepieces that provide image light to a user along with a view of the surrounding environment. The image light may be augmented reality data that provides information of one or more objects in the surrounding environment. Additionally, the image light provides other information to the user such as text messages, email messages, phone call information, etc. The HMD includes electronics and a display unit to project the image light to the user. The electronics are either coupled to a secondary electronics device that provides the data for generating the image light, or the electronics include wireless communication technology that allows for the receipt of the information via a wireless network, such as bluetooth, Wi-Fi or cellular.

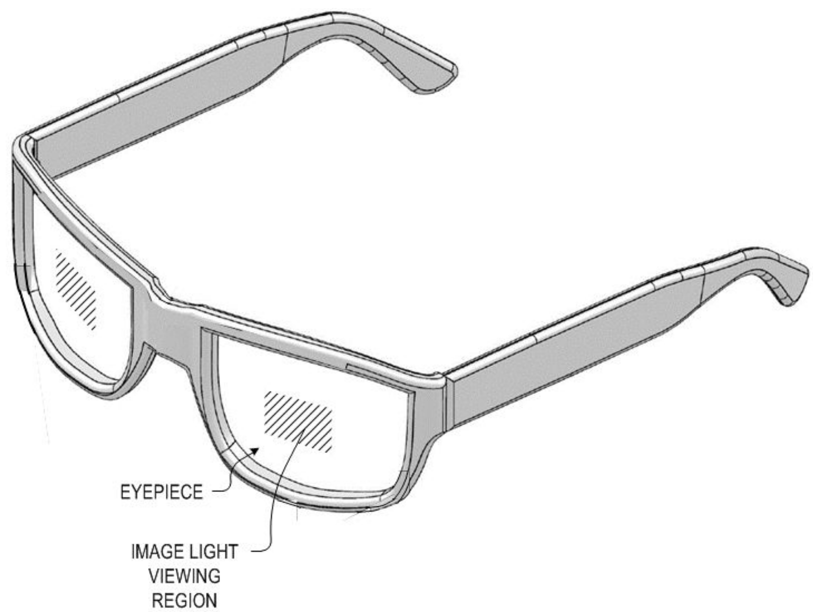

Fig. 1

Each eyepiece includes a lightguide that provides an optical pathway for the image light to propagate from the display unit to the image light viewing region, which is arranged to be aligned with the user's eye. The lightguide relies on total internal reflection (TIR) for propagating the image light from an input coupler to an output coupler, which redirects the light out of the HMD and toward the eye of the user in the image light viewing region. The eyepieces additionally include vision correction lensing for the user. Instead of providing vision correction lensing using a world-facing side of the HMD (similar to prior attempts), the present disclosure provides a method for adding vision correction lens to an eye-facing side of the eyepieces. Including the vision correction on the eye-facing side of the eyepiece may allow the user to view images of the surroundings through the HMD and images directed toward their eye via the HMD itself with their vision correction prescription.

An example eyepiece structure suited for an HMD is shown in Figure 2. The eyepiece structure includes a lightguide component, a see-through component, and a prescription layer. The prescription layer has been formed to provide a desired vision correcting prescription. Image light from a display source enters the eyepiece at a side location incident on an input coupler. The input coupler, which may be a refractive or diffractive optic, redirects the image light along a path within the lightguide component toward the output coupler. While in the lightguide component, the image light may experience TIR due to index of refraction differences between the lightguide component and two opposing Chiolite layers. The Chiolote layers may be between the see-through component and the lightguide component, and also between the prescription layer and the lightguide component. The Chiolite layers provide a low index of refraction layer that induces the TIR due to the delta of the index of refraction between the Chiolite and the material forming the lightguide component. The index of refraction of the Chiolite ranges from 1.3 to 1.35 at a wavelength of 500 nm, and the lightguide has an index of refraction from 1.6 to 1.67. The lightguide component is formed from glass or optics-grade plastic. The see-through component and the prescription layer along with an adhesive layer between the various components have respective indexes of refraction that are matched to the index of refraction of the lightguide component.

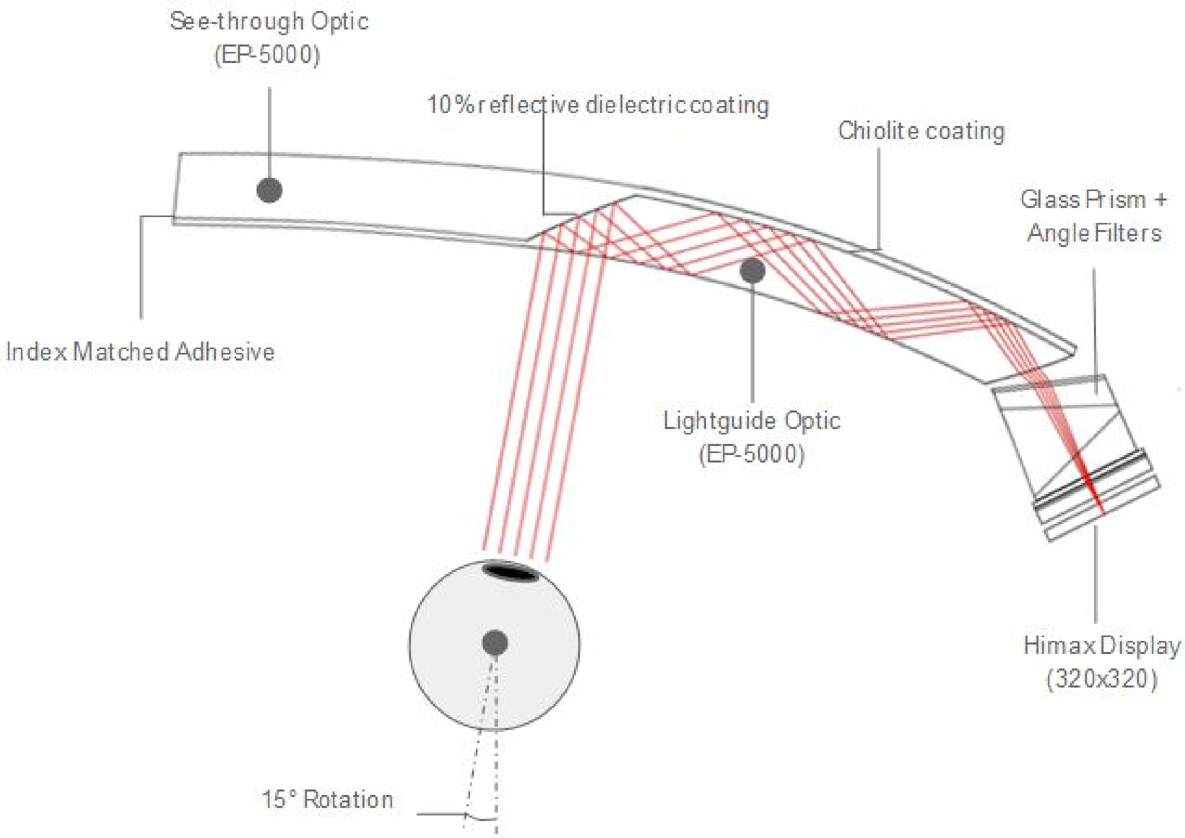

Fig. 2

The lightguide component has a thick portion and a thin portion, where the thick portion includes the input coupler and the output coupler. The thick portion also provides the optical path for the image light. The transition of the lightguide component from the thick portion to the thin portion is the output coupler. The output coupler provides a reflective or diffractive optic for redirecting the image light out of the eyepiece and toward a user's eye, and forms the image light viewing region as well. The thin portion of the lightguide component coincides and nests with a thick portion of the see-through component. Likewise, the thick portion of the lightguide component coincides and nests with a thin portion of the see-through component. Both the lightguide and see-through components of the eyepiece may extend across the entirety of the eyepiece so that no interfering features are formed within a user's field of view. Additionally, the see-through component is included so that that eyepiece is a constant thickness across the entire area of the eyepiece so not to introduce any aberrations, which also makes the eyepiece similar to conventional glasses eyepieces.

The Chiolite is not deposited on the point of transition of either the eye-facing side of the see-through component or the world-facing side of the lightguide component so that the point of transition is not visible due to the index of refraction mismatch. By preventing the Chiolite from being deposited in the transition points, the eyepieces will be free from visible lines even though the eyepieces are formed from and include multiple components and layers of varying thicknesses.

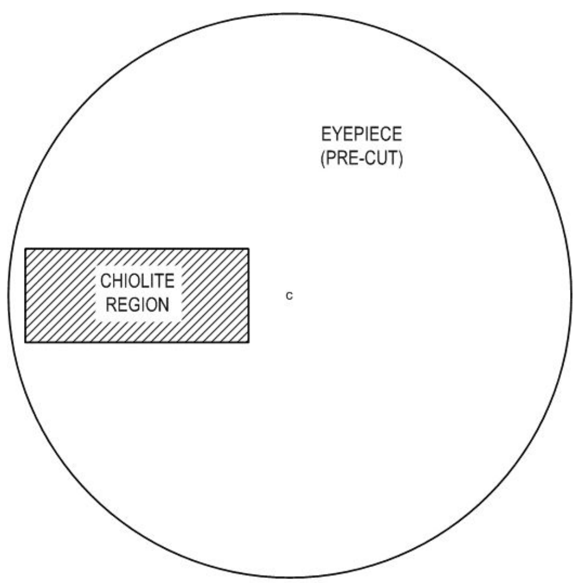

Fig. 3

The example eyepiece discussed above may be cut from a puck into a desired shape. An example puck is shown in Figure 3. The puck includes a see-through component, a lightguide component, a Chiolite region, and a prescription layer as shown in Figure 2. Figure 3 shows that the Chiolite is deposited in a rectangular region that provides the TIR from an input coupler to an output coupler. With regards to Figure 3, the input coupler is located toward the perimeter of the puck and the output coupler is located towards the center of the puck. The output coupler is just outside of the Chiolite region toward the center of the puck. The Chiolite region includes the Chiolite layer between the see-through component and the lightguide component, and the Chiolite layer between the lightguide component and the prescription layer.

An example process for producing an eyepiece and/or puck discussed above is shown in Figure 4 (note that the steps of Figure 4 are shown in a linear sequence for ease of illustration, although it will be appreciated in implementation that certain components would be manufactured in parallel and then combined together to form the eyepiece as described below). The manufacturing process shown in Figure 4 results in either a pre-cut puck that includes the various aspects of an eyepiece discussed above, or a cut eyepiece ready for installation in an HMD. The process begins with forming the see-through component. The see-through component can be molded from optics-grade plastic or glass, or cut from a blank of the same. The next step may include forming the lightguide component, which can be formed similar to the see-through component. Although the process shows the first two steps being performed serially, these two steps may be performed in any desired sequence or in parallel.

The process continues with coating the eye-facing side of the see-through component with Chiolite. The eye-facing side of the see-through component can be coated in a rectangular region as shown in Figure 3, or the entire surface may be coated then masked and etched to form the Chiolite region. Alternatively, the world-facing side of the lightguide component may be coated with the Chiolite. Regardless of the component, the Chiolite can be deposited using any known layer deposition process, such as atomic layer deposition, thermal evaporation, chemical vapor deposition, etc.

The process further includes bonding the see-through component to the lightguide component. To bond the two components, an adhesive bonding material with an index of refraction matched to both the see-through component and the lightguide component is used. A thin layer of the adhesive bonding material is dispensed onto either the world-facing side of the lightguide component or the eye-facing side of the see-through component, then the two components are nested as shown in Figure 2. A post boding cure may be performed depending on the adhesive material, which may be performed using heat, UV radiation, or a combination thereof.

Additionally, the prescription layer may be formed. Formation of the prescription layer includes forming the prescription layer with a desired prescription using any known method. Further, the prescription layer is formed from, for example, the same material as both the see-through component and the lightguide component. If the prescription layer is formed from a different material, the material may need to be closely matched for thermal expansion as well as index of refraction. As with the see-through and lightguide components, the prescription layer may be formed prior to the outlined sequence, and may be received pre-formed by a manufacturer.

Post formation of the prescription layer, the process continues with coating the world-facing side of the prescription layer with a Chiolite layer. The Chiolite layer may be deposited similarly as discussed above and is either deposited in only the desired region as shown in Figure 3, or the entire world-facing side of the prescription layer is coated with Chiolite prior to masking and etching the Chiolite. The prescription layer with the Chiolite layer is subsequently bonded to the eye-facing side of the see-through/lightguide composite component previously formed. The adhesive bond material is used to bond the prescription layer to the composite component.

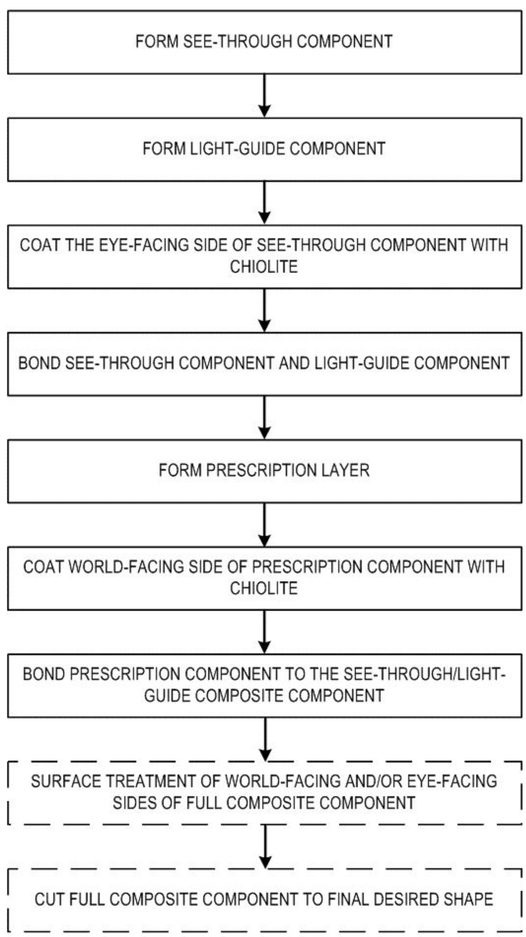

Fig. 4

Optionally, the last two steps of the process can be performed to fully form an HMD eyepiece. The optional steps include surface treatment of the world-facing side and/or the eye-facing side of the fully formed puck. For example, various coatings may be applied to the world-facing side such as hard coatings, anti-reflection coatings, tints, primers, photochromic layers, and combinations thereof. Additionally, an eyepiece of a desired shape can be cut from the formed and coated puck to be incorporated into an HMD.