

CLAIMS

WHAT IS CLAIMED IS:

1. An electrophoretic system for analyte migration, the system comprising:
 - 5 a substrate including a plurality of regions, each region configured to be electrically conductive, each region configured to comprise one or more capture probes and a biological sample comprising an analyte, wherein the substrate includes a first electrode contact, the first electrode contact being electrically connected to at least one of the plurality of regions;
 - 10 a substrate cassette configured to be disposed at the substrate and including a plurality of apertures corresponding to the plurality of regions of the substrate, the plurality of apertures configured to define a plurality of buffer chambers comprising the plurality of regions of the substrate, wherein the substrate cassette comprises a connection interface electrically coupled to the first electrode contact of the substrate;
 - 15 a cathode assembly including a plurality of electrodes positioned within the plurality of buffer chambers of the substrate cassette, respectively, wherein the cathode assembly includes a second electrode contact, the second electrode contact being electrically connected to at least one of the plurality of electrodes; and
 - 20 a power supply electrically connected with the first electrode contact of the substrate at the connection interface of the substrate cassette, and electrically connected with the second electrode contact of the cathode assembly, the power supply configured to generate an electric field between the plurality of regions and the plurality of electrodes, respectively, such that the analyte in the biological sample moves toward the capture probe on the substrate.
- 25 2. The electrophoretic system of claim 1, wherein the capture probe is coated, spotted or printed on each of the plurality of regions.
3. The electrophoretic system of claim 1 or 2, wherein the biological sample is placed in contact with one or more of the plurality of regions on the substrate.
- 30 4. The electrophoretic system of any one of claims 1-3, wherein the substrate cassette comprises:

a substrate holder including a substrate mount for securing the substrate; and
a gasket including a plurality of gasket apertures configured to align with the plurality of regions when the substrate is secured by the substrate holder, wherein the plurality of apertures includes the plurality of gasket apertures.

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5. The electrophoretic system of claim 4, wherein the substrate holder comprises:
a plurality of holder apertures configured to align with the plurality of gasket apertures when the substrate is secured by the substrate holder, wherein the plurality of apertures includes the plurality of gasket apertures and the plurality of holder apertures.

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6. The electrophoretic system of any one of claims 1-5, wherein the substrate includes a glass slide coated with a conductive material.

7. The electrophoretic system of claim 6, wherein the conductive material includes at least one of tin oxide (TO), indium tin oxide (ITO), a transparent conductive oxide (TCO), aluminum doped zinc oxide (AZO), fluorine doped tin oxide (FTO), or any combination thereof.

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8. The electrophoretic system of any one of claims 1-7, further comprising:
a first electrical wire connecting the power supply to the first electrode contact; and
a second electrical wire connecting the power supply to the second electrode contact.

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9. The electrophoretic system of any one of claims 1-8, wherein the plurality of buffer chambers are configured to receive a buffer.

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10. The electrophoretic system of claim 9, wherein the buffer includes a permeabilization reagent.

11. The electrophoretic system of any of claims 1-10, further comprising:
a light configured to illuminate onto the plurality of regions to permeabilize the biological sample on the plurality of regions.

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12. The electrophoretic system of any of claims 1-11, wherein the sample is permeabilized using a detergent before, after, or during enzymatic treatment.

13. The electrophoretic system of any of claims 1-12, wherein the sample is permeabilized with a lysis reagent being added to the sample.

5 14. The electrophoretic system of any of claims 1-13, wherein the sample is permeabilized by exposing the sample to a protease.

15. The electrophoretic system of any one of claims 1-14, wherein the substrate cassette includes:

10 a body defining a cavity configured to partially receive the substrate,
wherein the connection interface of the substrate cassette includes a slit defined at the body and configured for the substrate to partially extend out from the body such that the first electrode contact of the substrate is positioned outside the body.

15 16. The electrophoretic system of claim 15, wherein the body includes a main face and a lateral face extending from a periphery of the main face,
wherein the plurality of the apertures are defined at the main face of the body, and
wherein the slit is defined at the lateral face of the body.

20 17. The electrophoretic system of any one of claims 1-14, wherein the substrate cassette includes:
a body defining a cavity configured to receive the substrate,
wherein the connection interface of the substrate cassette includes a contact opening defined at the body and configured to expose the first electrode contact of the substrate there
25 through.

18. The electrophoretic system of claim 17, wherein the body includes a main face and a lateral face extending from a periphery of the main face,
wherein the plurality of the apertures are defined at the main face of the body, and
30 wherein the contact opening is defined at the main face adjacent the lateral face.

19. The electrophoretic system of claim 18, wherein the contact opening is defined further at the lateral face of the body to extend from the main face to the lateral face.

20. The electrophoretic system of any one of claims 1-14, further comprising:
a first contact pin electrically attached to the substrate and providing the first electrode contact,
wherein the substrate cassette includes:
5 a body defining a cavity configured to receive the substrate,
wherein the connection interface of the substrate cassette includes a contact hole defined at the body and configured to expose the first contact pin therethrough.
21. The electrophoretic system of claim 20, wherein the body includes a main face and a
10 lateral face extending from a periphery of the main face,
wherein the plurality of the apertures are defined at the main face of the body, and
wherein the contact hole is defined at the main face.
22. The electrophoretic system of any one of claims 1-14, wherein the substrate cassette
15 includes:
a body defining a cavity configured to receive the substrate; and
a contact pin extending through a wall of the body and having a first end and a second end opposite to the first end, the first end arranged exterior of the body, and the second end arranged interior of the body and configured to electrically contact with the first electrode
20 contact of the substrate.
23. The electrophoretic system of claim 22, further comprising:
a contact bracket that electrically engages with the substrate and provides the first electrode contact of the substrate,
25 wherein the second end of the contact pin is configured to electrically contact with the contact bracket.
24. The electrophoretic system of any one of claims 1-14, wherein the cathode assembly includes:
30 a cathode body configured to position at least partially on the substrate cassette,
wherein the plurality of electrodes project from the cathode body.
25. The electrophoretic system of claim 24, wherein each of the plurality of electrodes includes at least one of a conductive wire, a conductive rod, or an array of conductive wires.

26. The electrophoretic system of claim 25, wherein each of the plurality of electrodes includes a conductive plate at a distal end of the at least one of the conductive wire, the conductive rod, or the array of conductive wires.

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27. The electrophoretic system of claim 26, wherein the conductive plate is configured as at least one of a circular plate, a square plate, or a ring.

28. The electrophoretic system of any one of claims 24-27, wherein the cathode body
10 includes the second electrode contact.

29. The electrophoretic system of any one of claims 1-14, wherein the substrate cassette includes a second aperture corresponding to the first electrode contact of the substrate and configured to define a second buffer chamber on the first electrode contact of the substrate,
15 wherein the plurality of buffer chambers are configured to contain a first buffer, and wherein the second chamber is configured to contain a second buffer different from the first buffer.

30. The electrophoretic system of claim 29, wherein the second buffer has an electrolyte
20 strength greater than the first buffer.

31. The electrophoretic system of claim 30, wherein the second buffer includes a sodium chloride solution.

25 32. The electrophoretic system of any one of claims 29-31, wherein the cathode assembly includes:

a cathode body configured to position at least partially on the substrate cassette, wherein the plurality of electrodes projecting from the cathode body and configured to position within the plurality of buffer chambers, respectively; and

30 a second electrode projecting from the cathode body and configured to position within the second chamber.

33. The electrophoretic system of claim 32, wherein the cathode body includes:
an anode contact that is electrically connected to the second electrode,

wherein the power supply is electrically connected to the anode contact of the cathode body so that the power supply is electrically connected with the first electrode contact of the substrate via the second electrode that positions within the second chamber containing the second buffer on the first electrode contact of the substrate.

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34. The electrophoretic system of any one of claims 1-14, wherein the substrate cassette includes:

a cassette body defining a cavity configured to receive the substrate, wherein the cassette body includes the cathode assembly such that the plurality of electrodes are

10 configured to position within the plurality of buffer chambers; and

a plurality of cathode contact pins extending through a wall of the cassette body and electrically contacting with the second electrode contact such that the cathode contact pin is electrically connected to the at least one of the plurality of electrodes.

15 35. The electrophoretic system of claim 34, wherein each of the plurality of electrodes includes at least one of a conductive wire, a conductive rod, or an array of conductive wires.

36. The electrophoretic system of claim 35, wherein each of the plurality of electrodes includes a conductive plate at a distal end of the at least one of the conductive wire, the
20 conductive rod, or the array of conductive wires.

37. The electrophoretic system of any one of claim 34-36, wherein the cassette body includes:

25 an anode contact pin extending through the wall of the body and having a first end and a second end opposite to the first end, the first end arranged exterior of the cassette body and the second end arranged interior of the cassette body and configured to electrically contact with the first electrode contact of the substrate.

38. The electrophoretic system of claim 37, further comprising:

30 a contact bracket that electrically engages with the substrate and provides the first electrode contact of the substrate,

wherein the second end of the anode pin is configured to electrically contact with the contact bracket.

39. The electrophoretic system of claim 15 or 16, wherein the body includes the cathode assembly such that the plurality of electrodes are configured to position within the plurality of buffer chambers,

wherein the substrate cassette further includes:

- 5 a cathode contact pin extending through a wall of the body and electrically contacting with the second electrode contact such that the cathode contact pin is electrically connected to the at least one of the plurality of electrodes;
- an anode contact pin extending from the body; and
- 10 a conductive wire having a first end and an opposite second end, the first end electrically connected to the anode contact pin, and the second end electrically connected to the first electrode contact that is positioned outside the body.

40. The electrophoretic system of claim 15 or 16, further comprising:

- an anode cassette body defining a cavity configured to receive the first electrode
- 15 contact of the substrate that is positioned outside the body of the substrate cassette; and
- an anode contact pin extending through a wall of the anode cassette body and having a first end and a second end opposite to the first end, the first end arranged exterior of the anode cassette body and the second end arranged interior of the anode cassette body and configured to electrically contact with the first electrode contact of the substrate.

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41. The electrophoretic system of claim 40, further comprising:

- an anode contact bracket that electrically engages with the substrate and provides the first electrode contact of the substrate,
- wherein the second end of the anode contact pin is configured to electrically contact
- 25 with the anode contact bracket.

42. The electrophoretic system of any one of claims 1-41, further comprising:

- a system housing including the power supply;
- a cassette tray that extends from the system housing and is configured to receive the
- 30 substrate cassette thereon; and
- a cassette cover that extends from the system housing above the cassette tray.

43. The electrophoretic system of claim 37 or 38, further comprising:

 a system housing including the power supply;

a cassette tray that extends from the system housing and is configured to receive the substrate cassette thereon; and

5 a cassette cover that extends from the system housing above the cassette tray, the cassette cover including a cathode connector and an anode connector, the cathode connector configured to electrically engage with the cathode contact pin of the substrate cassette, the anode connector configured to electrically engage with the anode contact pin of the substrate cassette.

44. The electrophoretic system of claim 22 or 23, further comprising:

10 a system housing including the power supply;

a cassette tray that extends from the system housing and is configured to receive the substrate cassette thereon; and

15 a cassette cover that extends from the system housing above the cassette tray and includes the cathode assembly, wherein the plurality of electrodes project from the cassette cover toward the plurality of chambers of the substrate cassette, the cassette cover further including:

an anode connector configured to electrically engage with the contact pin of the substrate cassette.

20 45. A method for analyte migration, the method comprising:

loading a substrate comprising capture probes with a substrate cassette into an electrophoresis instrument, the substrate cassette including a plurality of buffer chambers, the substrate including a plurality of regions each comprising one or more capture probes and a biological sample containing an analyte;

25 arranging a cathode to place a plurality of electrodes within the plurality of buffer chambers, respectively;

electrically connecting a power supply to the substrate;

electrically connecting the power supply to the cathode;

applying a first voltage between the substrate and the cathode;

30 detecting an output parameter in response to the first voltage;

determining whether the output parameter meets a threshold value; and

based on the output parameter meeting the threshold value, applying a second voltage to generate electric fields between the plurality of regions of the substrate and the plurality of

electrodes through the plurality of buffer chambers to cause the analytes in the biological samples to move toward the capture probes on the substrate.

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46. The method of claim 45, wherein the output parameter is an impedance.
47. The method of claim 45 or 46, wherein the threshold value is indicative of a propriety of at least one of an electrical connection of the power supply to the substrate, an electrical connection of the power supply to the cathode, or an electrical property of the buffers.
- 10 48. The method of any one of claims 45-47, further comprising:
based on the output parameter not meeting the threshold value, generating a notification to inform an electrical connection is improper; and
ceasing to apply the second voltage to generate the electric fields.
- 15 49. The method of any one of claims 45-48, wherein the threshold value is a predetermined range of value.
50. The method of any one of claims 45-49, further comprising:
prior to loading the substrate with the substrate cassette, placing the biological
20 samples in contact with the capture probes on the substrate;
arranging the substrate cassette onto the substrate to align a plurality of apertures of the substrate cassette with a plurality of regions of the substrate and define the plurality of buffer chambers on the plurality of regions; and
supplying buffers in the plurality of buffer chambers.
- 25 51. The electrophoretic system of any of claims 1-44, wherein the substrate cassette comprises the connection interface that exposes the first electrode contact of the substrate.