example, white light LEDs that provide significant output power across the visible spectrum. Broad spectrum or white light LEDs are also attractive in biological applications such as PCR, since they allow for a broad range of dyes or markers to be used in a single sample or instrument. However, high power LEDs can have large power and spectral variations from the nominal specification. Thus, various LEDs having the same part number or output specification may result in unacceptably large instrument to instrument variation, particularly would couple with other system tolerance variation (e.g., variations in filter and beamsplitter optical characteristics). Thus, there exists a need for better control and calibration systems, devices, and methods when attempting to incorporate high power, broad spectrum LED into biological instruments.

SUMMARY

An aspect of the present invention provides a method of performing an biological assay, comprising:

providing an instrument including an optical system including a light emitting diode, an optical sensor, a sample processing system configured to retain a sample holder comprising one or more sample cells, and a calibration target is disposed within the instrument;

measuring an output from the optical sensor over a first predetermined duty cycle of the light emitting diode;

performing at least one of an interpolation or extrapolation;

calculating a duty cycle to produce a predetermined nominal optical sensor output;

first adjusting the light emitting diode duty cycle to produce the calculated duty cycle;

measuring a fluorescence radiation from a sample based on the calculated duty cycle.

~~Another aspect of the present invention provides~~There is also disclosed a method of calibrating an instrument for performing an biological assay, comprising:

providing an instrument including:

a sample processing system configured to retain a sample holder comprising one or more sample cells;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an instrument optical sensor configured to receive emission beams from the one or more sample cells;

an emission optical system configured to direct one or more emission beams from the sample processing system to the optical sensor;

a first excitation filter having a transmission wavelength band including only wavelengths that are less than the minima wavelength, first excitation filter configured to filter electromagnetic radiation from the excitation source;

a second excitation filter having a transmission wavelength band including only wavelengths that are greater than the minima wavelength, second excitation filter configured to filter electromagnetic radiation from the excitation source; and

a third excitation filter having a transmission wavelength band including only wavelengths that are greater than the minima wavelength, third excitation filter configured to filter electromagnetic radiation from the excitation source.

providing a reference material configured to produce a fluorescent signal at the optical sensor in response to illumination by electromagnetic radiation from the excitation source;

filtering electromagnetic radiation from the excitation source using the second excitation filter to produce a filtered excitation beam;

illuminating the reference material with the filtered excitation beam to produce an emission beam;

detecting at least a portion of the emission beam using a calibration sensor; and

calibrating an optical output of the light source based on the at least a portion of the detected emission beam.

~~Another aspect of the present invention provides~~There is also disclosed an instrument for biological analysis, comprising:

a sample processing system configured to retain a sample holder comprising one or more sample cells;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an instrument optical sensor configured to receive emission beams from the one or more sample cells;

an emission optical system configured to direct one or more emission beams from the sample processing system to the optical sensor;

wherein the excitation source is characterized by a spectral function of output power or intensity of the excitation source verses wavelength of output power or intensity, the spectral function comprising:

a minima wavelength corresponding to a local minima value of the output power or intensity;

a first maxima wavelength corresponding to a first local maxima of output power or intensity, the output power or intensity at the first local maxima being greater than the output power or intensity at any wavelength less than the minima wavelength;

a second maxima wavelength corresponding to a second local maxima of output power or intensity, the output power or intensity at the second local maxima being greater than the output at any wavelength greater than the minima wavelength;

the minima wavelength has a value that is between the first maxima wavelength and the second maxima wavelength.

~~Another aspect of the present invention provides~~There is also disclosed an instrument for biological analysis, comprising:

a sample processing system configured to retain a first sample holder comprising a first plurality of sample cells and a second sample holder comprising a second plurality of sample cells, wherein at least one of (a) a number of the sample cells or (b) a characteristic dimension of the sample cells is different between the first sample holder and the second sample holder;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an optical sensor configured to receive emission beams from the first plurality of sample cells and configured to receive emission beams from the second plurality of sample cells;

an emission optical system configured to direct the emission beams to the optical sensor;

an excitation source temperature controller comprising a temperature sensor thermally coupled to the excitation source;

an electronic processor; and

a storage device including data comprising a first target temperature for the first sample holder and a second target temperature for the second sample holder that is unequal to the first target temperature.

~~Another aspect of the present invention provides~~There is also disclosed an instrument for biological analysis, comprising:

a sample processing system configured to retain a first sample holder comprising a first plurality of sample cells and a second sample holder comprising a second plurality of sample cells, wherein at least one of (a) a number of the sample cells or (b) a characteristic dimension of the sample cells is different between the first sample holder and the second sample holder;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an optical sensor configured to receive emission beams from the first plurality of sample cells and configured to receive emission beams from the second plurality of sample cells;

an emission optical system configured to direct the emission beams to the optical sensor;

WHAT IS CLAIMED IS:

1. A method of performing an biological assay, comprising:

providing an instrument including an optical system including a light emitting diode, an optical sensor, a sample processing system configured to retain a sample holder comprising one or more sample cells, and a calibration target is disposed within the instrument;

measuring an output from the optical sensor over a first predetermined duty cycle of the light emitting diode;

performing at least one of an interpolation or extrapolation;

calculating a duty cycle to produce a predetermined nominal optical sensor output;

first adjusting the light emitting diode duty cycle to produce the calculated duty cycle;

measuring a fluorescence radiation from a sample based on the calculated duty cycle.

2. The method of claim 1, further comprising measuring the output from the optical sensor after the first adjusting step, wherein if the measurement is not within ~~the~~ a predetermined tolerance, measuring an output from the optical sensor over a second predetermined duty cycle of light emitting diode, performing at least one of an interpolation or extrapolation, and calculating a duty cycle to produce the predetermined nominal optical sensor output, and second adjusting the light emitting diode duty cycle to produce the newly calculated duty cycle.

3. The method of claim ~~1~~2, further comprising measuring the output from the optical sensor after the second adjusting step, wherein if the measurement is not within the predetermined tolerance, reporting a calibration failure.

~~4. A method of calibrating an instrument for performing an biological assay, comprising:~~

~~providing an instrument including:~~

~~a sample processing system configured to retain a sample holder comprising one or more sample cells;~~

~~an excitation source configured to produce one or more excitation beams;~~

~~an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;~~

~~an instrument optical sensor configured to receive emission beams from the one or more sample cells;~~

an emission optical system configured to direct one or more emission beams from the sample processing system to the optical sensor;

a first excitation filter having a transmission wavelength band including only wavelengths that are less than the minima wavelength, first excitation filter configured to filter electromagnetic radiation from the excitation source;

a second excitation filter having a transmission wavelength band including only wavelengths that are greater than the minima wavelength, second excitation filter configured to filter electromagnetic radiation from the excitation source; and

a third excitation filter having a transmission wavelength band including only wavelengths that are greater than the minima wavelength, third excitation filter configured to filter electromagnetic radiation from the excitation source.

providing a reference material configured to produce a fluorescent signal at the optical sensor in response to illumination by electromagnetic radiation from the excitation source;

filtering electromagnetic radiation from the excitation source using the second excitation filter to produce a filtered excitation beam;

illuminating the reference material with the filtered excitation beam to produce an emission beam;

detecting at least a portion of the emission beam using a calibration sensor; and

calibrating an optical output of the light source based on the at least a portion of the detected emission beam.

5. The method of claim 4, wherein the excitation source is characterized by a spectral function of output power or intensity of the excitation source verses wavelength of output power or intensity, the spectral function comprises:

a minima wavelength corresponding to a local minima value of the output power or intensity;

a first maxima wavelength corresponding to a first local maxima of output power or intensity, the output power or intensity at the first local maxima being greater than the output power or intensity at any wavelength less than the minima wavelength;

a second maxima wavelength corresponding to a second local maxima of output power or intensity, the output power or intensity at the second local maxima being greater than the output at any wavelength greater than the minima wavelength;

the minima wavelength has a value that is between the first maxima wavelength and the second maxima wavelength;

6. An instrument for biological analysis, comprising:

a sample processing system configured to retain a sample holder comprising one or more sample cells;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an instrument optical sensor configured to receive emission beams from the one or more sample cells;

an emission optical system configured to direct one or more emission beams from the sample processing system to the optical sensor;

wherein the excitation source is characterized by a spectral function of output power or intensity of the excitation source verses wavelength of output power or intensity, the spectral function comprising:

a minima wavelength corresponding to a local minima value of the output power or intensity;

a first maxima wavelength corresponding to a first local maxima of output power or intensity, the output power or intensity at the first local maxima being greater than the output power or intensity at any wavelength less than the minima wavelength;

a second maxima wavelength corresponding to a second local maxima of output power or intensity, the output power or intensity at the second local maxima being greater than the output at any wavelength greater than the minima wavelength;

the minima wavelength has a value that is between the first maxima wavelength and the second maxima wavelength.

7. The instrument of claim 6, wherein the output power or intensity is a relative intensity of the excitation source, a relative power of the excitation source, a relative luminous flux of the excitation source, or a radiant flux of the excitation source.

8. The instrument of claim 6, further comprising

a first excitation filter having a transmission wavelength band including only wavelengths that are less than the minima wavelength, first excitation filter configured to filter electromagnetic radiation from the excitation source;

a second excitation filter having a transmission wavelength band including only wavelengths that are greater than the minima wavelength, second excitation filter configured to filter electromagnetic radiation from the excitation source; and

a third excitation filter having a transmission wavelength band including only wavelengths that are greater than the minima wavelength, third excitation filter configured to filter electromagnetic radiation from the excitation source.

9. The instrument of claim 8, further comprising

an electronic processor; and

a storage device including data comprising calibration data based on calibration of the excitation source based on the use of the second excitation filter.

10. An instrument for biological analysis, comprising:

a sample processing system configured to retain a first sample holder comprising a first plurality of sample cells and a second sample holder comprising a second plurality of sample cells, wherein at least one of (a) a number of the sample cells or (b) a characteristic dimension of the sample cells is different between the first sample holder and the second sample holder;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an optical sensor configured to receive emission beams from the first plurality of sample cells and configured to receive emission beams from the second plurality of sample cells;

~~an emission optical system configured to direct the emission beams to the optical sensor;~~

~~an excitation source temperature controller comprising a temperature sensor thermally coupled to the excitation source;~~

~~an electronic processor; and~~

~~a storage device including data comprising a first target temperature for the first sample holder and a second target temperature for the second sample holder that is unequal to the first target temperature.~~

~~11. The instrument of claim 10, wherein the storage device comprises instructions to control a system temperature to the first target temperature when the first sample holder is retained by the instrument and to control a system temperature to the second target temperature when the first sample holder is retained by the instrument.~~

~~12. The instrument of claim 10, wherein the sample processing system is configured to retain one or more additional sample holders each comprising a plurality of sample cells, wherein at least one of a number of the sample cells or a characteristic dimension of the sample cells is different for the one or more additional sample holders as compared to either the first sample holder or the second sample holder.~~

~~13. The instrument of claim 10, wherein the first target temperature is a temperature of the thermal sensor, a temperature of the first sample holder, or a temperature of at least one sample contained in the first sample holder, and wherein the second target temperature is a temperature of the thermal sensor, a temperature of the second sample holder, or a temperature of at least one sample contained in the second sample holder.~~

~~14. The instrument of claim 10, wherein the temperature sensor is configured to provide a signal based on a temperature of a sample holder or on one or more of a plurality of sample cells of the sample holder.~~

~~15. The instrument of claim 10, wherein the excitation source is a light emitting diode.~~

16. The instrument of claim 10, wherein the excitation source is a light emitting diode comprising a maximum power output at a wavelength within the visible range of the electromagnetic spectrum, the light emitting diode having a power output that is at least 10 percent of the maximum power output over a wavelength range from 450 nanometers to 600 nanometers.

17. The instrument of claim 10, further comprising a retained sample holder that is retained by the sample processing system, wherein the storage device includes instructions to be performed by the processor, the instruction comprising:

operating the excitation source to provide one or more excitation beams having a predetermined power or intensity;

reading a sensor temperature of the temperature sensor a plurality of times over a predetermined time period; and

instructing the temperature controller to control the sensor temperature to a predetermined temperature or to within a predetermined temperature range;

determining if a target temperature of the excitation source can be maintained for the retained sample holder.

18. The instrument of claim 17, wherein the storage device further comprises one or more instructions to set a flag, produce an alarm, send a warning signal, or halt an operation of the instrument when it is determined that a target temperature of the excitation source cannot be maintained for the retained sample holder.

19. The instrument of claim 17, wherein the storage device further comprises one or more instructions to set the target temperature to the first target temperature or the second target temperature.

20. The instrument of claim 17, further comprising a memory or storage device containing a low temperature limit representative of a minimum target temperature of the excitation source and a high temperature limit representative of a maximum target temperature of the excitation source, and a nominal target temperature that is between the low temperature limit and the high temperature limit.

21. The instrument of claim 20, wherein determining if a target temperature can be maintained is based on whether the sensor temperature is at or between the low temperature limit and the high temperature limit.

22. The instrument of claim 20, wherein the storage device further comprises one or more instructions to set the target temperature to value of the sensor temperature that is at or between a low temperature limit and a high temperature limit.

23. The instrument of claim 20, wherein the low temperature limit, the high temperature limit, and the nominal target temperature are based on the performance of plurality of different instruments or of a plurality of different excitation sources in one or more instruments.

24. An instrument for biological analysis, comprising:

a sample processing system configured to retain a first sample holder comprising a first plurality of sample cells and a second sample holder comprising a second plurality of sample cells, wherein at least one of (a) a number of the sample cells or (b) a characteristic dimension of the sample cells is different between the first sample holder and the second sample holder;

an excitation source configured to produce one or more excitation beams;

an excitation optical system configured to direct the one or more excitation beams toward a plurality of samples retained by the sample processing system;

an optical sensor configured to receive emission beams from the first plurality of sample cells and configured to receive emission beams from the second plurality of sample cells;

an emission optical system configured to direct the emission beams to the optical sensor;

an excitation source temperature controller comprising a temperature sensor thermally coupled to the excitation source;

an electronic processor; and

a storage device including data comprising a first temperature range and a second temperature range that is unequal to the first temperature range;

~~wherein the temperature controller is configured to produce a first target temperature based on the first temperature range when the first sample holder is retained by the instrument and to produce a second target temperature based on the second temperature range when the second sample holder is retained by the instrument.~~