Claims:

1. A method of manufacturing a waveguide display, comprising:

manufacturing a waveguide display assembly configured to direct image light to an eyebox plane having a length (L_{Eyebox}) and to a user's eye, the waveguide display assembly comprising:

a waveguide combiner, and

an out-coupler grating, wherein the out-coupler grating has a grating period Λ_{OC} such that all angles of incidence θ_{in} of light from an external light source, result in diffracted angles θ_{out}, that miss the user's eye.

2. The method of claim 1, wherein the grating period Λ_{OC} satisfies the following first order diffraction equation (I):

$$\sin(\theta_{out}) = \sin(\theta_{in}) +/- \frac{\lambda}{\Lambda_{OC}} \text{ (I)}$$

wherein λ is the wavelength of the light from the external light source.

3. The method of claim 2, wherein the out-coupler grating has a length (L_{OC}) which is the sum of a length of the top half of the out-coupler grating ($L_{OC_{top}}$) and a length of the bottom half of the out-coupler grating ($L_{OC_{bottom}}$), and

wherein $L_{OC_{top}}$ is determined using the following equation (II):

$$L_{OC_{top}} = \frac{L_{Eyebox}}{2\cos(\theta_{tilt})} + \frac{\sin\left(\frac{\theta_{FoV}}{2} - \theta_0\right)}{\cos\left(\frac{\theta_{FoV}}{2} - \theta_0 + \theta_{tilt}\right)} z_{eye} \text{ (II)}$$

and $L_{OC_{bottom}}$ is determined using the following equation (III):

$$L_{OC_{bottom}} = \frac{L_{Eyebox}}{2\cos(\theta_{tilt})} + \frac{\sin\left(\frac{\theta_{FoV}}{2} + \theta_0\right)}{\cos\left(\frac{\theta_{FoV}}{2} + \theta_0 - \theta_{tilt}\right)} z_{eye} \text{ (III)}$$

wherein the field-of-view extent, θ_{FoV}, is the axis of the FoV in the direction of the effective out-coupler grating vector, which can be tilted by an amount (θ_0), (θ_{tilt}) is the tilt of the waveguide combiner relative to a plane defined by the eyebox plane, and the waveguide combiner is positioned a first distance z_{eye} from the eyebox plane.

4. The method of claim 3, wherein maximum angles (θ_{outmax}) from the boundaries of the out-coupler grating to the user's eye are determined using equation (IV), equation (V), and equation (VI).

$$\theta_{out_{up}} < \text{atan}\left(\frac{\frac{L_{Eyebox}}{2}+L_{OC_{top}}\cos(\theta_{tilt})}{z_{eye}+L_{OC_{top}}\sin(\theta_{tilt})}\right) \text{(IV)}$$

$$\theta_{out_{down}} < \text{atan}\left(\frac{\frac{L_{Eyebox}}{2}+L_{OC_{bottom}}\cos(\theta_{tilt})}{z_{eye}-L_{OC_{bottom}}\sin(\theta_{tilt})}\right) \text{(V)}$$

$$\theta_{outmax} = \theta_{out_{up}} + \theta_{out_{down}} \quad \text{(VI)}.$$

5. The method of claim 4, wherein the out-coupler grating has a maximum period satisfying the following equation (VII):

$$\Lambda_{OC} < \frac{\lambda_0}{1+\sin(\theta_{outmax})} \text{(VII)}$$

where λ_0 is the shortest wavelength of "rainbow" artifact considered.

6. The method of claim 5, wherein λ_0 is 450 nm.

7. The method of claim 5, wherein the waveguide combiner has a minimum refractive index (n) satisfying the following equation (VIII):

$$n > \sin\left(\frac{\theta_{FoV}}{2} - \theta_0 + \theta_{tilt}\right) + \frac{\lambda_R}{\Lambda_{OC}} \text{(VIII)}$$

where λ_R is the wavelength of the red display channel.

8. The method of claim 7, wherein λ_R is 620 nm.

9. A waveguide display, comprising:

the waveguide display configured to direct image light to an eyebox plane having a length (L_{Eyebox}) and to a user's eye, the waveguide display, comprising:

a waveguide combiner, and

an out-coupler grating, wherein the out-coupler grating has a grating period Λ_{OC} such that all angles of incidence θ_{in} of light from an external light source, result in diffracted angles θ_{out}, that miss the user's eye.

10. The waveguide display of claim 9, wherein the grating period Λ_{OC} satisfies the following first order diffraction equation (I):

$$\sin(\theta_{out}) = \sin(\theta_{in}) +/- \frac{\lambda}{\Lambda_{OC}} \text{ (I)}$$

wherein λ is the wavelength of the light from the external light source.

11. The waveguide display of claim 10, wherein the out-coupler grating has a length (LOC) which is the sum of a length of the top half of the out-coupler grating ($L_{OC_{top}}$) and a length of the bottom half of the out-coupler grating ($L_{OC_{bottom}}$), and

wherein $L_{OC_{top}}$ is determined using the following equation (II):

$$L_{OC_{top}} = \frac{L_{Eyebox}}{2\cos(\theta_{tilt})} + \frac{\sin\left(\frac{\theta_{FoV}}{2} - \theta_0\right)}{\cos\left(\frac{\theta_{FoV}}{2} - \theta_0 + \theta_{tilt}\right)} z_{eye} \text{ (II)}$$

and $L_{OC_{bottom}}$ is determined using the following equation (III):

$$L_{OC_{bottom}} = \frac{L_{Eyebox}}{2\cos(\theta_{tilt})} + \frac{\sin\left(\frac{\theta_{FoV}}{2} + \theta_0\right)}{\cos\left(\frac{\theta_{FoV}}{2} + \theta_0 - \theta_{tilt}\right)} z_{eye} \text{ (III)}$$

wherein the field-of-view extent, θ_{FoV}, is the axis of the FoV in the direction of the effective out-coupler grating vector, which can be tilted by an amount (θ_0), (θ_{tilt}) is the tilt of the waveguide combiner relative to a plane defined by the eyebox plane, and the waveguide combiner is positioned a first distance z_{eye} from the eyebox plane.

12. The waveguide display of claim 11, wherein maximum angles (θ_{outmax}) from the boundaries of the out-coupler grating to the user's eye are determined using equation (IV), equation (V), and equation (VI).

$$\theta_{out_{up}} < \text{atan}\left(\frac{\frac{L_{Eyebox}}{2}+L_{OC_{top}}\cos(\theta_{tilt})}{z_{eye}+L_{OC_{top}}\sin(\theta_{tilt})}\right) \text{(IV)}$$

$$\theta_{out_{down}} < \text{atan}\left(\frac{\frac{L_{Eyebox}}{2}+L_{OC_{bottom}}\cos(\theta_{tilt})}{z_{eye}-L_{OC_{bottom}}\sin(\theta_{tilt})}\right) \text{(V)}$$

$$\theta_{outmax} = \theta_{out_{up}} + \theta_{out_{down}} \quad \text{(VI)}.$$

13. The waveguide display of claim 12, wherein the out-coupler grating has a maximum period satisfying the following equation (VII):

$$\Lambda_{OC} < \frac{\lambda_0}{1+\sin(\theta_{outmax})} \text{(VII)}$$

where λ_0 is the shortest wavelength of "rainbow" artifact considered.

14. The waveguide display of claim 13, wherein λ_0 is 450 nm.

15. The waveguide display of claim 13, wherein the waveguide combiner has a minimum refractive index (n) satisfying the following equation (VIII):

$$n > \sin\left(\frac{\theta_{FoV}}{2} - \theta_0 + \theta_{tilt}\right) + \frac{\lambda_R}{\Lambda_{OC}} \text{(VIII)}$$

where λ_R is the wavelength of the red display channel.

16. The waveguide display of claim 15, wherein λ_R is 620 nm.

17. A near-eye display, comprising:

a frame; and

a display coupled with the frame, comprising:

a waveguide display configured to direct image light to an eyebox plane having a length (L_{Eyebox}) and to a user's eye, the waveguide display, comprising:

a waveguide combiner, and

an out-coupler grating, wherein the out-coupler grating has a grating period Λ_{OC} such that all angles of incidence θ_{in} of light from an external light source, result in diffracted angles θ_{out}, that miss the user's eye.

18. The near-eye display of claim 17, wherein the grating period Λ_{OC} satisfies the following first order diffraction equation (I):

$$\sin(\theta_{out}) = \sin(\theta_{in}) +/- \frac{\lambda}{\Lambda_{OC}} \text{ (I)}$$

wherein λ is the wavelength of the light from the external light source.

19. The near-eye display of claim 18, wherein the out-coupler grating has a length (LOC) which is the sum of a length of the top half of the out-coupler grating ($L_{OC_{top}}$) and a length of the bottom half of the out-coupler grating ($L_{OC_{bottom}}$) and wherein $L_{OC_{top}}$ is determined using the following equation (II):

$$L_{OC_{top}} = \frac{L_{Eyebox}}{2\cos(\theta_{tilt})} + \frac{\sin\left(\frac{\theta_{FoV}}{2} - \theta_0\right)}{\cos\left(\frac{\theta_{FoV}}{2} - \theta_0 + \theta_{tilt}\right)} z_{eye} \text{ (II)}$$

and $L_{OC_{bottom}}$ is determined using the following equation (III):

$$L_{OC_{bottom}} = \frac{L_{Eyebox}}{2\cos(\theta_{tilt})} + \frac{\sin\left(\frac{\theta_{FoV}}{2} + \theta_0\right)}{\cos\left(\frac{\theta_{FoV}}{2} + \theta_0 - \theta_{tilt}\right)} z_{eye} \text{ (III)}$$

wherein the field-of-view extent, θ_{FoV}, is the axis of the FoV in the direction of the effective out-coupler grating vector, which can be tilted by an amount (θ_0), (θ_{tilt}) is the tilt of the waveguide combiner relative to a plane defined by the eyebox plane, and the waveguide combiner is positioned a first distance z_{eye} from the eyebox plane.

20. The near-eye display of claim 19,

wherein maximum angles (θ_{outmax}) from the boundaries of the out-coupler grating to the user's eye are determined using equation (IV), equation (V), and equation (VI).

$$\theta_{out_{up}} < \text{atan}\left(\frac{\frac{L_{Eyebox}}{2}+L_{OC_{top}}\cos(\theta_{tilt})}{z_{eye}+L_{OC_{top}}\sin(\theta_{tilt})}\right) \text{(IV)}$$

$$\theta_{out_{down}} < \text{atan}\left(\frac{\frac{L_{Eyebox}}{2}+L_{OC_{bottom}}\cos(\theta_{tilt})}{z_{eye}-L_{OC_{bottom}}\sin(\theta_{tilt})}\right) \text{(V)}$$

$$\theta_{outmax} = \theta_{out_{up}} + \theta_{out_{down}} \quad \text{(VI);}$$

wherein the out-coupler grating has a maximum period satisfying the following equation (VII):

$$\Lambda_{OC} < \frac{\lambda_0}{1+\sin(\theta_{outmax})} \text{(VII)}$$

where λ_0 is the shortest wavelength of "rainbow" artifact considered;

wherein λ_0 is 450 nm;

wherein the waveguide combiner has a minimum refractive index (n) satisfying the following equation (VIII):

$$n > \sin\left(\frac{\theta_{FoV}}{2} - \theta_0 + \theta_{tilt}\right) + \frac{\lambda_R}{\Lambda_{OC}} \text{(VIII)}$$

where λ_R is the wavelength of the red display channel; and

wherein λ_R is 620 nm.