Systems and Methods for Assessing Biological Samples

Background of the Invention

Field of the Invention

The present invention relates generally to systems, devices, and methods for observing, testing, and/or analyzing one or more biological samples, and more specifically to systems, devices, and methods comprising an optical system for observing, testing, and/or analyzing one or more biological samples.

Description of the Related Art

Summary

According to an aspect of the present disclosure, there is provided an instrument for biological analysis, comprising:

an excitation source configured to produce at least one excitation beam;

an optical sensor configured to receive emissions from one or more biological samples in response to the excitation source;

an excitation optical system disposed along an excitation optical path;

an emission optical system disposed along an emission optical path;

a sensor lens configured to direct emissions from at least some of the one or more biological samples onto the optical sensor;

an illuminated surface disposed along the excitation optical path, the illuminated surface configured to produce reflected radiation comprising radiation from the excitation source that is reflected by the illuminated surface;

a radiation shield, and

a power detection unit comprising a power sensor optically coupled to one end of a light pipe, wherein an opposite end of the light pipe is configured to be illuminated by the at least one excitation beam, and wherein the power sensor is located outside of the excitation optical path,

wherein the radiation shield comprises a sensor aperture disposed along the emission optical path and a blocking structure configured to cooperate with the sensor aperture such that none of the reflected radiation is received by the optical sensor that does not also reflect off another surface of the instrument.

Brief Description of the Drawings

Embodiments of the present invention may be better understood from the following detailed description when read in conjunction with the accompanying drawings. Such

embodiments, which are for illustrative purposes only, depict novel and non-obvious aspects of the invention. The drawings include the following figures:

FIG. 1 is a schematic representation of a system according to an embodiment of the present invention.

FIG. 2 is a schematic representation of an excitation source according to an embodiment of the present invention.

FIG. 3 is a normalized spectrum plot of various light sources, including a light source according to an embodiment of the present invention.

FIG. 4 is plot of spectral integration over various wavelength ranges for the light source spectrums shown in FIG. 3

FIGS. 5 and 6 are perspective views of an instrument housing according to an embodiment of the present invention.

FIG. 7 is a solid model representation of an optical and sample processing system according to an embodiment of the present invention.

FIG. 8 is a magnified, solid model representation of the optical system shown in FIG. 7.

FIG. 9 is an exploded view of a portion of the sample processing system shown in FIG. 7.

CLAIMS

1. An instrument for biological analysis, comprising:

an excitation source configured to produce at least one excitation beam;

an optical sensor configured to receive emissions from one or more biological samples in response to the excitation source;

an excitation optical system disposed along an excitation optical path;

an emission optical system disposed along an emission optical path;

a sensor lens configured to direct emissions from at least some of the one or more biological samples onto the optical sensor;

an illuminated surface disposed along the excitation optical path, the illuminated surface configured to produce reflected radiation comprising radiation from the excitation source that is reflected by the illuminated surface;

a radiation shield; and

a power detection unit comprising a power sensor optically coupled to one end of a light pipe, wherein an opposite end of the light pipe is configured to be illuminated by the at least one excitation beam, and wherein the power sensor is located outside of the excitation optical path,

wherein: the radiation shield comprises a sensor aperture disposed along the emission optical path and a blocking structure configured to cooperate with the sensor aperture such that none of the reflected radiation is received by the optical sensor that does not also reflect off another surface of the instrument.

2. The instrument according to claim 1, further comprising a beamsplitter disposed along both the excitation optical path and along the emission optical path.

3. The instrument according to claim 2, further comprising:

a base configured to receive a sample holder comprising a plurality of spatially separated reaction regions for processing the one or more biological samples,

wherein:

the excitation optical path is between the excitation source and the sample holder;

the emission optical path is between the sample holder and the optical sensor;

the emission optical system is configured to direct the emissions from the biological samples to the optical sensor;

the illuminated surface is disposed along the excitation optical path between the beamsplitter and the base; and

the sensor aperture is disposed between the beamsplitter and the sensor lens.

4. The instrument according to claim 3, wherein the base comprises a thermal controller.

5. The instrument according to claim 4, wherein

the thermal controller is configured to control a temperature of at least one of

the base,

the sample holder, or

the separated biological samples, or

the thermal controller comprises a thermal cycler configured to perform a PCR assay.

6. The instrument according to any one of claims 3 to 5, further comprising a heated cover disposed adjacent the base, the heated cover including a plurality of apertures configured to correspond to the plurality of reaction regions.

7. The instrument according to any one of claims 3 to 6, wherein:

the excitation optical system comprises a sample lens configured to direct the at least one excitation beam toward the base;

the sample lens comprises a field lens configured to extend over the plurality of spatially separated regions; and

the sample lens provides a telecentric optical system for a least one of

the sample holder,

the spatially separated reaction regions, or

the optical sensor.

8. The instrument according to any one of claims 2 to 7, wherein the beamsplitter is characterized by a reflectance that is constant over a wavelength band from 450 nanometers to 680 nanometers.

9. The instrument according to any preceding claim, wherein the blocking structure is configured to cooperate with the sensor aperture such that none of the reflected radiation impinges on the sensor lens that does not also reflect off another surface of the instrument.

10. The instrument according to any preceding claim, wherein the excitation source is configured to provide a plurality of excitation beams to illuminate the biological samples, at least

some of the emissions optionally comprising a fluorescent emission from at least some of the biological samples in response to at least one of plurality of the excitation beams.

11. The instrument according to claim 10, wherein the excitation source is configured to produce a first excitation beam characterized by a first wavelength and a second excitation beam characterized by a second wavelength that is different from the first wavelength.

12. The instrument according to claim 11, wherein the first excitation beam and the second excitation beam are temporally separated and/or spatially separated.

13. The instrument according to claim 9, 10 or 11, wherein the plurality of excitation beams comprises a first excitation beam that comprises a first wavelength range over which an intensity, power, or energy of the first excitation beam is above a first predetermined value, and a second excitation beam that comprises a second wavelength range over which an intensity, power, or energy of the second excitation beam is above a second predetermined value,

the first wavelength being at least one of

(1) a central wavelength of the first wavelength range or

(2) a wavelength of maximum electromagnetic intensity, power, or energy over the first wavelength range, and

the second wavelength being at least one of

(1) a central wavelength of the second wavelength range or

(2) a wavelength of maximum electromagnetic intensity, power, or energy over the second wavelength range.

14. The instrument according to any preceding claim, wherein the excitation source comprises a plurality of individual excitation sources, the plurality of individual excitation sources optionally forming a two-dimensional array of individual excitation sources.

15. The instrument according to any preceding claim, wherein the optical sensor comprises an array sensor, the array sensor optionally comprising at least one of a complementary metal-oxide-semiconductor sensor or a charge-coupled device sensor, the optical sensor optionally comprising at least two array sensors.