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Injection Molding Eyepieces for Head Mounted Display

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Abstract

A technique is provided for manufacturing eyepieces for a head mounted display by forming the eyepiece in two parts: a coated, smaller insert part with a first coating (e.g. chiolite), and a second, larger supporting part with an opening or gap for the coated smaller part. The inset and supporting parts are formed from an eyepiece material via injection molding, and the inset part is then coated with the first coating. The inset is inserted into the gap of the supporting part, and the two parts are cast with an index matching material. The casting forms a front and back shell around the eyepiece, and also bonds the two parts together. By forming the lens in this way, the amount of material used in eyepiece formation is reduced. Further, the formation of ophthalmic lenses is simplified.

Background

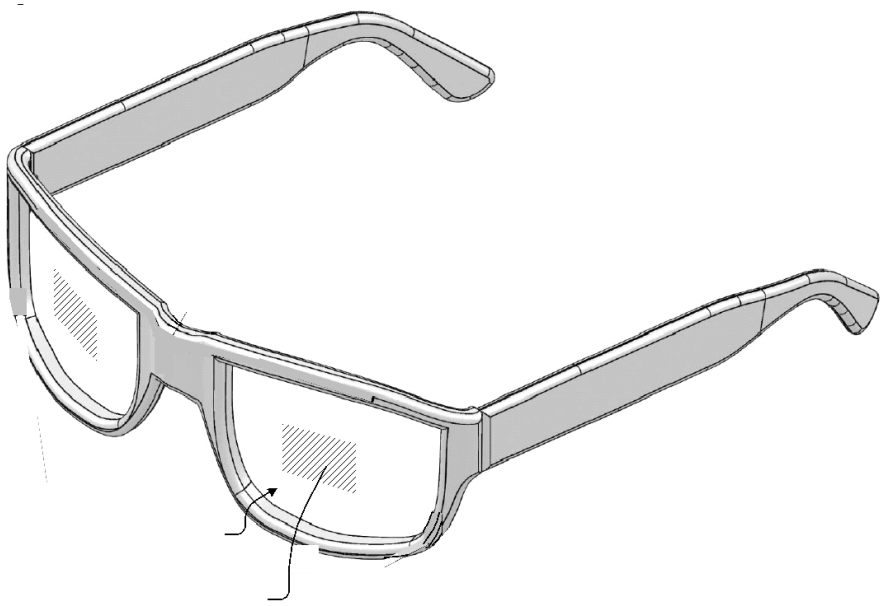
Head mounted display (HMD) systems include one or more see-through eyepieces. The eyepieces are generally configured to perform multiple functions, such as provision of image light (that is, light representing a displayed image) to a user and provision of a view of the surrounding environment. In addition, the eyepieces may perform other functions, such as an ophthalmic correction function (i.e., correcting the native vision of the user). In previous art, an eyepiece is formed by bonding two relatively large parts, made from expensive optical plastics, such as EP5000. Then the bonded parts are machined to form lens, similar to those inside eyeglasses. The machining process typically results in a loss of a substantial portion of the

eyepiece material from the original form, thereby undesirably increasing the cost of manufacture of the eyepiece.

In addition, the casting process simplifies bonding, and form the shells in front and back of the lens. Front shell can act as a photochromic layer to make the lens usable both indoor and outdoor. Back shell can be thicker and be machined for prescription.

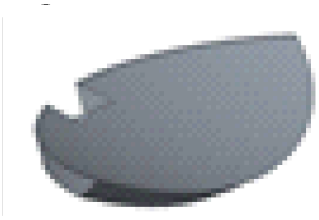
Description

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 Wi-Fi or cellular.



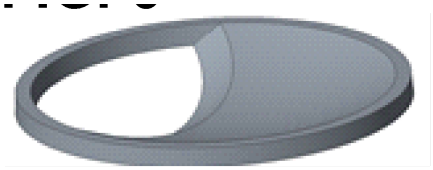
Each eyepiece includes a lightguide that provides an optical pathway for the image light to propagate from the display unit to the image light viewing region, which is arranged to be aligned with the user's eye. The lightguide relies on total internal reflection (TIR) for propagating the image light 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. The present disclosure provides a technique for forming the eyepiece for the HMD.

In one embodiment, the eyepiece is formed of two pieces, referred to herein as an inset piece and a supporting piece. An example of the inset piece is illustrated at FIG. 2.



The inset piece can be formed via injection molding from optical polymers, such as EP5000 In one embodiment, the inset piece is generally formed to provide, at least in part, the lightguide for the image light of the HMD. Accordingly, to set the refractive index of the inset piece to a specified point (such that the inset piece can provide the specified lightguide), after formation the inset piece is coated with a low refractive index material such as chiolite. In at least one embodiment, a frontside and a backside of the inset piece are coated differently. The frontside is coated with chiolite and partially reflective film, while the backside is coated with chiolite.

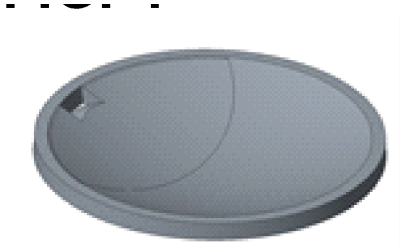
An example of the supporting piece is illustrated at FIG. 3:



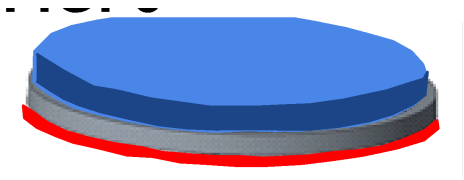
The supporting piece is formed via injection molding using the same lens material as used for the inset piece, such as EP5000. As depicted, the supporting piece is formed with a gap or opening having substantially the same shape as the inset piece, so that the inset piece can be placed in the

gap or opening. Further, to simplify embedding the eyepiece as described further below, the inset piece and the supporting piece are formed to have a substantially uniform thickness. In one embodiment, the supporting piece is not coated with the same coating as the inset piece, so that the supporting piece has different refractive properties than the inset piece. This allows the inset piece to provide the lightguide for image light, while the supporting piece provides a view of the environment surrounding the HMD.

After the supporting piece has been formed, and the inset piece formed and coated, the inset piece is placed in the gap or opening of the supporting piece, thereby forming a structure referred to herein as an eyepiece layer. An example of the eyepiece layer is illustrated at FIG. 4:

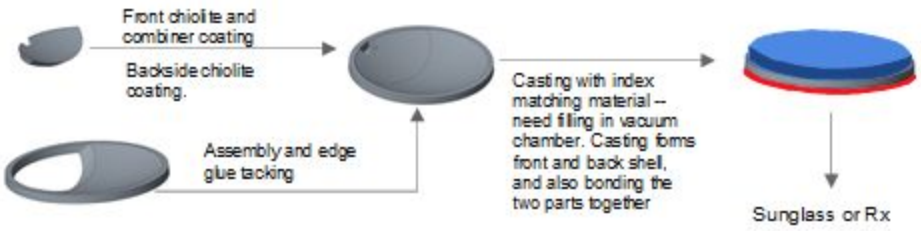


In one embodiment, the two pieces of the eyepiece layer (i.e. the inset layer and supporting layer) are not directly bonded together. Instead, the combined pieces are placed between two glass molds, then lens casting material, such as MR8 or MR10 is filled in. This way, the combined pieces are embedded in the final cast lens. An example is illustrated at FIG. 5:



The casting layers are formed of a material having a similar refractive index as the material used to form the inset piece and the supporting piece. The casting layers form a front and back shell for the eyepiece, and also bonds the inset piece and the supporting piece together. In at least one embodiment, the casting layers are cast using a vacuum filling or vacuum casting process.

The above-described manufacturing process is summarized at FIG. 6:



Forming the eyepiece in this way provides several possible advantages, including:

- Much less consumption of material
- No ophthalmic process except for the final user prescription
- For the final prescription, because the eyepiece layer is formed of standard lens materials, a standard ophthalmic process can be used
- Photochromic materials can be used for the eyepiece layer