CLAIMS

1. A gel electrophoresis system, comprising:

a base module, comprising:

a cassette slot configured to receive a gel electrophoresis cassette;

a light element configured to illuminate the gel electrophoresis cassette when the gel electrophoresis cassette is positioned within the cassette slot; and

a camera module comprising a camera,

wherein the camera module is selectively connectable to the base module to facilitate imaging of the gel electrophoresis cassette when the gel electrophoresis cassette is positioned within the cassette slot;

wherein the base module further comprises a fan assembly, the fan assembly comprising one or more fans configured to facilitate air cooling of contents of the gel electrophoresis cassette when the gel electrophoresis cassette is positioned within the cassette slot;

wherein one or more spring-loaded pin connectors facilitate electrical communication between the camera module and the base module when the camera module is selectively connected to a top portion of the base module;

wherein the base module further comprises a viewing window configured to provide a view of the gel electrophoresis cassette when the gel electrophoresis cassette is positioned within the cassette slot, and wherein the base module further comprises a perimeter wall extending upward from the viewing window and about a perimeter of the viewing window; and

wherein the camera module defines an imaging chamber on an underside thereof, the imaging chamber being configured to be disposed over the viewing window when the camera module is selectively connected to the base module, the camera module further comprising an engagement wall configured to reside over the viewing window and within a perimeter defined by the perimeter wall of the base module when the camera module is selectively connected to the base module.

2. The gel electrophoresis system of claim 1, wherein the camera module is configured to receive power from the base module when the camera module is selectively connected over a top portion of the base module.

3. The gel electrophoresis system of claim 1 or 2, wherein the air cooling contributes to improved band separation resolution and/or reduced band loss due to gel melting for gel electrophoresis performed using the gel electrophoresis system.

4. The gel electrophoresis system of any one of claims 1 through 3, wherein the one or more fans are configured to direct air along an upper air cooling path that extends over a top of the gel electrophoresis cassette when the gel electrophoresis cassette is positioned within the cassette slot.

5. The gel electrophoresis system of claim 4, wherein the upper air cooling path is at least partially defined by an inclined air duct, the inclined air duct being configured to prevent liquid seepage.

6. The gel electrophoresis system of any one of claims 1 through 4, wherein the one or more fans are configured to direct air along a bottom air cooling path that extends below the cassette slot.

7. The gel electrophoresis system of claim 6, wherein the bottom air cooling path extends through a heatsink positioned below a light emitting diode (LED) array positioned below the cassette slot.

8. The gel electrophoresis system of any one of claims 1 through 7, wherein the base module further comprises an excitation filter arranged between the light element and the gel electrophoresis cassette when the gel electrophoresis cassette is positioned within the cassette slot, and wherein a distance between light element and the excitation filter is within a range of about 20 mm to about 27 mm.

9. The gel electrophoresis system of any one of claims 1 through 8, wherein the light element comprises an LED array optionally disposed in a checkerboard pattern.

10. The gel electrophoresis system of claim 9, wherein the LED array comprises a number of LEDs within a range of 35 to 45.

11. The gel electrophoresis system of claim 10, wherein the checkerboard pattern comprises alternating rows of different numbers of LEDs, such as a checkerboard pattern with

six rows, wherein a first row, a third row, and a fifth row each comprise seven LEDs, and wherein a second row, a fourth row, and a sixth row each comprise six LEDs.

12. The gel electrophoresis system of any one of claims 9 through 11, wherein a center to center distance between adjacent LEDs within a same row is within a range of about 21.5 mm to about 23.5 mm, and/or wherein a center to center row offset distance between adjacent rows of the checkerboard pattern is within a range of about 17.5 mm to about 19.5 mm.

13. The gel electrophoresis system of claim 12, wherein the center to center distance between adjacent LEDs within a same row is about 22.4 mm, and wherein the center to center row offset distance between adjacent rows of the checkerboard pattern is about 18.7 mm.

14. The gel electrophoresis system of any one of claims 9 through 13, wherein the checkerboard pattern comprises a width within a range of about 130 mm to about 140 mm, and wherein the checkerboard pattern comprises a height within a range of about 90 mm to about 100 mm.

15. The gel electrophoresis system of any one of claims 1 through 14, wherein the base module comprises a pin connection slot, the one or more spring-loaded pin connectors being configured to facilitate electrical communication between the camera module and the base module at the pin connection slot.

16. The gel electrophoresis system of claim 15, wherein the pin connection slot comprises a depth within a range of about 2.2 mm to about 5.4 mm.

17. The gel electrophoresis system of any one of claims 1 through 16, wherein the base module comprises a flex catch slot, and wherein the camera module comprises a corresponding flex catch, the flex catch slot and the corresponding flex catch being configured to engage with one another when the camera module is selectively connected over a top portion of the base module to reduce tilting motion of the camera module relative to the base module.

18. The gel electrophoresis system of any one of claims 1 through 17, wherein the engagement wall comprises one or more tabs configured to intervene between the engagement wall and the perimeter wall when the camera module is selectively connected over a top portion of the base module, the one or more tabs being operable to tighten engagement between the camera module and the base module.

19. The gel electrophoresis system of any one of claims 1 through 18, wherein the perimeter wall comprises a height within a range of about 2 mm to about 5 mm.

20. The gel electrophoresis system of any one of claims 1 through 19, wherein the base module and the camera module each comprise one or more magnets that correspond to facilitate selective connection between the camera module and the base module.

21. The gel electrophoresis system of any one of claims 1 through 20, wherein the camera module comprises an air inlet path.

22. The gel electrophoresis system of claim 21, wherein the air inlet path extends from an exterior opening of the camera module to an interior opening of the camera module, and wherein the air inlet path comprises at least one path bend between the exterior opening and the interior opening.

23. The gel electrophoresis system of claim 22, wherein the air inlet path comprises at least two path bends between the exterior opening and the interior opening.

24. The gel electrophoresis system of claim 22 or claim 23, wherein the exterior opening comprises an elongated exterior opening, the elongated exterior opening forming an exterior shape on an exterior of the camera module, and wherein the interior opening comprises an elongated interior opening, the elongated interior opening forming an interior shape on an interior of the camera module.

25. The gel electrophoresis system of claim 24, wherein the interior shape comprises a smaller perimeter than the exterior shape.

26. The gel electrophoresis system of any one of claims 21 through 25, wherein the air inlet path is defined by a housing of the camera module and a handle of the camera module.

27. The gel electrophoresis system of any one of claims 21 through 26, further comprising a second air inlet path arranged opposite the air inlet path.

28. The gel electrophoresis system of any one of claims 1 through 27, wherein the camera module further comprises a camera adjustment stage supporting the camera.

29. The gel electrophoresis system of claim 28, the camera adjustment stage being securable to the camera module to facilitate spherical joint adjustment of the camera adjustment stage.

30. The gel electrophoresis system of claim 29, wherein the camera module comprises a stage support configured to support the camera adjustment stage, the stage support comprising a spherical surface.

31. The gel electrophoresis system of claim 30, wherein the camera adjustment stage comprises a corresponding spherical surface configured to interface with the spherical surface of the stage support of the camera module, and wherein spherical joint adjustment of the camera adjustment stage is facilitated by adjusting a position of the corresponding spherical surface of the camera adjustment stage relative to the spherical surface of the stage support.

32. The gel electrophoresis system of claim 31, wherein the camera adjustment stage is securable to the stage support of the camera module utilizing a plurality of spherical washers, wherein the plurality of spherical washers facilitates securement of the camera adjustment stage

to the stage support of the camera module in a manner that accommodates multiple positionings of the camera adjustment stage relative to the stage support.

33. The gel electrophoresis system of claim 32, wherein the plurality of spherical washers comprises four spherical washers, each being associated with a respective corner of the camera adjustment stage.

34. The gel electrophoresis system of any one of claims 28 through 33, wherein the camera module further comprises a lens assembly extending from the camera adjustment stage.

35. The gel electrophoresis system of claim 34, wherein the lens assembly comprises a lens sleeve, the lens sleeve housing a lens, the lens sleeve being rotatable to facilitate focusing of the lens.

36. The gel electrophoresis system of claim 35, wherein the lens sleeve comprises a lens gear, the lens gear comprising gear teeth extending radially outward from the lens sleeve, the gear teeth being configured to engage with corresponding gear teeth of a focus adjustment gear such that rotation of the focus adjustment gear causes rotation of the lens sleeve.

37. The gel electrophoresis system of claim 36, wherein the lens gear is configured to reside within an imaging chamber defined by the camera module, and wherein the focus adjustment gear is rotatable from outside of the imaging chamber when the camera module is selectively connected to the base module.

38. The gel electrophoresis system of claim 36 or claim 37, wherein a position of the focus adjustment gear is selectively lockable.

39. The gel electrophoresis system of claim 38, wherein selective locking of the position of the focus adjustment gear is facilitated utilizing one or more locking members that are configured to selectively tighten about the focus adjustment gear to selectively lock the position of the focus adjustment gear.

40. The gel electrophoresis system of claim 39, wherein the one or more locking members comprises at least two locking members positioned on opposing sides of at least a portion of the focus adjustment gear, and wherein selective tightening of the at least two locking members about the focus adjustment gear is facilitated utilizing a locking screw configured to draw the at least two locking members toward one another upon rotating of the locking screw in a first direction.

41. The gel electrophoresis system of any one of claims 35 through 40, wherein the lens assembly comprises an octopus ring that facilitates optical alignment between the camera and the lens.

42. The gel electrophoresis system of any one of claims 1 through 41, wherein the camera module further comprises a supercapacitor array, the supercapacitor array being configured to become charged when the camera module is selectively connected to the base module, the

supercapacitor array being configured, when charged, to supply power to one or more components of the camera module when the camera module is selectively disconnected from the base module.

43. The gel electrophoresis system of claim 42, wherein an initial charging time for the supercapacitor array is less than about 10 seconds, or less than about 16 seconds, or within a range of about 10 seconds to about 16 seconds.

44. The gel electrophoresis system of claim 43, wherein the initial charging time for the supercapacitor array is within a range of about 12 seconds to about 16 seconds.

45. The gel electrophoresis system of any one of claims 42 through 44, wherein the supercapacitor array is configured to supply power to the one or more components of the camera module when the camera module is selectively disconnected from the base module for about three seconds or longer, or about four seconds or longer, or about five seconds or longer, or about six seconds or longer.

46. The gel electrophoresis system of claim 45, wherein the supercapacitor array is configured to supply power to the one or more components of the camera module when the camera module is selectively disconnected from the base module for about seven seconds or longer.

47. The gel electrophoresis system of claim 46, wherein the supercapacitor array is configured to supply power to the one or more components of the camera module when the camera module is selectively disconnected from the base module for about nine seconds or longer.

48. The gel electrophoresis system of any one of claims 42 through 47, wherein one or more supercapacitors of the supercapacitor array comprise double layer supercapacitors.

49. The gel electrophoresis system of any one of claims 42 through 48, wherein the supercapacitor array comprises at least four supercapacitors.

50. The gel electrophoresis system of any one of claims 42 through 49, wherein the supercapacitor array comprises a capacitance within a range of about 30 farads to about 50 farads.

51. The gel electrophoresis system of claim 50, wherein the supercapacitor array comprises a capacitance of about 40 farads.

52. The gel electrophoresis system of any one of claims 1 through 51, further comprising:

one or more processors; and

one or more hardware storage devices storing instructions that are executable by the one or more processors to configure the gel electrophoresis system to:

obtain an image captured by the camera, the image capturing an electrophoresis gel positioned within a gel electrophoresis cassette positioned within the cassette slot;

perform a gel size differentiation operation configured to determine a size of the electrophoresis gel;

in response to determining that the size of the electrophoresis gel satisfies a threshold, perform a well configuration detection operation to determine a configuration of wells of the electrophoresis gel; and

perform an image deconvolution operation based on the image to generate a deconvolved image.

53. The gel electrophoresis system of claim 52, wherein the gel size differentiation operation comprises:

performing an edge detection operation to detect a presence of wells within the electrophoresis gel;

performing a region of interest operation, the region of interest operation comprising identifying a region of interest within the image, cropping the image based on the region of interest to generate a cropped image, and rotating the cropped image if necessary to cause a long edge of the cropped image to become a horizontal edge; and

applying a threshold to the cropped image to identify a label within the cropped image, wherein presence of the label along a right side or left side of the cropped image indicates a first gel size, and wherein presence of the label along a top or a bottom of the cropped image indicates a second gel size.

54. The gel electrophoresis system of claim 53, wherein the well configuration detection operation comprises:

removing a label region from the image, generating a modified image;

applying edge detection to the modified image to identify well edges, generating a well edge image; and

applying a threshold to the well edge image to generate a well contour image.

55. The gel electrophoresis system of claim 54, wherein the well configuration detection operation further comprises fitting a well matrix template to the well contour image.

56. The gel electrophoresis system of claim 54 or claim 55, wherein the well configuration detection operation further comprises:

detecting a band number associated with the well contour image, the band number being based upon column-wise average pixel values obtained for one or more rows of the well contour image; and

determining a well configuration based upon the band number.