Claims

1. A waveguide combiner, comprising:

a first surface;

a second surface;

an in-coupler located on the first surface and configured to receive a plurality of input beams and diffract a first subset of beams and a second subset of beams into total-internal-reflection (TIR) in two opposite directions in K-Space;

a first fold grating located on the first surface and configured to receive the first subset of beams from the in-coupler at a first region in K-Space and diffract the first subset of beams in TIR to a second region in K-Space;

a second fold grating located on the first surface and configured to receive the second subset of beams from the in-coupler at a third region in K-Space and diffract the second subset of beams in TIR to the second region in K-Space; and

a first out-coupler located on the first surface.

2. The waveguide combiner of claim 1, wherein the first out-coupler is configured to receive the first subset of beams from the first fold grating and the second subset of beams from the second fold grating at the second region in K-Space, diffract a first portion of the first subset of beams and of the second subset of beams to a fourth region in K-Space, and out-couple a second portion of the first subset of beams and of the second subset of beams.

3. The waveguide combiner of claim 2, wherein the first out-coupler is a two-dimensional out-coupler.

4. The waveguide combiner of claim 2, further comprising a second out-coupler located on the second surface and configured to receive the first subset of beams from the first fold grating and the second subset of beams from the second fold grating at the second region in K-Space, diffract the second portion of the first subset of beams and the second subset of beams to a fifth region in K-Space, and out-couple the first portion of the first subset of beams and the second subset of beams.

5. The waveguide combiner of claim 4, further comprising a third fold grating located on the second surface.

6. The waveguide combiner of claim 5, further comprising a fourth fold grating located on the second surface.

7. The waveguide combiner of claim 6, wherein the fourth fold grating is located adjacent to the third fold grating and both the third fold grating and the fourth fold grating are located adjacent to the second out-coupler.

8. A waveguide combiner, comprising:

a first surface;

a second surface;

an in-coupler located on the first surface and configured to receive a plurality of input beams and diffract the plurality of input beams into total-internal-reflection (TIR);

a first replicator grating located adjacent to and below the in-coupler on the first surface and configured to receive the plurality of input beams from the in-coupler at a first region in K-Space and diffract the plurality of input beams in TIR to a second region in K-Space;

a second replicator grating located adjacent to and below the first replicator grating on the first surface;

a first out-coupler located adjacent to or below the second replicator grating on the first surface; and

a second out-coupler located on the second surface.

9. The waveguide combiner of claim 8, wherein the first replicator grating and the second replicator grating are square or rectangular shaped.

10. The waveguide combiner of claim 8, wherein the first out-coupler or the second out-coupler is a two-dimensional out-coupler.

11. The waveguide combiner of claim 8, further comprising a third replicator grating located on the second surface.

12. The waveguide combiner of claim 11, further comprising a fourth replicator grating located on the second surface.

13. The waveguide combiner of claim 1, wherein:

light in-coupled by the in-coupler is diffracted as beams along a first path to the first region corresponding to directions of light which will propagate to the first fold grating and a second path to the second region corresponding to directions of light which will propagate to the second fold grating;.

the beams incident on the first fold grating are diffracted along a third path to a region corresponding to directions of light which will propagate the first out-coupler and a second out-coupler on the second surface;

the beams incident on the second fold grating are diffracted along a fourth path to the region corresponding to directions of light which will propagate to the first out-coupler and the second out-coupler;

the beams incident to the first out-coupler are diffracted by the first out-coupler along a fifth path to a region corresponding to directions of light which will propagate to the second out-coupler, the second out-coupler then out-couples the light along a path to a user eyebox; and

the beams on the incident to the second out-coupler are diffracted by the second out-coupler along a path to a region corresponding to directions of light which will propagate to the first out-coupler, the first out-coupler then out-couples the light along a path to the user eyebox.

14. The waveguide combiner of claim 8, wherein:

light in-coupled by the in-coupler is diffracted as beams along a path to a first region;

beams incident on the first replicator grating are diffracted along a path to a region corresponding to directions of light which will propagate to the first replicator grating where the beams re-encounter the first replicator grating and are diffracted back to the first region;

the beams diffracted back to the first region encounter the second replicator grating and are diffracted along a path to a region corresponding to directions of light which will propagate to the second replicator grating where the beams are diffracted back to the first region;

the beams diffracted back to the first region by the second replicator grating that are incident to the first out-coupler are diffracted by the first out-coupler along a path to region corresponding to directions of light which will propagate to the second out-coupler, the second out-coupler then out-couples the light along a path to a user eyebox; and

the beams diffracted back to the first region by the second replicator grating that are incident to the second out-coupler are diffracted by the second out-coupler along a path to region corresponding to directions of light which will propagate to the first out-coupler, the first out-coupler then out-couples the light along a path to the user eyebox.