[0009] According to a first aspect of the present disclosure, there is provided an optical system for performing distance measurements including a bulk transmitter optic, an illumination source, and a micro-optic channel array disposed between the illumination source and the bulk transmitter optic. The illumination source includes a plurality of light emitters aligned to project discrete beams of light through the bulk transmitter optic into a field ahead of the optical system. The micro-optic channel array defines a plurality of micro-optic channels having a one-to-one relationship with light emitters in the plurality of light emitters where each micro-optic channel includes a micro-optic lens unique to that channel and spaced apart from a corresponding light emitter from the plurality of light emitters with the micro-optic lens being configured to receive a light cone from the corresponding light emitter and generate a reduced-size spot image of the corresponding emitter at a focal point displaced from the corresponding emitter at a location between the corresponding emitter and the bulk transmitter optic. The micro-optic lens for each channel can be configured to receive a light cone from a light emitter and generate a reduced-size real spot image of the emitter at a focal point between the micro-optic lens and the bulk transmitter optic. A divergence of the light cone from the light emitter can be less than a divergence of a light cone from the second optical surface of the micro-optic lens for generating the reduced-size real spot image

[0010] According to a second aspect of the present disclosure, there is provided an optical system for performing distance measurements including a light emission system and a light detection system. The light emission system includes a bulk transmitter optic, an illumination source comprising a plurality of light emitters aligned to project discrete beams of light through the bulk transmitter optic into a field ahead of the optical system, and a micro-optic channel array disposed between the illumination source and the bulk transmitter optic. The micro-optic channel array defines a plurality of micro-optic channels where each micro-optic channel includes a micro-optic lens spaced apart from a light emitter from the plurality of light emitters with the micro-optic lens being configured to receive a light cone from the light emitter and generate a reduced-size spot image of the emitter at a focal point displaced from the emitter at a location between the emitter and the bulk transmitter optic. The light detection system includes a bulk receiver optic configured to receive the discrete beams of light from the field, and an optical assembly having a plurality of micro-optic receiver channels defining a plurality of discrete, non-overlapping fields of view in the field. The optical assembly includes: an aperture layer having a plurality of discrete apertures arranged along a focal plane of the bulk receiver optic; an array of photosensors

disposed behind the aperture layer; and a plurality of lenses positioned between the aperture layer and the array of photosensors.

[0011] According to a third aspect of the present disclosure, there is provided an optical system for performing distance measurements including a stationary housing having an optically transparent window, and a light ranging device disposed within the housing. The light ranging device includes an optical transmitter coupled to a platform. The optical transmitter includes a bulk transmitter optic, an illumination source, and a micro-optic channel array disposed between the illumination source and the bulk transmitter optic. The illumination source including a plurality of light emitters aligned to project discrete beams of light through the bulk transmitter optic into a field ahead of the optical system. The micro-optic channel array can be disposed between the illumination source and the bulk transmitter optic, and the micro-optic channel array can define a plurality of micro-optic channels having a one-to-one relationship with light emitters in the plurality of light emitters where each micro-optic channel can include a micro-optic lens unique to that channel and spaced apart from a corresponding light emitter from the plurality of light emitters with the micro-optic lens being configured to receive a light cone from the corresponding light emitter and generate a reduced-size spot image of the corresponding emitter at a focal point displaced from the corresponding emitter at a location between the corresponding emitter and the bulk transmitter optic.

[0012] Disclosed herein is an optical system including a bulk receiver optic configured to receive light rays originating from a field external to the optical system, and an optical assembly having a plurality of micro-optic receiver channels defining a plurality of discrete, non-overlapping fields of view in the field. The optical assembly includes an aperture layer having a plurality of discrete apertures arranged along a focal plane of the bulk receiver optic, an array of photosensors disposed behind the aperture layer, and a non-uniform optical filter layer configured to allow different micro-optic channels to measure different ranges of wavelengths. The non-uniform optical filter can include a graduated optical filter that gradually increases in thickness in one dimension, or increases in thickness in a step-wise fashion in one direction such that each channel has a constant optical filter layer thickness, but where the thicknesses for different micro-optic channels are different.

[0013] Disclosed herein is an optical system including a bulk receiver optic configured to receive light from a field external to the optical system, an aperture layer disposed behind the bulk optic and including a plurality of apertures located at a focal plane of the bulk optic, a lens layer

CLAIMS

1. An optical system for performing distance measurements, the optical system comprising:

a bulk transmitter optic;

an illumination source comprising a plurality of light emitters aligned to project discrete beams of light through the bulk transmitter optic into a field ahead of the optical system; and

a micro-optic channel array disposed between the illumination source and the bulk transmitter optic, the micro-optic channel array defining a plurality of micro-optic channels having a one-to-one relationship with light emitters in the plurality of light emitters, each micro-optic channel including a micro-optic lens unique to that channel and spaced apart from a corresponding light emitter from the plurality of light emitters with the micro-optic lens being configured to receive a light cone from the corresponding light emitter and generate a reduced-size spot image of the corresponding emitter at a focal point displaced from the corresponding emitter at a location between the corresponding emitter and the bulk transmitter optic.

2. The optical system for performing distance measurements set forth in claim 1 wherein the bulk transmitter optic comprises one or more lenses configured as an image space telecentric lens in which the discrete beams of light output from the illumination source through the micro-optic channel array are parallel to each other.

3. The optical system for performing distance measurements set forth in claim 2 further comprising a light sensing module configured to detect photons emitted from the illumination source and reflected from surfaces within the field.

4. The optical system for performing distance measurements set forth in claim 3 wherein the light sensing module comprises:

a bulk receiver optic;

an aperture layer including a plurality of apertures;

a lens layer including a plurality of lenses; and

a photosensor layer including a plurality of photosensors, wherein the aperture layer, lens layer, and photosensor layer are arranged to form a plurality of receiver channels with

each receiver channel in the plurality of receiver channels including an aperture from the plurality of apertures, a lens from the plurality of lenses and a photosensor from the plurality of photosensors and being configured to communicate light incident from the bulk receiving optic to the photosensor of the receiver channel.

5. The optical system for performing distance measurements set forth in claim 4 wherein the illumination source is configured to selectively project the discrete beams of light through the bulk transmitter optic according to an illumination pattern that matches, in size and geometry across a range of distances from the system, the fields of view of the receiver channels.

6. The optical system for performing distance measurements set forth in claim 1 wherein the micro-optic lens for each channel is configured to receive a light cone from a light emitter and generate a reduced-size real spot image of the emitter at a focal point between the micro-optic lens and the bulk transmitter optic.

7. The optical system for performing distance measurements set forth in claim 6 wherein the micro-optic lens for each channel includes a first optical surface with an optical power on a side facing the light emitter and a second optical surface with an optical power on an opposing side facing away from the light emitter and wherein the reduced-size real spot image of the emitter is formed at a focal point after the first and second optical surfaces.

8. The optical system for performing distance measurements set forth in claim 7, wherein a divergence of the light cone from the light emitter is less than a divergence of a light cone from the second optical surface of the micro-optic lens for generating the reduced-size real spot image.

9. The optical system for performing distance measurements set forth in claim 7, wherein the micro-optic lens is separated from the illumination source to define an open space between the micro-optic lens and the illumination source.

10. The optical system for performing distance measurements set forth in claim 6 wherein the micro-optic lens for each channel includes an optical surface with an optical

power on a side facing away from the light emitter and wherein the reduced-size real spot image of the emitter is formed at a focal point after the optical surface.

11. The optical system for performing distance measurements set forth in claim 6 wherein the optical surface includes a plurality of convex lenses positioned on a substrate, the substrate having a first surface upon which the optical surface is disposed and a second surface opposite of the first surface that is directly attached to a surface of the illumination source.

12. The optical system for performing distance measurements set forth in claim 1 wherein the micro-optic lens for each channel is configured to receive a light cone from a light emitter and generate a reduced-size virtual spot image of the emitter.

13. The optical system for performing distance measurements set forth in claim 12 wherein the micro-optic lens for each channel includes an optical surface with an optical power on a side facing away from the light emitter and wherein the reduced-size virtual spot image of the emitter is formed at a focal point within the respective channel.

14. The optical system for performing distance measurements set forth in claim 13 wherein the optical surface includes a plurality of concave surfaces formed on substrate, the substrate having a first surface upon which the optical surface is disposed and a second surface opposite of the first surface that is directly attached to a surface of the illumination source

15. The optical system for performing distance measurements set forth in claim 1 wherein the bulk transmitter optic comprises multiple aperture stops configured to reduce stray light emitted by the optical system.

16. An optical system for performing distance measurements, the optical system comprising:

a light emission system comprising:

a bulk transmitter optic;

an illumination source comprising a plurality of light emitters aligned to project discrete beams of light through the bulk transmitter optic into a field ahead of the optical system; and

a micro-optic channel array disposed between the illumination source and the bulk transmitter optic, the micro-optic channel array defining a plurality of micro-optic channels, each micro-optic channel including a micro-optic lens spaced apart from a light emitter from the plurality of light emitters with the micro-optic lens being configured to receive a light cone from the light emitter and generate a reduced-size spot image of the emitter at a focal point displaced from the emitter at a location between the emitter and the bulk transmitter optic; and

a light detection system comprising:

a bulk receiver optic configured to receive the discrete beams of light from the field; and

an optical assembly having a plurality of micro-optic receiver channels defining a plurality of discrete, non-overlapping fields of view in the field, the optical assembly comprising:

an aperture layer having a plurality of discrete apertures arranged along a focal plane of the bulk receiver optic;

an array of photosensors disposed behind the aperture layer; and

a plurality of lenses positioned between the aperture layer and the array of photosensors.

17. The optical system for performing distance measurements set forth in claim 16 wherein the bulk transmitter optic comprises one or more lenses configured as image space telecentric lens in which the discrete beams of light output from the illumination source through the micro-optic channel array are parallel to each other

18. An optical system for performing distance measurements, the optical system comprising:

a stationary housing having an optically transparent window; and

a light ranging device disposed within the housing, the light ranging device comprising an optical transmitter coupled to a platform, the optical transmitter comprising:

a bulk transmitter optic;

an illumination source comprising a plurality of light emitters aligned to project discrete beams of light through the bulk transmitter optic into a field ahead of the optical system; and

a micro-optic channel array disposed between the illumination source and the bulk transmitter optic, the micro-optic channel array defining a plurality of micro-optic channels having a one-to-one relationship with light emitters in the plurality of light emitters, each micro-optic channel including a micro-optic lens unique to that channel and spaced apart from a corresponding light emitter from the plurality of light emitters with the micro-optic lens being configured to receive a light cone from the corresponding light emitter and generate a reduced-size spot image of the corresponding emitter at a focal point displaced from the corresponding emitter at a location between the corresponding emitter and the bulk transmitter optic.

19. The optical system for performing distance measurements set forth in claim 18 wherein the light ranging device is a spinning light ranging device further comprising:

a motor disposed within the housing and operatively coupled to spin the light ranging device including the platform and optical transmitter within the housing;

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

20. The optical system for performing distance measurements set forth in claim 18 wherein the bulk transmitter optic comprises one or more lenses configured as image space telecentric lens in which the discrete beams of light output from the illumination source through the micro-optic channel array are parallel to each other.