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;

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 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 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 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 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.

## 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 table of the filter functions for a plurality of filter used in the emission filter assembly shown in FIG. 1

FIG. 3 is a table of the filter functions for a plurality of filter used in the excitation filter assembly shown in FIG. 1

FIG. 4 is a top view of a sample holder and carrier according to an embodiment of the present invention.

FIG. 5 is a top view and magnified views of a sample holder according to another embodiment of the present invention.

FIG. 6 is a perspective view of a sample holder according to yet another embodiment of the present invention.

FIG. 7 is a top view of a sample holder and carrier according to another embodiment of the present invention.