CLAIMS

What is claimed is:

1. An apparatus, comprising:

a flow cell to receive a sample;

a system, comprising:

a flow cell receptacle to receive the flow cell; and

an imaging system including:

a light source assembly to form a substantially collimated beam;

an optical assembly including an asymmetric beam expander group that includes one or more asymmetric elements or anamorphic elements disposed along an optical axis, the optical assembly to receive the substantially collimated beam from the light source assembly, and transform the substantially collimated beam into a shaped sampling beam having an elongated cross section in a far field at or near a focal plane of the optical assembly to optically probe the sample in the flow cell; and

an imaging device to obtain image data associated with the sample in response to the optical probing of the sample with the shaped sampling beam.

2. The apparatus of claim 1, wherein the substantially collimated beam has a first aspect ratio and the shaped sampling beam has a second aspect ratio, wherein the first aspect of the substantially collimated beam is at most 4:1, and the second aspect ratio of the shaped sampling beam is at least 8:1.

3. The apparatus of any one of the preceding claims, wherein the asymmetric beam expander group is to provide a first magnification in a first axis, and a second different magnification in a second different axis, wherein the first magnification is at least twice the second magnification.

4. The apparatus of any one of the preceding claims, wherein the optical assembly comprises:

the asymmetric beam expander group to asymmetrically or anamorphically expand the substantially collimated beam having a first aspect ratio to form a shaped beam having a second different aspect ratio; and

an objective group disposed along the optical axis to receive the shaped beam from the

asymmetric beam expander group, and transform the shaped beam into the shaped sampling beam at or near the focal plane of the optical assembly.

5. The apparatus of any one of the above claims, wherein the light source assembly includes:

a beam source to provide input radiation, and

a collimator to substantially collimate the input radiation to form the substantially collimated beam having a first aspect ratio.

6. The apparatus of claim 5, wherein the collimator includes a waveguide having the first aspect ratio, wherein the waveguide comprises at least one of a rectangular optical fiber, or a light pipe having the first aspect ratio, and wherein the collimator includes at least of a spherical lens or an aspherical lens disposed to collimate an output of the optical fiber.

7. The apparatus of any one of the preceding claims, wherein the optical assembly comprises:

a beam shaping group having one or more optical elements disposed along the optical axis to receive the substantially collimated beam from the collimator, and transform the substantially collimated beam into a first shaped beam having a first aspect ratio;

the asymmetric beam expander group is to asymmetrically or anamorphically expand the first shaped beam having the first aspect ratio to form a second shaped beam having a second different aspect ratio; and

an objective group disposed along the optical axis to receive the second shaped beam from the asymmetric beam expander group, and transform the second shaped beam into the shaped sampling beam at or near the focal plane of the optical assembly.

8. The apparatus of any one of the preceding claims, wherein the imaging device includes a time domain integration (TDI) image sensor having an aspect ratio corresponding to an aspect ratio of the sampling beam.

9. The apparatus of any one of the preceding claims, wherein the asymmetric beam expander group includes one or more pairs of crossed cylindrical lenses disposed along the optical axis, wherein each pair of the one or more pairs of crossed cylindrical lenses includes two cylindrical lenses with different powers and oriented on different axes.

10. The apparatus of any one of claims 1 - 8, wherein the asymmetric beam expander group includes a cylindrical telescope disposed along the optical axis.

11. The apparatus of claim 10, wherein the cylindrical telescope includes a singlet lens or an afocal doublet lens that is achromatic.

12. The apparatus of any one of claims 10 – 11, wherein the asymmetric beam expander group includes a second cylindrical telescope, wherein the cylindrical telescope and the second cylindrical telescope magnify by different amounts in different axes.

13. The apparatus of claim 12, wherein the cylindrical telescope and the second cylindrical telescope are at least one of in series, nested, or interleaved.

14. The apparatus of any one of claims 1 - 8, wherein the asymmetric beam expander group includes one or more anamorphic prisms disposed along the optical axis such that magnification is provided in substantially one axis.

15. The apparatus of claim 14, wherein the anamorphic prisms comprise a first prism comprising a first glass type and a second prism comprising a second glass type.

16. An apparatus, comprising:

a system, comprising:

a flow cell receptacle to receive a flow cell that receives a sample; and

an imaging system including:

a light source assembly to form a substantially collimated beam;

an optical assembly including an asymmetric beam expander group that includes one or more asymmetric elements or anamorphic elements disposed along an optical axis, the optical assembly to receive the substantially collimated beam from the light source assembly, and transform the substantially collimated beam into a shaped sampling beam having an elongated cross section in a far field at or near a focal plane of the optical assembly to optically probe the sample in the flow cell; and

an imaging device to obtain image data associated with the sample in response to the optical probing of the sample with the sampling beam.

17. The apparatus of 16, wherein the asymmetric beam expander group includes one or more diffractive elements disposed along the optical axis, wherein the one or more diffractive elements comprise at least one of a refractive homogenizer, a refractive diffuser, or a cylindrical microlens array.

18. The apparatus of any one of claims 16 - 17, wherein the asymmetric beam expander group includes a lens disposed along the optical axis, the imaging system to move the

lens along the optical axis to switch the asymmetric beam expander group between a high irradiance mode and a low irradiance mode.

19. The apparatus of any one of claims 16 - 17, wherein the imaging system further includes an actuator and a reflective element, the actuator to position the reflective element to sweep the shaped sampling beam across the flow cell within an exposure time.

20. The apparatus of claim 19, wherein the asymmetric beam expander group further includes at least one of a crossed pair of cylindrical lens, a cylindrical telescope, an anamorphic prism, or a diffractive element to provide anamorphically expansion along a first axis, and wherein the actuator is to position the reflective element to sweep the shaped sampling beam along a second, different axis.

21. The apparatus of any one claims 19 – 20, wherein the actuator is to position the reflective element within a range to sweep the shaped sampling beam across the flow cell.

22. A method, comprising:

generating a collimated beam using a light source assembly;

transforming the collimated beam into a shaped sampling beam having an elongated cross section in a far field at a focal plane of an optical assembly using the optical assembly, wherein the optical assembly has an asymmetric beam expander group that includes one or more asymmetric elements or anamorphic elements disposed along an optical axis; and

optically probing a sample with the shaped sampling beam.

23. The method of claim 22, wherein generating the collimated beam comprises passing an input beam through a waveguide, wherein the waveguide comprises at least one of a rectangular optical fiber or a light pipe.

24. The method of any one of claims 22 – 23, wherein transforming the collimated beam into the shaped sampling beam includes asymmetrically or anamorphically expanding the substantially collimated beam having a first aspect ratio using the asymmetric beam expander group to form a shaped beam having a second aspect ratio.

25. The method of any one of claim 24, wherein transforming the collimated beam into the shaped sampling beam includes transforming the shaped beam into the shaped sampling beam at or near the focal plane of the optical assembly using an objective group disposed along the optical axis.

26. The method of any one of claims 24 – 25, wherein asymmetrically or anamorphically expanding the substantially collimated beam includes passing the substantially collimated beam through at least one of: 1) one or more pairs of crossed cylindrical lenses; 2) one or more cylindrical telescopes; 3) one or more anamorphic prisms; or 4) one or more diffractive elements.

27. The method of any one of claims 24 – 25, wherein asymmetrically or anamorphically expanding the substantially collimated beam includes moving a lens of the asymmetric beam expander group along the optical axis to switch the asymmetric beam expander group between a high irradiance mode and a low irradiance mode.

28. The method of any one of claims 24 – 27, further comprising sweeping the shaped sampling beam across the sample.