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Optical reader device for multiplexed diagnostic systems and methods of use

Abstract

An apparatus for performing analyte detection, wherein the apparatus comprises an optoelectronic reader device, the optoelectronic reader device comprising a microfluidic subassembly comprising a microfluidic pump, the microfluidic pump configured to route the flow of at least a fluid, wherein the at least a fluid contains an analyte, and at least a reservoir configured to contain the at least a fluid, an optics subassembly, the optics subassembly comprising an optical device having at least one light source directed at the at least a fluid, and a sensor device configured to sense the at least a fluid and detect at least an optical property of the analyte, and a portable device, wherein the portable device is configured for point of care diagnostics.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application claims the benefit of priority of U.S. Provisional Patent Application Ser. No. 63/302,370, filed on Jan. 24, 2022, and titled "OPTICAL READER DEVICE FOR MULTIPLEXED DIAGNOSTIC SYSTEMS," which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

(1) The present invention generally relates to the field of opto-electronic reader devices. In particular, the present invention is directed to an opto-electronic reader device to be used for analyte detection in point of care and at-home diagnostics.

BACKGROUND

(2) Over the past decade and especially post the SARS COVID-2 pandemic, the demand for accurate and inexpensive point-of-care and at-home diagnostics has rapidly increased. A multitude of approaches including but not limited to chemical, electrical, and optical sensing have since been researched, proposed, implemented, and commercialized to meet this spiked need for simplified diagnostics.

SUMMARY OF THE DISCLOSURE

(3) In an aspect an apparatus for performing analyte detection is illustrated. Apparatus includes an optoelectronic reader device, wherein the optoelectronic reader device includes a microfluidic subassembly having a microfluidic pump, the microfluidic pump configured to route the flow of at least a fluid, wherein the at least a fluid contains an analyte, and at least a reservoir configured to contain the at least a fluid. Optoelectronic reader device further includes an optics subassembly, the optics subassembly having an optical device having at least one light source directed at the at least a fluid and a sensor device configured to sense the at least a fluid and detect at least an optical property of the analyte. Optoelectronic reader device further includes a portable device, wherein the portable device is configured for point of care diagnostics.

(4) In another aspect a method for analyte detection is illustrated. The method includes receiving an optoelectronic reader device. The optoelectronic reader device includes a microfluidic subassembly having a microfluidic pump, the microfluidic pump configured to route the flow of at least a fluid, wherein the at least a fluid contains an analyte, and at least a reservoir configured to contain the at least a fluid. The optoelectronic reader device further includes an optics subassembly, the optics subassembly having an optical device having at least one light source directed at the at least a fluid, and a sensor device configured to sense the at least a fluid and detect at least an optical property of the analyte. The method further includes flowing, using the microfluidic subassembly, the at least a fluid through the at least a reservoir, emitting, using the optical device, the at least one light source onto the fluid, and sensing, using the sensor device, the optical property of the at least a fluid, wherein the optoelectronic reader device is a portable device configured for point of care diagnostics.

(5) These and other aspects and features of non-limiting embodiments of the present invention will become apparent to those skilled in the art upon review of the following description of specific non-limiting embodiments of the invention in conjunction with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) For the purpose of illustrating the invention, the drawings show aspects of one or more embodiments of the invention. However, it should be understood that the present invention is not limited to the precise arrangements and instrumentalities shown in the drawings, wherein:

(2) FIG. **1** is an exemplary embodiment of an apparatus for performing analyte detection;

(3) FIG. **2** illustrates an expanded view of an exemplary embodiment of an optical reader device;

(4) FIG. **3** illustrates an exemplary embodiment of the optical sub-assembly comprising a custom-packaged TO-can laser;

(5) FIG. **4** illustrates an exemplary embodiment of a laser sub-assembly;

(6) FIG. **5** illustrates an exemplary embodiment of a silica polarization maintaining splitter;
(7) FIG. **6**A depicts waveguide cross-section geometry of a silicon nitride waveguide based unbalanced MZI on a chip.
(8) FIG. **6**B depicts a general configuration of an unbalanced MZI;
(9) FIG. **6**C depicts experimental results of a fiber array attached chip with a 14 pm free-spectral range at 1310 nm.
(10) FIG. **6**D depicts mode simulations of the silicon nitride waveguide based unbalanced MZI on a chip;
(11) FIG. **7** illustrates an exemplary embodiment of a photodetector sub-assembly;
(12) FIG. **8** is a block diagram of a system including an example of a workflow that may be used with such a system according to an embodiment of the invention;
(13) FIG. **9** is an exemplary embodiment of an optoelectronics subassembly having an analog board and a digital board;
(14) FIGS. **10**A-B show an exemplary embodiment of TO-can laser mounted onto an opto-electronic board;
(15) FIG. **11** is a block diagram of an exemplary embodiment of a processor firmware architecture;
(16) FIG. **12** block diagram of an exemplary embodiment of a cloud architecture;
(17) FIG. **13** is an exemplary embodiment of a motor-subassembly;
(18) FIG. **14** is an exemplary embodiment of a spring-loaded collet;
(19) FIG. **15** is an exemplary embodiment of a mechanical housing;
(20) FIG. **16** is a flow diagram of an exemplary method for analyte detection;
(21) FIG. **17** is a flow diagram for yet another exemplary method for analyte detection;
(22) FIG. **18** depicts the measured sweep repeatability error of an optical-sub assembly as compared to a commercial low-noise laser; and
(23) FIG. **19** is a block diagram of a computing system that can be used to implement any one or more of the methodologies disclosed herein and any one or more portions thereof.
(24) The drawings are not necessarily to scale and may be illustrated by phantom lines, diagrammatic representations, and fragmentary views. In certain instances, details that are not necessary for an understanding of the embodiments or that render other details difficult to perceive may have been omitted.

DETAILED DESCRIPTION

(25) At a high level, aspects of the present disclosure are directed to systems and methods for analyte detection. In some embodiments apparatus includes an optoelectronic reader device and a portable device. The optoelectronic reader device includes a microfluidic sub assembly and an optical sub assembly. In some cases, apparatus may further include a computing device used to receive data related to an analyte. In some cases, apparatus may be enclosed within a housing. In some cases, apparatus may include a battery wherein apparatus may be powered without a wall socket.
(26) Aspects of the present disclosure can be used to perform analyte detection outside of a lab. Users or patients may use apparatus in the comfort of their own home. In addition, users may receive results quicker than in a conventional lab.
(27) Aspects of the present disclosure also allow for multiplexed diagnostics. Exemplary embodiments illustrating aspects of the present disclosure are described below in the context of several specific examples.
(28) Foundry compatible and mass-manufacturable integrated photonic sensor chips when developed in combination with carefully designed biochemistry, analyte collection methods, and microfluidic routing, can enable inexpensive, disposable cartridges for highly sensitive and specific, multiplexed diagnostics. An apparatus as shown in FIG. **1**, that interrogates with such cartridges entails an ensemble combination of miniaturized optics, microfluidics, customized driver, and acquisition electronics, and finally a data-secure yet user-friendly, cloud-connected

software solution. The present disclosure discusses in part a hand-held optoelectronic reader device apparatus with a miniaturized microfluidic pump that interrogates with disposable microfluidic cartridges containing an integrated photonic chip to be used for point-of-care (POC) or at-home diagnostic systems. In some embodiments, the apparatus as depicted in FIG. **2**, is a single, non-limiting example of the reader diagnostic device that can be used to simultaneously detect multiple biological analytes.

(29) Referring now to FIG. **1**, an exemplary embodiment of an apparatus **100** for performing analyte detection is illustrated. As used in this disclosure "analyte detection" is the identification of a substance. Substance may include organic or inorganic chemicals. In some embodiments, apparatus **100** used for analyte detection may include a wide range of applications such as medical diagnostics, drug discovery, environmental monitoring, food safety testing and the like. Apparatus **100** may include a computing device. Computing device **148** may include any computing device **148** as described in this disclosure, including without limitation a microcontroller, microprocessor, digital signal processor **152** (DSP) and/or system on a chip (SoC) as described in this disclosure. Computing device **148** may include, be included in, and/or communicate with a mobile device such as a mobile telephone or smartphone. Computing device **148** may include a single computing device **148** operating independently or may include two or more computing device **148** operating in concert, in parallel, sequentially or the like; two or more computing devices may be included together in a single computing device **148** or in two or more computing devices. Computing device **148** may include a processor **152** and a memory communicatively connected to the processor. Computing device **148** may interface or communicate with one or more additional devices as described below in further detail via a network interface device. Network interface device may be utilized for connecting computing device **148** to one or more of a variety of networks, and one or more devices. Examples of a network interface device include, but are not limited to, a network interface card (e.g., a mobile network interface card, a LAN card), a modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (e.g., the Internet, an enterprise network), a local area network (e.g., a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network, a data network associated with a telephone/voice provider (e.g., a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. A network may employ a wired and/or a wireless mode of communication. In general, any network topology may be used. Information (e.g., data, software etc.) may be communicated to and/or from a computer and/or a computing device. Computing device **148** may include but is not limited to, for example, a computing device **148** or cluster of computing devices in a first location and a second computing device **148** or cluster of computing devices in a second location. Computing device **148** may include one or more computing devices dedicated to data storage, security, distribution of traffic for load balancing, and the like. Computing device **148** may distribute one or more computing tasks as described below across a plurality of computing devices of computing device, which may operate in parallel, in series, redundantly, or in any other manner used for distribution of tasks or memory between computing devices. Computing device **148** may be implemented, as a non-limiting example, using a "shared nothing" architecture.

(30) With continued reference to FIG. **1**, computing device **148** may be designed and/or configured to perform any method, method step, or sequence of method steps in any embodiment described in this disclosure, in any order and with any degree of repetition. For instance, computing device **148** may be configured to perform a single step or sequence repeatedly until a desired or commanded outcome is achieved; repetition of a step or a sequence of steps may be performed iteratively and/or recursively using outputs of previous repetitions as inputs to subsequent repetitions, aggregating inputs and/or outputs of repetitions to produce an aggregate result, reduction or decrement of one or more variables such as global variables, and/or division of a larger processing task into a set of iteratively addressed smaller processing tasks. Computing device **148** may perform any step or

sequence of steps as described in this disclosure in parallel, such as simultaneously and/or substantially simultaneously performing a step two or more times using two or more parallel threads, processor **152** cores, or the like; division of tasks between parallel threads and/or processes may be performed according to any protocol suitable for division of tasks between iterations. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various ways in which steps, sequences of steps, processing tasks, and/or data may be subdivided, shared, or otherwise dealt with using iteration, recursion, and/or parallel processing.

(31) With continued reference to FIG. **1**, apparatus **100** includes an optoelectronic reader device **104**. Optoelectronic reader device **104** includes a microfluidic subassembly **108**. "Optoelectronic reader device" as described herein is a device configured for detection of an analyte using light. "Microfluidic subassembly" is a device and/or subassembly that is configured to act upon fluids on a small or micro scale. On a microscale, the physical and chemical properties of fluids behave differently wherein a microfluidic device may exploit those differences. Microfluidic subassembly **108** may be consistent with a microfluidic device as described in U.S. patent application Ser. No. 17/859,932, filed on Jul. 7, 2022, entitled "SYSTEM AND METHODS FOR FLUID SENSING USING PASSIVE FLOW," the entirety of which is incorporated herein by reference.

(32) With continued reference to FIG. **1**, Microfluidic subassembly **108** includes a microfluidic pump **112**. Microfluidic pump **112** may include pump. Pump may include a substantially constant pressure pump (e.g., centrifugal pump) or a substantially constant flow pump (e.g., positive displacement pump, gear pump, and the like). Pumps can be hydrostatic or hydrodynamic. As used in this disclosure, a "pump" is a mechanical source of power that converts mechanical power into fluidic energy. A pump may generate flow with enough power to overcome pressure induced by a load at a pump outlet. A pump may generate a vacuum at a pump inlet, thereby forcing fluid from a reservoir **120** into the pump inlet to the pump and by mechanical action delivering this fluid to a pump outlet. Hydrostatic pumps are positive displacement pumps. Hydrodynamic pumps can be fixed displacement pumps, in which displacement may not be adjusted, or variable displacement pumps, in which the displacement may be adjusted. Exemplary non-limiting pumps include gear pumps, rotary vane pumps, screw pumps, bent axis pumps, inline axial piston pumps, radial piston pumps, and the like. Pump may be powered by any rotational mechanical work source, for example without limitation and electric motor or a power take off from an engine. In some embodiments, microfluidic pump **112** may include a syringe pump. "Syringe pump" as described herein is a device used to deliver a fluid using a syringe barrel and a syringe plunger. The syringe plunger may be used to route a fluid through the syringe barrel and into a microfluidic channel as will be described in further detail below. In some embodiments, syringe plunger may refer to a piston wherein a motor drives the piston and routes a fluid through syringe barrel. In some cases, syringe pump may be used to draw a fluid into syringe barrel. Syringe pump may be utilized in situations in which a user may seek to control the flow of a fluid. In some embodiments, a syringe needle diameter may vary such that a user may vary the flow rate of a fluid. In some embodiments, microfluidic pump **112** may include a precision pump also known as a pressure driven pump. A precision pump as defined herein is a pneumatic pump in which a flow of a fluid is controlled through a source of pressure applied onto the fluid. A pressure is applied, using a pressured gas, into a fluid reservoir **120** wherein the fluid is pushed through microfluidic channels. The flow rate of the fluid is measured by the pressure applied onto the fluid. In some embodiments, microfluidic pump **112** may include a peristaltic pump. "Peristaltic pump" as described herein, also referred to hose and tube and pump is a pump in which rollers squeeze a tube thereby routing the fluid through the tube. Rollers may be turned using a motor. Additional disclosure on plungers and actuating microfluids is disclosed in U.S. Nonprovisional application Ser. No. 18/107,135, filed on Feb. 8, 2023, and entitled "APPARATUS AND METHODS FOR ACTUATING FLUIDS IN A BIOSENSOR CARTRIDGE," the entirety of each of which is incorporated herein by reference.

(33) With continued reference to FIG. **1**, microfluidic pump **112** is configured to rout the flow of at

least a fluid **116**, wherein the fluid contains an analyte. At least a fluid **116** may include a fluid. Fluid may contain one or more suspensions and/or solutions of reagents, molecules, or other items to be analyzed and/or utilized, including without limitation monomers such as individual nucleotides, amino acids, or the like, one or more buffer solutions and/or saline solutions for rinsing steps, and/or one or more analytes to be detected and/or analyzed. Fluid and/or microfluidic subassembly **108** may be used, without limitation, in processes as disclosed in U.S. Nonprovisional application Ser. No. 17/337,931, filed on Jun. 3, 2021, and entitled "METHODS AND SYSTEMS FOR MONOMER CHAIN FORMATION," and/or as disclosed in U.S. Nonprovisional application Ser. No. 17/403,480, filed on Aug. 16, 2021, and entitled "TAGGED-BASE DNA SEQUENCING READOUT ON WAVEGUIDE SURFACES," the entirety of each of which is incorporated herein by reference.

(34) With continued reference to FIG. **1**, microfluidic subassembly **108** further includes at least a reservoir **120** configured to contain at least a fluid **116**. At least a reservoir **120** includes a reservoir **120**. Reservoir **120** may have at least an inlet, at least an outlet, or both. Reservoir **120** may further include, without limitation, a well, a channel, a flow path, a flow cell, a pump, and the like. In a non-limiting example, fluid may be input through at least an inlet into reservoir **120** and/or output through the at least an outlet. At least an outlet may be connected to other components and/or devices within microfluidic sub assembly or optoelectronic reader device **104**. For instance, and without limitation, at least an outlet may be connected to other microfluidic subassembly **108** such as a microfluidic channel as described below in this disclosure.

(35) With continued reference to FIG. **1**, in some embodiments, microfluidic subassembly **108** may include at least a channel. Additionally, or alternatively, reservoir **120** may include a channel. As used in this disclosure, a "channel" is a reservoir **120** having one or more of an inlet (i.e., input) and an outlet (i.e., output). Channels may have a sub millimeter scale consistent with microfluidics. Channels may have channel properties which affect other system properties (e.g., flow properties, flow timing, and the like). As used in this disclosure, "flow timing" is any time-dependent property associated with a flow of at least a fluid **116**. For instance, in some cases, flow timing may include a duration for a flow to reach, pass through, or otherwise interact with an element of microfluidic device **104** and/or other microfluidic features; for instance, and without limitation, flow out from reservoir **120**. As used in this disclosure, "channel properties" are objective characteristics associated with channels or a microfluidic device generally. Exemplary non-limiting channel properties include width, height, length, material, surface roughness, cross-sectional area, layout, and the like. Additionally, or alternatively, microfluidic subassembly **108** may include a microfluidic circuit. As used in this disclosure, a "microfluidic circuit" is a configuration of a plurality of microscale fluidic components within microfluidic subassembly **108**. Microscale fluidic components may include any components of microfluidic subassembly **108** as described herein. In a non-limiting example, microfluidic circuit may include a configuration of channels, individually addressable valves, and chambers through which fluid is allowed to flow. Additional disclosure on microfluidic subassemblies or features is disclosed in U.S. Nonprovisional application Ser. No. 18/121,712, filed on Mar. 15, 2023, and entitled "APPARATUS AND METHODS FOR PERFORMING MICROFLUIDIC-BASED BIOCHEMICAL ASSAYS," the entirety of each of which is incorporated herein by reference

(36) With continued reference to FIG. **1**, optoelectronic reader device **104** includes an optics subassembly **124**. "Optics subassembly" as described herein is a device used to detect the analyte within microfluidic subassembly **108**. Optics subassembly **124** includes an optical device **128** having at least one light source directed at the at least a fluid **116**. "Optical device" as described herein is a device capable of emitting light. In some embodiments, optical device **128** may emit multiple lights from multiple light sources. Optical device **128** may include a laser emitting device. Optical device **128** may include a distributed feedback laser (DFB), a (sampled grating) distributed Bragg reflector laser (DBR laser), a vertical-cavity semiconductor emitting laser (VCSEL), a

Vernier-tuned (VT) DBR laser, coupled ring-resonator laser (CRR), or any other laser diode configuration that may be tunable thermally across the resonances of a sensing element. The optics subassembly **124** and/or its components may be fully or partially integrated on a chip or through alignment and packaging of multi-photonic chips or a hybrid version of these alternatives. The choice of the light source of optical device **128** may be determined by the required wavelength resolution for sensing, the material platform of the passive components, and/or the sampling rate of the read-out electronics. The frequency drift of the laser caused by the inherent white and flicker frequency noise components may lower the achievable wavelength resolution in the sampling period while the required relative-intensity-noise and the output power of the laser may be determined by the dynamic range of the electronics and the extinction ratio of the sensor element. In some embodiments, optical device **128** may include a light emitting diode (LED) or an organic LED. Optical device **128** may further include optical fibers to transit at least one or more light. Optical

(37) With continued reference to FIG. **1**, optical device **128** may include an optical splitter **180** configured to split at least one light source **128** into more than one light beam. "Optical splitter" as defined herein is a waveguide structure used to split one or more optical signals such as at least one light source **128**. Optical splitters **180** receive a light beam through an input and output two or more separate light beams. Optical splitter **180** may include a waveguide beam splitter **182**. "Waveguide beam splitter" as described herein is a splitter that outputs multiple light sources from at least one light source **128**. Waveguide beam splitter **182** as described herein is a device used to split an incoming electromagnetic wave or light beam into two or more electromagnetic waves or light beams. The two or more electromagnetic waves or light beams are emitted in differing directions such that the waves or light beams are emitted at different objects or areas. In some embodiments an optical splitter **180** or a waveguide beam splitter **182** may be used to combine one or more light sources into one unfirm beam. Waveguide beam splitter **182** is a passive device in which a light is input into one end and two or more light sources are output at a second end. In some embodiments, waveguide beam splitter **182** may split at least one light source **128** into at least 50 light beams. In some embodiments, waveguide beam splitter **182** may split one or more light beams into differing ratios wherein one or more light beams have differing power outputs. For example, and without limitation a 50:50 splitter may contain similar output power settings whereas a 5:95 splitter may contain highly differing power output signals; other non-equal splitter ratios may alternatively or additionally be used, including without limitation 25:75, 20:80, 40:60, or the like. In some embodiments optical splitter **180** may include a Y-junction splitter wherein one light source is split into two evenly distributed light sources. Optical splitter **180** may contain multiple Y-junction splitter wherein multiple light sources are split evenly. In some embodiments, optical splitter **180** may include a multimode splitter wherein one light beam may be split into two or more light beams. The two or more light beams may have differing ratios as opposed to Y-junction splitters. In some embodiments, optical device **128** may include a planar-waveguide circuit splitter (PLC). PLC splitter may include, without limitation, an input fiber, an optical splitter **180** chip and a plurality of output fibers; PLC splitter may alternatively include an on-chip and/or photonic component, and may, for instance, be integrated with one or more on-chip waveguides or other optical interfaces. PLC splitter may further include a silica glass substrate wherein multiple waveguides are created by inputting at least one waveguide onto the silica glass substrate. In some embodiments, optical splitter **180** may include a polarization maintaining (PM) splitter. Pm splitter is a splitter wherein the two or more light beams that are output contain the same polarization state as the input signal or light. PM splitters contain output signals in configuration of 2,4 and 8 output signals. PM splitter may be used in situations wherein preserving polarization is beneficial or essential. This may include laboratory testing, medical applications, and the like. In some embodiments PLC splitter may include a PM splitter wherein the output waveguides of PLC maintain their polarization. PLC splitter may include a PM splitter such that at PM fiber array is placed on either end of the PLC

splitter. In some embodiments, optical device **128** may include a waveguide, wherein the waveguide is configured to guide at least one light source **128**. "Waveguide" as defined herein is a device configured to carry and control electromagnetic waves. Waveguide may control light beams across a specific path. Waveguide may include a cable, glass fiber, or a hollow tube containing a dielectric material that is designed to transmit electromagnetic waves. In some embodiments optical splitter **180** may be configured for multiplexed diagnostics. "Multiplexed diagnostics" as described herein is a process in which a plurality of analyte and/or biological samples are analyzed in a single given sample or fluid. This may be done using multiple light beams wherein each light beam is configured to detect a single analyte, molecule, nucleic acid or the like. In some embodiments, the one or more light beams are individually emitted at more than one analyte, wherein at least one of the more than one light beams is exposed to at least a fluid **116**.
(38) With continued reference to FIG. **1**, optics subassembly **124** includes a sensor. In some embodiments, sensor may include a photonic sensor. "Photonic sensor" as described herein is a device that is used to detect the physical properties of an analyte. Sensor may detect an optical property **140** such as a refractive index of the material, absorption, or emission properties. Optical properties received from the sensor may then be used to determine what the analyte in question may be. In addition, sensor may detect analyte properties such as the quantity or size of the analyte. Sensor may include a fiber optic sensor. "Fiber optic sensor" as described herein is a sensor using fiber-optic cables to transmit light to and from the analyte or the sensing element. Fiber optic sensor may receive an incoming light and convert the light into an electrical signal wherein the electrical signal may be used to extrapolate data such as the physical properties of the analyte or the sensing element. Fiber optics sensor may include a fiber Bragg grating sensor, a Fabry-Perot sensor, an evanescent wave sensor and any other fiber optic sensor that may be used to detect an analyte or sensing element. Sensor may include an evanescent wave (EW) sensor wherein EW sensor measures changes in refractive index, fluorescence, spectroscopic shifts, and any other changes in the evanescent field. Sensor may further include planar waveguide sensors, laser-based sensors, fluorescence sensors, photonic crystal sensors and the like. In some embodiments, sensor device **136** includes a photodetector **168**, the photodetector **168** configured to collect a receiving light emitted from optical device **128**. optical device **128** may emit a light beam onto an analyte, wherein a receiving light is reflected off of the analyte and detected by a sensor. In some embodiments, photodetector **168** may be configured to detect at least an optical property **140**. Photodetector **168** may include a photoemission detector, a thermal detector, a polarization detector, a photochemical detector, a P-N photodiode, a P-I-N photodiode, avalanche photodiodes, phototransistors, an MSM photodetector **168** and the like. Sensor may further include a phototransistor and a signal converter wherein the phototransistor detects a receiving light and converts the receiving light into electrical signals. Signal converter may then convert received light into an electric signal or another signal that may be used to detect an optical property **140**.
(39) With continued reference to FIG. **1**, in some embodiments, sensor device **136** may include a photodetector **168**. In some cases, sensor device **136** may include a plurality of photodetector **168***s*, for instance at least a first photodetector **168** and at least a second photodetector **168**. In some cases, at least a first photodetector **168** and/or at least a second photodetector **168** may be configured to measure one or more of first optical output and second optical output, from a first waveguide and a second waveguide, respectively. As used in this disclosure, a "photodetector **168**" is any device that is sensitive to light and thereby able to detect light. In some cases, a photodetector **168** may include a photodiode, a photoresistor, a photosensor, a photovoltaic chip, and the like. In some cases, photodetector **168** may include a Germanium-based photodiode. Light detectors may include, without limitation, Avalanche Photodiodes (APDs), Single Photon Avalanche Diodes (SPADs), Silicon Photomultipliers (SiPMs), Photo-Multiplier Tubes (PMTs), Micro-Channel Plates (MCPs), Micro-Channel Plate Photomultiplier Tubes (MCP-PMTs), Indium gallium arsenide semiconductors (InGaAs), photodiodes, and/or photosensitive or photon-detecting

circuit elements, semiconductors and/or transducers. Avalanche Photo Diodes (APDs), as used herein, are diodes (e.g., without limitation p-n, p-i-n, and others) reverse biased such that a single photon generated carrier can trigger a short, temporary “avalanche” of photocurrent on the order of milliamps or more caused by electrons being accelerated through a high field region of the diode and impact ionizing covalent bonds in the bulk material, these in turn triggering greater impact ionization of electron-hole pairs. APDs provide a built-in stage of gain through avalanche multiplication. When the reverse bias is less than the breakdown voltage, the gain of the APD is approximately linear. For silicon APDs this gain is on the order of 10-100. Material of APD may contribute to gains. Germanium APDs may detect infrared out to a wavelength of 1.7 micrometers. InGaAs may detect infrared out to a wavelength of 1.6 micrometers. Mercury Cadmium Telluride (HgCdTe) may detect infrared out to a wavelength of 14 micrometers. An APD reverse biased significantly above the breakdown voltage is referred to as a Single Photon Avalanche Diode, or SPAD. In this case the n-p electric field is sufficiently high to sustain an avalanche of current with a single photon, hence referred to as “Geiger mode.” This avalanche current rises rapidly (sub-nanosecond), such that detection of the avalanche current can be used to approximate the arrival time of the incident photon. The SPAD may be pulled below breakdown voltage once triggered in order to reset or quench the avalanche current before another photon may be detected, as while the avalanche current is active carriers from additional photons may have a negligible effect on the current in the diode. At least a first photodetector **168** may be configured to generate a first signal as a function of variance of an optical property **140** of the first waveguide, where the first signal may include without limitation any voltage and/or current waveform. Additionally, or alternatively, sensor device **136** may include a second photodetector **168** located down beam from a second waveguide. In some embodiments, second photodetector **168** may be configured to measure a variance of an optical property **140** of second waveguide and generate a second signal as a function of the variance of the optical property **140** of the second waveguide.

(40) With continued reference to FIG. **1**, in some cases, photodetector **168** may include a photosensor array, for example without limitation a one-dimensional array. Photosensor array may be configured to detect a variance in an optical property **140** of waveguide. In some cases, first photodetector **168** and/or second photodetector **168** may be wavelength dependent. For instance, and without limitation, first photodetector **168** and/or second photodetector **168** may have a narrow range of wavelengths to which each of first photodetector **168** and second photodetector **168** are sensitive. As a further non-limiting example, each of first photodetector **168** and second photodetector **168** may be preceded by wavelength-specific optical filters such as bandpass filters and/or filter sets, or the like; in any case, a splitter may divide output from optical matrix multiplier as described below and provide it to each of first photodetector **168** and second photodetector **168**. Alternatively, or additionally, one or more optical elements may divide output from waveguide prior to provision to each of first photodetector **168** and second photodetector **168**, such that each of first photodetector **168** and second photodetector **168** receives a distinct wavelength and/or set of wavelengths. For example, and without limitation, in some cases a wavelength demultiplexer may be disposed between waveguides and first photodetector **168** and/or second photodetector **168**; and the wavelength demultiplexer may be configured to separate one or more lights or light arrays dependent upon wavelength. As used in this disclosure, a “wavelength demultiplexer” is a device that is configured to separate two or more wavelengths of light from a shared optical path. In some cases, a wavelength demultiplexer may include at least a dichroic beam splitter. In some cases, a wavelength demultiplexer may include any of a hot mirror, a cold mirror, a short-pass filter, a long pass filter, a notch filter, and the like. An exemplary wavelength demultiplexer may include part No. WDM-11P from OZ Optics of Ottawa, Ontario, Canada. Further examples of demultiplexers may include, without limitation, gratings, prisms, and/or any other devices and/or components for separating light by wavelengths that may occur to persons skilled in the art upon reviewing the entirety of this disclosure. In some cases, at least a photodetector **168** may be communicative with

computing device, such that a sensed signal may be communicated with computing device.
(41) With continued reference to FIG. **1**, sensor is configured to sense at least a fluid **116** and detect an optical property **140**. At least a fluid **116** may include an analyte as described above. Sensor may detect an optical property **140** by sensing a receiving light emitted or radiated from analyte. Sensor may convert receiving light into electrical signals. Sensor may detect an optical property **140** of an analyte using the photoelectric effect. "Photoelectric effect" as described herein is an effect in which charged particles are released from a sensing element or analyte when it receives an incoming light or electromagnetic radiation. Sensor may receive the charged particles to detect an optical property **140**. Sensor may detect an optical property **140** by determining a change in the amount of light received and the amount of light sent from optical device **128**. Sensor may further detect an optical property **140** using the photelectric effect on a plurality of sensors as discussed in this disclosure. In some embodiments receiving light comprises an evanescent wave. "Evanescent wave" as described herein is a wave in which a light beam is emitted at a transparent media and total internal reflection occurs. In an evanescent wave, a receiving light may not be reflected off of the analyte to be detected. Instead, an interferometer device may be used to detect an optical property **140** of the analyte. "Interferometer device" as described herein is a device used to determine a phase shift between two beams emitted from a singular light source. An interferometer splits a light into two beams which travel in two differing directions wherein the two beams are then joined to produce interference. The interference may then be used to detect an optical property **140**. In some cases optical device **128** may include a Mach-Zehnder interferometer (MZI), a Michelson interferometer or a Fabry-Perot interferometer (FPI). Optical device **128** may further include any interferometer as described in this disclosure.
(42) With continued reference to FIG. **1**, sensor may contain an optical frequency discriminator configured to interpolate a change in resonance wavelength. "Optical frequency discriminator" as described herein is a device that determines a change in frequency between two optical signals. An optical frequency discriminator may contain a sample referencing element in which a signal is received from the sample referencing element for reference. Optical frequency discriminator may use two or more light beams from optical device **128** wherein one of the two or more light beams is emitted at a sample referencing element. Optical frequency discriminator may include an interferometer as described in this disclosure. optical frequency discriminator may contain structures including but not limited to an MZI, which may include, without limitation, a loaded and/or unbalanced ring-grating MZI or the like. MZI may consist of a first beam split into two light beams, wherein one the two light beams is emitted at a referencing element and a relative phase shift is determined between the two beams. Optical frequency discriminator may further contain an FPI wherein a light or optical wave passes through two parallel reflecting surfaces in which multiple reflected beams are created and detected. Optical frequency discriminator may be configured to interpolate a change in resonance wavelength by determining a change in frequency or phase shift between two optical signals as described above. Alternatively or additionally, optical frequency discriminator may detect optical differences such as without limitation phase differences for light or optical waves passed through cascaded rings and/or gratings.
(43) Still referring to FIG. **1**, in some embodiments, sensor device **136** may be in communication with computing device. For instance, and without limitation, sensor device **136** may communicate with computing device **148** using one or more signals. As used in this disclosure, a "signal" is a human-intelligible and/or machine-readable representation of data, for example and without limitation an electrical and/or digital signal from one device to another; signals may be passed using any suitable communicative connection. As used in this disclosure, "communicatively connected" means connected by way of a connection, attachment, or linkage between two or more relata which allows for reception and/or transmittance of information therebetween. For example, and without limitation, this connection may be wired or wireless, direct, or indirect, and between two or more components, circuits, devices, systems, and the like, which allows for reception and/or

transmittance of data and/or signal(s) therebetween. Data and/or signals therebetween may include, without limitation, electrical, electromagnetic, magnetic, video, audio, radio, and microwave data and/or signals, combinations thereof, and the like, among others. A communicative connection may be achieved, for example and without limitation, through wired or wireless electronic, digital, or analog, communication, either directly or by way of one or more intervening devices or components. Further, communicative connection may include electrically coupling or connecting at least an output of one device, component, or circuit to at least an input of another device, component, or circuit. For example, and without limitation, via a bus or other facility for intercommunication between elements of a computing device. Communicative connecting may also include indirect connections via, for example and without limitation, wireless connection, radio communication, low power wide area network, optical communication, magnetic, capacitive, or optical coupling, and the like. In some instances, the terminology "communicatively coupled" may be used in place of communicatively connected in this disclosure. A signal may include an optical signal, a hydraulic signal, a pneumatic signal, a mechanical signal, an electric signal, a digital signal, an analog signal, and the like. In some cases, a signal may be used to communicate with a computing device, for example by way of one or more ports. In some cases, a signal may be transmitted and/or received by computing device, for example by way of an input/output port. An analog signal may be digitized, for example by way of an analog to digital converter. In some cases, an analog signal may be processed, for example by way of any analog signal processing steps described in this disclosure, prior to digitization. In some cases, a digital signal may be used to communicate between two or more devices, including without limitation computing devices. In some cases, a digital signal may be communicated by way of one or more communication protocols, including without limitation internet protocol (IP), controller area network (CAN) protocols, serial communication protocols (e.g., universal asynchronous receiver-transmitter [UART]), parallel communication protocols (e.g., IEEE 128 [printer port]), and the like.

(44) Still referring to FIG. **1**, in some cases, apparatus **100**, sensor, and/or computing device **148** may perform one or more signal processing steps on a signal. For instance, apparatus **100**, sensor, and/or computing device **148** may analyze, modify, and/or synthesize a signal representative of data in order to improve the signal, for instance by improving transmission, storage efficiency, or signal to noise ratio. Exemplary methods of signal processing may include analog, continuous time, discrete, digital, nonlinear, and statistical. Analog signal processing may be performed on non-digitized or analog signals. Exemplary analog processes may include passive filters, active filters, additive mixers, integrators, delay lines, compandors, multipliers, voltage-controlled filters, voltage-controlled oscillators, phase-locked loops, and/or any other process using operational amplifiers or other analog circuit elements. Continuous-time signal processing may be used, in some cases, to process signals which vary continuously within a domain, for instance time. Exemplary non-limiting continuous time processes may include time domain processing, frequency domain processing (Fourier transform), and complex frequency domain processing. Discrete time signal processing may be used when a signal is sampled non-continuously or at discrete time intervals (i.e., quantized in time). Analog discrete-time signal processing may process a signal using the following exemplary circuits sample and hold circuits, analog time-division multiplexers, analog delay lines and analog feedback shift registers. Digital signal processing may be used to process digitized discrete-time sampled signals. Commonly, digital signal processing may be performed by a computing device **148** or other specialized digital circuits, such as without limitation an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a specialized digital signal processor **152** (DSP). Digital signal processing may be used to perform any combination of typical arithmetical operations, including fixed-point and floating-point, real-valued, and complex-valued, multiplication and addition. Digital signal processing may additionally operate circular buffers and lookup tables. Further non-limiting examples of algorithms that may be performed according to digital signal processing techniques include fast

Fourier transform (FFT), finite impulse response (FIR) filter, infinite impulse response (IIR) filter, and adaptive filters such as the Wiener and Kalman filters. Statistical signal processing may be used to process a signal as a random function (i.e., a stochastic process), utilizing statistical properties. For instance, in some embodiments, a signal may be modeled with a probability distribution indicating noise, which then may be used to reduce noise in a processed signal.

(45) With continued reference to FIG. **1**, apparatus **100** may further comprise a computing device **148** having processor **152** and memory wherein memory is communicatively connected to processor. Computing device **148** may include any computing device **148** as described in this disclosure. Memory may contain instructions configuring processor **152** to receive an analyte datum **160** form the optoelectronic reader device **104**. “Analyte datum” as described herein refers to the optical properties of analyte. Analyte datum **160** may include data. Analyte datum **160** may include data referring to the refractive index, intensity, frequency wavelength, polarization and the like. analyte datum **160** may be received by an input device as described in this disclosure. Input device may include any sensor as described in this disclosure. In some cases, memory contains instructions to transmit the analyte datum **160**. analyte datum **160** may be transmitted to a display device as described in this disclosure. User may view analyte datum **160** on a display device to determine optical properties of analyte. Memory may further contain instructions to transmit analyte datum **160** to a database **164**. Database **164** may be implemented, without limitation, as a relational database **164**, a key-value retrieval database **164** such as a NOSQL database **164**, or any other format or structure for use as a database **164** that a person skilled in the art would recognize as suitable upon review of the entirety of this disclosure. Database **164** may alternatively or additionally be implemented using a distributed data storage protocol and/or data structure, such as a distributed hash table or the like. Database **164** may include a plurality of data entries and/or records as described above. Data entries in a database **164** may be flagged with or linked to one or more additional elements of information, which may be reflected in data entry cells and/or in linked tables such as tables related by one or more indices in a relational database **164**. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various ways in which data entries in a database **164** may store, retrieve, organize, and/or reflect data and/or records as used herein, as well as categories and/or populations of data consistently with this disclosure. In some cases, computing device **148** may generate analyte information as a function of the analyte datum **160**. “Analyte information” as described herein is data relating to the specific name of the analyte. For example Analyte information may include data relating to the name of a Virus or a biomolecule that was detected by sensor device **136**. analyte datum **160** may be compared to a plurality of predetermined data and a specific analyte information is generated as a result. Plurality of predetermined data may include a plurality of biomolecules or organic compounds having specific optical properties wherein each optical property **140** may be correlated to a specific biomolecule. Computing device **148** may receive analyte datum **160** and compare it to the plurality of determined data such that analyte information is generated based on a “match” between the optical properties of analyte datum **160** and a match of a specific biomolecule in plurality of predetermined data. In some cases, a user may receive analyte datum **160** from database **164**. For example, a user may view analyte datum **160** on a remote device such as a smart phone wherein the smart phone receives analyte datum **160** from database **164**. User as described in this disclosure may include an ordinary user such as an individual seeking to determine whether a virus is present within a specific user sample. User may further include a lab technician, a scientist seeking to extrapolate data, a doctor and any other individual that may benefit from receiving and viewing analyte datum **160**.

(46) With continued reference to FIG. **1**, apparatus **100** contains a portable device **144**, wherein the portable device **144** is configured for point of care diagnostics. “Portable device” as defined herein refers to a device that may be carried or moved around from one location to another without the use of specialized equipment such as a forklift. Portable device **144** may be a device which can be used in a plurality of locations and not a specialized location such as a lab. Portable device **144** may

further include a device that does not need to be plugged into a wall outlet, or mounted onto a surface prior to use. "Point of care diagnostics" as described herein refers to the ability to detect and diagnose a disease or an analyte at or near a patient site. As opposed conventional to lab testing wherein a sample must be shipped or delivered to a lab, point of care diagnostics allows a physician, operator, or user to determine the properties of an analyte at or near the same location at a patient. Point of care diagnostics may include a device situated within an office or within a room in the office. Point of care diagnostics may further include a device that be used at home without the need for special equipment. Special equipment may include any equipment that may ordinarily be within a doctor's office and not within the home of an ordinary person. Point of care diagnostics may further include a "device kit" wherein the device kit contains any and all material necessary for detection of an analyte on site. Point of care diagnostics may further include same day testing wherein an analyte is detected within the same day as the sample/analyte was received. Pont of care diagnostics may further include same time testing wherein an analyte is detected at the same time the patient is present within the room. This may include a time up to an hour, or in some cases, up to six hours. Portable device **144** may be configured for point of care diagnostics such that portable device **144** may be carried outside of a conventional lab and into a plurality of areas, such as a home or a doctor's office. Portable device **144** may further be configured for point of care diagnostics wherein a user may place portable device **144** within a bag, backpack or purse and used in any remote location. In some embodiments, optoelectronic reader device **104** is substantially encased within portable device **144**. In some embodiments, optoelectronic reader device **104** includes portable device **144**. In some embodiments, apparatus **100** includes a battery **172**. Additionally, or alternatively, portable device **144** may include a battery **172** wherein portable device **144** may be used without an electrical connection such as a wall outlet. In some embodiments, portable device **144** may include a removable battery **172**, wherein a battery **172** can be removed and replaced with a new battery **172**. Battery **172** as defined herein refers to any battery **172** used to power conventional battery-operated devices. This may include a battery **172** suitable to power a flashlight, a smartphone, a lamp, a radio, a watch, and the like. In some embodiments, battery **172** may include a disposable battery **172**. In some embodiments battery **172** may include a rechargeable battery **172**. In some embodiments, portable device **144** may include a charging port wherein a charging chord may be used to recharge battery **172**. Charging port may be connected to an electrical outlet such as a wall socket or a power bank. Charging port may further be connected to another device containing a battery **172** or a source of electricity wherein the device may recharge battery **172**. In some embodiments, battery **172** may be used to power computing device, microfluidic pump **112**, optics subassembly **124** and any other components described in this disclosure that may use electrical devices as described in this disclosure.

(47) With continued reference to FIG. **1**, apparatus **100** may include a mechanical housing. As used in this disclosure, a "housing" refers to an outer structure configured to contain a plurality of components, such as, without limitation, components of apparatus **100** as described in this disclosure. In a non-limiting example, housing may include an outer casing of apparatus **100**. In some cases, housing may be made from a durable, lightweight material such as without limitation, plastic, metal, and/or the like. In some embodiments, housing may be designed and configured to protect sensitive components of apparatus **100** from damage or contamination. In a non-limiting example, apparatus **100** may include one or more flat facets located on mechanical housing configured to constrain optoelectronic reader device **104** as described above in this disclosure. As described herein "flat facet" refers to a surface or object that is smooth and event, without any significant curvature or bumps. In another non-limiting example, mechanical housing may include one or more physical notches and/or grooves that allow for precise placement of devices and/or components. In yet another non-limiting example, at least a mechanical housing may include one or more optical markers or alignment indicators that are visible (through human eye, microscope, any other imaging system, and/or the like) and allow for accurate positioning of devices and/or

components. In a further non-limiting example, mechanical housing may include one or more tapered or angled surfaces that guide the one at least a fluid **116** through apparatus **100**. In other non-limiting example, mechanical housing may include one or more surface coatings and/or modifications that reduce the likelihood of unwanted adhesion or interference with external components such as, without limitation, external device as described in further detail below. Additionally, or alternatively, mechanical housing may further include features such as latches, clips, or other fasteners that help to secure apparatus **100** in place during use.

(48) With continued reference to FIG. **1**, apparatus **100** may further contain a receiving pocket **176**, the receiving pocket **176** configured to receive a microfluidic cartridge. Receiving pocket **176** may be located on mechanical housing wherein microfluidic cartridge is inserted at least partially into mechanical housing. "Microfluidic cartridge" as defined herein is a component used for detection or analysis of fluids on a microscale level. Microfluidic cartridge may include a channel, reservoir **120** or valves that are configured to hold a microfluid containing the analyte that will be detected. Microfluidic cartridge may be made of a transparent material such glass or plastic wherein a light may emit through the transparent material and receive an optical property **140** form the fluid. Microfluidic cartridge may be a disposable cartridge wherein the microfluidic cartridge may be used for one-time use applications. Microfluidic cartridge may be placed within receiving pocket **176** wherein apparatus **100** may sense an optical property **140** of fluid contained within microfluidic cartridge. Microfluidic cartridge may contain an inlet wherein a fluid such as a blood sample is injected into the inlet. Microfluidic cartridge may include any microfluidic cartridge, microfluidic feature or microfluidic device as disclosed in U.S. Nonprovisional application Ser. No. 18/121,712.

(49) Referring now to FIG. **2**, an exemplary embodiment of an apparatus **200** for analyte detection is illustrated. FIG. **2**. shows an artistic illustration of the expanded view of one embodiment of apparatus **200** comprising three different sub-assemblies: the optical sub-assembly, the optoelectronics sub-assembly, and the microfluidic pump sub-assembly. Apparatus **200** includes an upper housing **204**, and an on-off switch cover. The optoelectronics sub assembly includes an on-off switch **212**, a digital board **216**, a ribbon cable **220** and an analog board **224**. The motor sub-assembly includes limit sensors **228**, motor boards **232**, a plunger grabbing mechanism **236** and a stepper motor **240**. The optics sub assembly includes an optical board **244**. A cartridge pocket **248** is connected to the optical board **244** and configured to receive a microfluidic cartridge as described in this disclosure. Apparatus **200** further includes a bottom housing **252**, wherein the bottom housing **252** and the upper housing **204** contain the components within apparatus **200**. Apparatus **200** further includes the pocket where the disposable cartridge can be inserted, and the mechanical housing. Mechanical housing includes an upper housing **204** and a lower/bottom housing **252**. Mechanical housing may contain any housing as described in this disclosure. Apparatus **200** further includes an on/off switch. On/off switch may be used to control the power output of apparatus **200**. For instance on/off switch may engage apparatus **200** in an "position" wherein electrical power is delivered to a light source or a sensor for analyte detection. One/off switch may further include an on/off cover, wherein the cover is configured such that a user may interact with on/off switch. Cover may further provide aesthetics benefits to apparatus **200** wherein cover compliments an upper housing. Cover may further constrain on/off switch withing upper housing and lower housing. Apparatus **200** further includes a digital board. Digital board may include a computing device as described in this disclosure. Digital board may provide for communicative connection between a variety of components of apparatus **200**. digital board may be configured to handle binary or digital signals such as communication with a remote device and the like. for example, and without limitation digital board may provide a communicative connection between processor and memory, wherein memory contains instructions configuring process to generate a result or to transmit data across a network. Apparatus **200** further includes an analog board. Analog board may be used to collect analog signals such as inputs from a sensor device

analog board and digital board may be connected using an analog to digital converter wherein input signals into analog board may be received by digital board. Apparatus **200** further contains a ribbon cable wherein the ribbon cable connects the analog board to the digital board. On/off switch, Digital board, ribbon cable and analog board may be included in an optoelectronics sub-assembly. Optoelectronics sub-assembly is a sub assembly of apparatus **200** which primarily deals with data acquisition and the processing of data using a computing device.

(50) With continued reference to FIG. **2**, apparatus **200** includes a motor-sub assembly including at least one limit sensor **228**, at least one motor board, at least one plunger grabbing mechanism and at least one stepper motor. “Motor-sub assembly” as defined herein is a sub assembly of apparatus **200** which is configured to route a biological sample that is received by apparatus **200**. Biological sample may be located within a microfluid cartridge wherein moto assembly is configured to route biological sample within microfluidic cartridge. At least one limit sensor **228** may include any sensor as described in this disclosure. At least one limit sensor **228** may further comprise a limit switch. A “limit switch” as described herein is a switch operated by the motion of a part. In a non-limiting example, limit switch may be used to indicate detect receiving of a microfluidic cartridge. The placement of a microfluidic cartridge within a receiving pocket will trigger motor-sub assembly to being detection of the analyte. Apparatus **200** further includes motor board wherein motor board may contain an electronically driven motor or at least one stepper motor. Motor board may be used to drive at least one plunger mechanism.

(51) With continued reference to FIG. **2**, apparatus **200** includes the optics sub assembly. Optics sub assembly may include any optics subassembly as described in this disclosure. Optics sub assembly includes an optical board. Optical board may include a light emitting device and a sensor as described in this disclosure. The optical source in apparatus **200** may be a distributed feedback laser (DFB), a (sampled grating) distributed Bragg reflector laser (DBR laser), a vertical-cavity semiconductor emitting laser (VCSEL), a Vernier-tuned (VT) DBR laser, coupled ring-resonator laser (CRR), or any other laser diode configuration that may be tunable thermally across the resonances of the sensing element. The optical-subassembly and/or its components may be fully or partially integrated on a chip or through alignment and packaging of multi-photonic chiplets or a hybrid version of these alternatives.

(52) With continued reference to FIG. **2**, apparatus **200** further includes a cartridge pocket. Cartridge pocket may include a receiving pocket or any other openings or pockets that may be configured to receive a microfluidic cartridge.

(53) Referring now to FIG. **3**, an exemplary embodiment of an optical subassembly **300** of apparatus as described in this disclosure is illustrated. The optical subassembly includes a custom-packaged TO-can laser **304**, a silica planar-waveguide circuit (PLC) splitter **308**, a silicon-nitride waveguide based unbalanced Mach-Zehnder interferometer on a photonic chip **312**, an array of photodiodes wire-bonded to a carrier **316**, a printed-circuit board (PCB) **320** that is fiber-coupled to a ribbon cable **324**, and connected to a male mechanical transfer (MT) ferrule inside a multi-fiber push-on (MPO) connector **328**. The MPO connector is attached to a multi-fiber push-on (MPO) adapter **332** housed inside the cartridge pocket that accepts an MPO connector with a female MT ferrule. The sub assembly further contains a housing **336** configured to hold the optical subassembly **300** together. The optical source/device in apparatus may be a distributed feedback laser (DFB), a (sampled grating) distributed Bragg reflector laser (DBR laser), a vertical-cavity semiconductor emitting laser (VCSEL), a Vernier-tuned (VT) DBR laser, coupled ring-resonator laser (CRR), or any other laser diode configuration that may be tunable thermally across the resonances of the sensing element. The optical subassembly **300** and/or its components may be fully or partially integrated on a chip or through alignment and packaging of multi-photonic chiplets or a hybrid version of these alternatives. It may be possible to include a silica PLC splitter as described in this disclosure. Additionally or alternatively, in some embodiments, it may be possibly to eliminate the need of the silica PLC splitter described in this disclosure that is used to

tap off the output power of laser into a frequency discriminator chip through realization of both the splitter and the UMZI on the same chip. It may also be possible to integrate a photodiode array sub-assembly as illustrated in FIG. **7** and/or the entailed trans-impedance amplifiers (TIAs) (depicted to be included on the electro-optic board of the optoelectronics sub-assembly in FIG. **9** as a nonlimiting example) on the same passive chip through bonding or transfer-printing or a separate active/passive/hybrid chiplet. Optoelectronic reader device **104** may be configured to interrogate optical subassembly and/or photonics chip and/or chiplets via horizontal edge coupling. For the purposes of this disclosure, an "edge coupling" is a process of coupling light from an optical waveguide or resonator to a photodetector or optical fiber located in close proximity and on the edge of the waveguide or the resonator. As a non-limiting example, in the edge coupling, components including optoelectronic reader device **104**, optical subassembly, photonics chip, and/or chiplets may be positioned horizontally to each other, and the light propagating through the waveguide may be directed towards optical and/or electro-optical elements. Alternatively or additionally, components including optoelectronic reader device **104**, optical subassembly, photonics chip, and/or chiplets may be coupled and/or transfer signals therebetween using a vertical coupling. For the purposes of this disclosure, a "vertical coupling" is a process of coupling light from an optical waveguide or resonator to a photodetector or optical fiber located in close proximity and vertically to the waveguide or the resonator. As a non-limiting example, in the vertical coupling, components including optoelectronic reader device **104**, optical subassembly, photonics chip, and/or chiplets may be positioned perpendicular to each other, and the light propagating through a waveguide may be directed upwards towards one or more elements from one or more other elements. Alternatively or additionally, optoelectronic reader device **104** may be configured to interrogate optical subassembly and/or photonics chip and/or chiplets using one or more grating couplers such as etched and/or surface grating couplers, using one or more polymer optic connector, or the like; for the purposes of this disclosure, a "grating coupler" is an optical component that is used to couple light into and out of an optical waveguide.. One or more elements and/or components of optoelectronic reader device **104**, optical subassembly, photonics chip, and/or chiplets using co-packaged optics, thermo-plastic and/or other polymer based micro-lenses and light turn modules.
(54) The relative movement of the output frequency of the source may then be evaluated (e.g. by using the spacing between the output fringes of the UMZI as shown in the bottom right power vs. time). The choice of the optical source may be determined by the required wavelength resolution for sensing, the material platform of the passive components, and/or the sampling rate of the read-out electronics. The frequency drift of the laser caused by the inherent white and flicker frequency noise components may lower the achievable wavelength resolution in the sampling period while the required relative-intensity-noise and the output power of the laser may be determined by the dynamic range of the electronics and the extinction ratio of the sensor element.
(55) Referring now to FIG. **4**, an exemplary embodiment of a TO-can laser **400** for an optics subassembly is illustrated. Optical device includes a TO-can **400** laser sub assembly. "TO-can **400** Laser" as described herein is a laser encased within a metal can **404**, wherein the metal can **404** may be used to mount TO-can **400** laser onto an assembly. TO-can **400** laser may include a laser diode **408**. Laser sub assembly includes a 1310 nm distributed feedback laser chip commonly used in fiber to the home (FTTH) applications which is custom-packaged with a Peltier thermo-electric controller element **412**, thermistor, and monitor photodiode into a fiber-coupled TO-can **400** with a broad aluminum base **416** to maximize heat-sinking efficiency. FIG. **4** further shows also shows wire-bonds **420** going from laser contact pads to sub-carrier pads that are then routed to the leads of the TO-can laser **400**.
(56) Referring now to FIG. **5**, a silica PLC-based splitter **500** is illustrated. Silica PLC-based splitter **500** is an optical splitter similar to an optical splitter as described in this disclosure. The splitter **500** is realized by packaging the silica PLC splitter chip **504** with a PM fiber array **508** on

either side. Silica PLC based splitter **500** (Splitter) is a device that splits an incoming light beam into multiple light beams. Splitter **500** may include an input and an output wherein a light beam is fed into the input and a plurality of light beams are emitted through the output. Splitter **500** may include a waveguide similar to a waveguide as described in this disclosure. splitter may further include a plurality of waveguides wherein each waveguide is configured to guide the waves of the plurality of light beams. Silica may be used as a substrate in a PLC splitter due to its favorable optical properties. Splitter **500** may include a polarization maintaining (PM) PLC splitter with a 5/95 splitting ratio. The splitter is realized by packaging the silica PLC splitter chip with a PM fiber array on either side.

(57) Referring now to FIGS. **6**A-D, an exemplary illustrative layout of a silicon nitride waveguide based unbalanced MZI on a chip **600** to be used as a frequency discriminator to linearize the wavelength sweep of the laser is illustrated. In addition, FIG. **6** illustrates Shown are the waveguide cross-section geometry, mode simulations, general configuration of an unbalanced MZI, and a non-limiting example of experimental results of a fiber-array attached chip with a 14 pm free-spectral range at 1310 nm. The frequency discriminator depicted in FIG. **6** may be used to evaluate the relative wavelength movement of the tuned optical source. While the illustrative example of the discriminator depicted in FIG. **6** utilizes an unbalanced Mach-Zehnder configuration, devices such as stable Fabry-Perot cavity, a ring resonator, a gas cell, a free-space etalon, or any other reference cavity with a known free-spectral range and higher degree of thermal stability may be employed for clocking the read-out electronics as the source wavelength is tuned across the sensing element. In some examples, only the relative movement of source wavelength is of interest and the knowledge of absolute wavelength of source is not required, assuming the material and waveguide dispersion of the sensing element do not significantly vary the group index over the anticipated wavelength drift of the source and reference during the time of measurement.

(58) Referring to FIG. **6**D, mode simulations of the silicon nitride waveguide based unbalanced MZI on a chip are illustrated.

(59) Referring now to FIG. **7**, an exemplary embodiment of a photodetector subassembly **700** is illustrated. Photodetector subassembly **700** includes an arrangement of photodiode array **704** wire-bonded on a PCB **708** and optically coupled to a fiber array **712** routed into a male MT ferrule inside a MPO connector **716**. Photodetector subassembly **700** includes a 16-channel fiber array from MPO connector **716** providing the input signals for the photodetectors that are biased and interrogated via the optoelectronics sub-assembly through the leads on the left of the PCB.

(60) Referring now to FIG. **8**, an exemplary high level system diagram of an optoelectronics reader device **800** is illustrated. An electro-optic board **804** contains a component that plugs into an optics board via a male header on a photodiode array assembly. Reader device **800** further includes a printed circuit board (PCB) **808** having a low-noise driver and amplifier electronics for a laser current. Reader device **800** further includes a TEC, a monitor photodiode, a thermistor monitor, and a photodetector array. PCB **808** controls the electro-optic (EO) board **804** electronics, handles power management, data acquisition, and streaming. Reader device **800** may be designed to be capable of running via a 5V supply from a common USB-C cable. Computer **812** may also transit or receive data from reader device through the USB-C. The driver, acquisition, control, and power management electronics described herein may be considered as one of the embodiments of the optoelectronics sub-assemblies for Reader device **800** described here with. It may be possible to integrate an electro-optic board **804** (also referred to as an analog board in this disclosure) and digital board on a similar PCB or realize an ASIC comprising all or part of the electronic components on these PCBs. The implementation of microcontroller-based design of acquisition, streaming, biasing, and monitoring of a laser, thermistor, sensor elements and other communication controls may be considered as one of the embodiments of the reader device **800**. The same control system may be realized using a field-programmable gated array (FPGA) or a microprocessor or a system-on-module (SOM). While each of these variants offer their own advantages of flexibility

and programmability features, the design choice of these control elements depends on the number of sensing elements involved, and the SWAP+C (size, weight, area, power, and cost) constraints. Reader device may include a battery **812** to power reader device.

(61) Referring now to FIG. **9**, An exemplary embodiment of an optoelectronic subassembly **900** is illustrated. Optoelectronic subassembly **900** may include an analog board **904**, a digital board **908**, a ribbon cable **912** to connect the analog board **904** to the digital board **908**, on/off switch **916**, and a battery **920** to power the optoelectronics subassembly **900**.

(62) Referring now to FIG. **10**, an exemplary embodiment of an assembly **1000** of a TO-can laser **1004** mounted on an analog board **1008** is illustrated. TO-can laser **1004** may include a connecter wherein the connecter is mounted to analog board **1008** and TO-can laser **1004** is mounted to connecter. Connecter may be used to orient the direction of TO-can laser **1004**. Connector may include a heat-sink mount wherein TO-can laser sub-assembly **1000** is interfaced on a heat-sink mount with the EO board via through-holes. The pins on the TO-can laser **1004** may be bent 90 degrees up to pass through the holes on the EO-board and soldered for firm contact.

(63) Referring now to FIG. **11**, An exemplary embodiment of a schematic of a firmware architecture **1100** with two microcontrollers in a master/slave configuration is illustrated. Firmware architecture may include firmware controls that are controlled through application core logic **1104**. The firmware controls may use a bang-bang control system to repeatedly sweep the wavelength of the laser by controlling the current on the TEC element while monitoring the voltage output of the thermistor. A data acquisition **1108**, a storage controller **1112**, and a communication controller (inter-processing comm) **1116** are controlled by a master microcontroller to acquire a plurality of data, save it on an on-board non-volatile memory **1120** for later retrieval of diagnostic measurement, and/or stream the plurality data via user-chosen protocol such as USB-C through a USB interface **1124**, a windows (Win) interface **1128** or Wi-Fi. An object pool **1132** may allow for already initialized objects wherein objects are retrieved from an object pool **1132** rather than allocated and destroyed continuously. Object pool **1132** may allow for faster processing times since objects are continuously used. A thermoelectric (TEC) controller **1136** may be used to transport heat away from various processing components in order to maintain ideal processing temperatures. Firmware architecture **1100** may include a plurality of drivers in order to allow firmware architecture **1100** to interact with a variety of components. This includes, but is not limited to an ADC driver **1140**, an FMC driver **1144**, a USB driver **1148**, a timer driver **1152**, a DAC driver **1156**, a UART driver **1160**, a DMA driver **1164**, and an I2C driver **1168**. System **1100** may include a stream controller **1172** to control the stream of data that is being delivered. Firmware architecture and/or system **1100** may include a power control **1182** to control the power output of a device. System may further include a laser control **1186** to control the power and various setting of a laser on a device. System may further include LEDS **1190** that may be used as indicators that a particular process is running; system is powered on and/or system has completed processing data. Buttons **1194** may be used as input device where buttons **1194** are used to input a command into a device. For example, button may be used to signify to a system that a process should begin or end. A gas gauge **1198** may determine the amount of gas present within a cell wherein the gas is used for laser absorption spectroscopy.

(64) Referring now to FIG. **12**, shows an exemplary embodiment of a cloud architecture **1200**. A “cloud architecture” as described herein is a server or a platform that may be accessed through a network. A cloud may contain software that allows users to interact with the network. A cloud may be used to share files or communicate with other devices on a similar work. Clouds may be utilized for a wide variety of application such as data storage, business (processing transactions, making payments, purchasing products, tracking shipments and the like) entertainment, (Movies, films, streaming, music, and the like) social networking, education, GPS, and the like. Cloud architecture as described herein refers to the design and structure that make up the cloud network. In a cloud architecture, a device proximal to apparatus (or integrated within apparatus or connected by wired

or wireless/connection) as described above, transmits data to a remote device and/or end device for processing. The end device may contain sufficient computing power to process data and determine calculations and various outputs that may be required. End device may connect using any suitable local or global connection protocol and/or network, including local area network, wide area network, wired and/or wireless connections. Connection protocols may include, without limitation, any protocol for connection including without limitation the MATTER or THREAD protocols promulgated by the Thread Group, Inc. of San Ramon, California. Remote device may then transmit data back to apparatus to display results. A cloud network may include a network and physical components, such as wiring and the like to maintain the network. A cloud network may further include servers such as a computing device that is designed to provide a service to a customer. A cloud network may further include storage such that users may store data on the network. A user may utilize cloud architecture **1200** to securely acquire data from an apparatus as described in this disclosure. A user may further utilize cloud architecture **1200** to securely acquire a plurality of data from a plurality of apparatuses as described in this disclosure. Cloud architecture **1200** may be accessed using a remote device. Cloud architecture **1200** may be stored on a database wherein the plurality of data may be stored on a database as well. In some embodiments cloud architecture **1200** and/or firmware architecture as described in FIG. **11**, may perform processing of acquired sensor data from an apparatus as described in this disclosure. Alternatively, apparatus may perform onboard processing of acquired sensor data. Additionally, or alternatively apparatus may limit the data that is processed or uploaded to a cloud or database. Cloud architecture **1200** may include an end device **1204**, wherein the end device **1204** may function as a source or destination of the information being received. End device **1204** in this disclosure may refer, in a non-limiting example, to a database or the apparatus described above. End device **1204** may be configured according to a Message Queue Telemetry Transport (MQTT) protocol **1208** wherein the MQTT protocol **1208** is utilized to send and receive data through a network. End device may be connected to an Internet of things (IoT) device such as IoT core **1212**, wherein IoT core **1212** is a cloud service that allows end device **1204** to be connected to a plurality of devices on a network and connect with cloud applications on the network. IoT core may be a fully managed cloud service that allows devices to connect seamlessly over a network. IoT core **1212** may communicate with an event processor **1216** wherein event processor **1216** performs actions once an event is received. Information processed by event processor may be stored on a device table **1220**. End device may further send an IoT rule **1224** wherein the IoT rule **1224** performs actions on a network and communicates with other devices. An IoT rule **1224** may send data from a device to a cloud or other cloud networks. Cloud architecture **1200** may further include a data firehouse **1228** wherein the data firehose **1228** may capture and load streaming data into a data lake, a warehouse, or analytical services. A firehouse processor **1232** may send any data to a measurement table **1236**. Firehouse processor is a processor configured to process data from data firehouse **1228**. Processor may include any processor described herein. Cloud architecture may further include a data formatter **1244**, wherein the data formatter **1244** is a computing process in which data is formatted in order to ensure compatibility with another device. Data may be formatted to ensure that data may be accessed through multiple networks. The formatted data may be placed in a formatted data bucket **1248**, wherein the formatted data bucket is configured to store the formatted data. Cloud architecture may include a start measurement feature **1256** wherein the start measurement feature sends a signal or commands a device to start measuring data. The data may then be stored on a device table. Cloud architecture may further include a stop measurement **1260** feature wherein the stop measurement feature is configured to stop the measurement of an analyte as described above. Data acquire from the stop measurement **1260** feature is then placed into device table **1220**.

(65) Referring now to FIG. **13**, an exploded view of a motor subassembly **1300** is illustrated. FIG. **13** shows an expanded view of one of the embodiments of motor assembly **1300** used to grab the plunger in a disposable cartridge that would then be used to route the biological sample on the

microfluidic cartridge. The motor subassembly **1300** includes limit sensors **1304**, motor boards, **1308**, a plunger grabbing mechanism **1312**, a stepper motor **1316** and a battery **1320**. The optics sub assembly includes an optical board **244**. Motor subassembly **1300** may include a microfluidic assembly as described in this disclosure. Motor subassembly **1300** may be used to grab a plunger in a disposable cartridge that would then be used to route a biological sample on a microfluidic cartridge. In this embodiment, an Arduino driven stepper-motor is used to drive a spring-loaded collet forward to grab the plunger designed to be within the cartridge.
(66) Referring now to FIG. **14**, an exemplary embodiment of a spring-loaded collet mechanism **1400** is illustrated. Spring collet mechanism **1400** may be used to implement a pump such as a syringe pump as described in this disclosure, for a microfluidic cartridge. The motor sub-assembly described in FIG. **13** comprises an Arduino driven stepper motor that controls a bi-phase stepper motor driver to control the spring-loaded collet via the movement of a stepper motor. This miniaturized version of microfluidic pump and the accompanying grabbing mechanism fits right beside an MPO connector attached to the photodiode array of the optics sub-assembly in the cartridge pocket, as shown in FIG. **15**. This enables seamless control of cartridge photonics and microfluidics. However, it may be noted that the miniaturized pump can as well be operated via the optoelectronics sub-assembly with an additional and compatible driver or an ASIC or a peristaltic or piezo driven pump or may be discarded altogether when operating with a passive microfluidic cartridge. The mechanism includes a mock syringe **1404**, a collet, **1408**, a second collet **1412** and a spring **1416**.
(67) Referring now to FIG. **15**, an exemplary embodiment of a mechanical housing **1500** for an apparatus is illustrated. Mechanical housing **1500** includes an upper housing **1504** and a lower housing **1508**. An interfacing housing part **1512** allows for simultaneous interrogation of optics via the MPO adapter and the fluidics via the spring-loaded collet mechanism.
(68) Referring now to FIG. **16**, a method **1600** for analyte detection is illustrated. At step **1605**, method **1600** includes receiving an optoelectronic device. Optoelectronic reader device includes a microfluidic subassembly. Microfluidic assembly includes a microfluidic pump, the microfluidic pump configured to route the flow of at least a fluid, wherein the at least a fluid contains an analyte and at least a reservoir configured to contain the at least a fluid. Optoelectronic reader device further includes an optics subassembly. Optics sub assembly includes an optical device having at least one light source directed at the at least a fluid and a sensor device configured to sense the at least a fluid and detect at least an optical property. In some embodiments, sensor device includes a photodetector, the photodetector configured to collect a receiving light from the optical device. In some cases, the receiving light furthering comprising an evanescent wave. In some cases, the optical device further comprising an optical splitter, the optical splitter configured to split the at least one light source into more than one light beams. In some cases, the more than one light beam individually emitted at more than one analyte, wherein at least one of the more than one light beams is exposed to the at least a fluid. In some cases, the optics subassembly further includes an optical frequency discriminator, the optical frequency discriminator configured to interpolate a change in resonance wavelength. This may be implemented, without limitation, as described above in reference to FIGS. **1-16**.
(69) With continued reference to FIG. **16**, at step **1610** method **1600** includes flowing, using the microfluidic subassembly, the at least a fluid through the at least a reservoir. This may be implemented, without limitation, as described above in reference to FIGS. **1-16**.
(70) With continued reference to FIG. **16**, at step **1615** method **1600** includes emitting, using the optical device, at least one light source onto the fluid. This may be implemented, without limitation, as described above in reference to FIGS. **1-16**.
(71) With continued reference to FIG. **16**, at step **1620** method **1600** includes sensing, using the sensor device, the optical property of the at least a fluid, wherein the optoelectronic reader device is a portable device configured for point of care diagnostics. In some cases, sensing the optical

property of the at least a fluid further includes sensing a plurality of optical properties of the at least a fluid, wherein the optical splitter is configured for multiplexed diagnostics. This may be implemented, without limitation, as described above in reference to FIGS. **1-16**.

(72) Referring now to FIG. **17**, an exemplary embodiment of a method **1700** for detecting an analyte is illustrated. The method includes emitting light using a tunable laser **1704** through a splitter **1708**. The method may further include measuring the frequency of an optical wave using a wavemeter **1712**. The method further includes emitting a light into a second splitter **1716**. The method may further include emitting a first light from splitter **1716** onto a sensor ring **1720**. The method may further include using a photodetector **1728** to determine an optical property of the sensor ring. The method may further include emitting a second light from splitter onto a reference ring **1724**. A second photodetector **1732** may then detect the optical properties of the reference ring **1724**. In some cases, FIG. **17** illustrates the concept of an apparatus as described in this disclosure to sense the relative shift in resonance wavelength between two identical photonic sensing elements on a chip, one of which is exposed to the biological analyte sample of interest. Depending on the sweep-repeatability error achievable with the optical sub-assembly and the sensitivity requirements of analyte detection, it may also be possible for the apparatus to determine absolute shift of a single sensing element. This evanescent field sensing element on the photonic chip can be one of, or a hybrid combination of possible photonic resonant structures including but not limited to micro-ring resonators photonic crystal cavities, or photonic grating-based resonators or Mach-Zehnder interferometer (MZI) or other interferometric structures. The change in the resonance wavelength is determined by splitting the output power of a laser among all the sensing elements while sweeping the wavelength of the laser across multiple resonances of the sensing elements and processing their optical output spectra. An optical frequency discriminator like an unbalanced MZI or a Fabry-Perot (FP) resonant cavity with a known free spectral range (FSR) and high thermal stability is employed to interpolate and linearize the tuned laser wavelength. As depicted in FIG. **17**, the apparatus determines the nature of biological analyte through detection of change in the resonance wavelength by sweeping the wavelength of a tunable laser through the resonances of the sensor chip. The optical source may be split across an array of sensing elements allowing simultaneous sensing of a variety of analytes. This may allow the flexibility for each of the photonic component in the proposed design to be realized in the photonic platform of choice. This includes but is not limited to the currently foundry friendly materials like, silicon, silica, silicon nitride for the ring resonators, splitters, and the frequency discriminator, while the optical source and the photodetectors may be realized in silicon, germanium, III-V, or other waveguide platforms. Such flexibility may enable customization of individual components of the sensor from a myriad of photonic platforms to suit the requirements of the sensing application and/or environment.

(73) Referring now to FIG. **18**, the measured sweep repeatability error of an optical sub-assembly as compared to a commercial low-noise laser is illustrated. Shown is a non-limiting example of validation of the laser sweep repeatability inside the complete reader apparatus described in FIGS. **1-17**. The sweep repeatability error was evaluated using a standard Hydrogen-Fluoride gas cell with an absorption peak near 1312 nm. The repeatability when compared to a commercial low-noise laser is plotted herein.

(74) It is to be noted that any one or more of the aspects and embodiments described herein may be conveniently implemented using one or more machines (e.g., one or more computing devices that are utilized as a user computing device for an electronic document, one or more server devices, such as a document server, etc.) programmed according to the teachings of the present specification, as will be apparent to those of ordinary skill in the computer art. Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as will be apparent to those of ordinary skill in the software art. Aspects and implementations discussed above employing software and/or software modules may also include appropriate hardware for assisting in the implementation of the machine executable instructions of

the software and/or software module.
(75) Such software may be a computer program product that employs a machine-readable storage medium. A machine-readable storage medium may be any medium that is capable of storing and/or encoding a sequence of instructions for execution by a machine (e.g., a computing device) and that causes the machine to perform any one of the methodologies and/or embodiments described herein. Examples of a machine-readable storage medium include, but are not limited to, a magnetic disk, an optical disc (e.g., CD, CD-R, DVD, DVD-R, etc.), a magneto-optical disk, a read-only memory “ROM” device, a random-access memory “RAM” device, a magnetic card, an optical card, a solid-state memory device, an EPROM, an EEPROM, and any combinations thereof. A machine-readable medium, as used herein, is intended to include a single medium as well as a collection of physically separate media, such as, for example, a collection of compact discs or one or more hard disk drives in combination with a computer memory. As used herein, a machine-readable storage medium does not include transitory forms of signal transmission.
(76) Such software may also include information (e.g., data) carried as a data signal on a data carrier, such as a carrier wave. For example, machine-executable information may be included as a data-carrying signal embodied in a data carrier in which the signal encodes a sequence of instruction, or portion thereof, for execution by a machine (e.g., a computing device) and any related information (e.g., data structures and data) that causes the machine to perform any one of the methodologies and/or embodiments described herein.
(77) Examples of a computing device include, but are not limited to, an electronic book reading device, a computer workstation, a terminal computer, a server computer, a handheld device (e.g., a tablet computer, a smartphone, etc.), a web appliance, a network router, a network switch, a network bridge, any machine capable of executing a sequence of instructions that specify an action to be taken by that machine, and any combinations thereof. In one example, a computing device may include and/or be included in a kiosk.
(78) FIG. **19** shows a diagrammatic representation of one embodiment of a computing device in the exemplary form of a computer system **1900** within which a set of instructions for causing a control system to perform any one or more of the aspects and/or methodologies of the present disclosure may be executed. It is also contemplated that multiple computing devices may be utilized to implement a specially configured set of instructions for causing one or more of the devices to perform any one or more of the aspects and/or methodologies of the present disclosure. Computer system **1900** includes a processor **1904** and a memory **1908** that communicate with each other, and with other components, via a bus **1912**. Bus **1912** may include any of several types of bus structures including, but not limited to, a memory bus, a memory controller, a peripheral bus, a local bus, and any combinations thereof, using any of a variety of bus architectures.
(79) Processor **1904** may include any suitable processor, such as without limitation a processor incorporating logical circuitry for performing arithmetic and logical operations, such as an arithmetic and logic unit (ALU), which may be regulated with a state machine and directed by operational inputs from memory and/or sensors; processor **1904** may be organized according to Von Neumann and/or Harvard architecture as a non-limiting example. Processor **1904** may include, incorporate, and/or be incorporated in, without limitation, a microcontroller, microprocessor, digital signal processor (DSP), Field Programmable Gate Array (FPGA), Complex Programmable Logic Device (CPLD), Graphical Processing Unit (GPU), general purpose GPU, Tensor Processing Unit (TPU), analog or mixed signal processor, Trusted Platform Module (TPM), a floating point unit (FPU), system on module (SOM), and/or system on a chip (SoC).
(80) Memory **1908** may include various components (e.g., machine-readable media) including, but not limited to, a random-access memory component, a read only component, and any combinations thereof. In one example, a basic input/output system **1916** (BIOS), including basic routines that help to transfer information between elements within computer system **1900**, such as during start-up, may be stored in memory **1908**. Memory **1908** may also include (e.g., stored on one or more

machine-readable media) instructions (e.g., software) **1920** embodying any one or more of the aspects and/or methodologies of the present disclosure. In another example, memory **1908** may further include any number of program modules including, but not limited to, an operating system, one or more application programs, other program modules, program data, and any combinations thereof.

(81) Computer system **1900** may also include a storage device **1924**. Examples of a storage device (e.g., storage device **1924**) include, but are not limited to, a hard disk drive, a magnetic disk drive, an optical disc drive in combination with an optical medium, a solid-state memory device, and any combinations thereof. Storage device **1924** may be connected to bus **1912** by an appropriate interface (not shown). Example interfaces include, but are not limited to, SCSI, advanced technology attachment (ATA), serial ATA, universal serial bus (USB), IEEE 1394 (FIREWIRE), and any combinations thereof. In one example, storage device **1924** (or one or more components thereof) may be removably interfaced with computer system **1900** (e.g., via an external port connector (not shown)). Particularly, storage device **1924** and an associated machine-readable medium **1928** may provide nonvolatile and/or volatile storage of machine-readable instructions, data structures, program modules, and/or other data for computer system **1900**. In one example, software **1920** may reside, completely or partially, within machine-readable medium **1928**. In another example, software **1920** may reside, completely or partially, within processor **1904**.

(82) Computer system **1900** may also include an input device **1932**. In one example, a user of computer system **1900** may enter commands and/or other information into computer system **1900** via input device **1932**. Examples of an input device **1932** include, but are not limited to, an alpha-numeric input device (e.g., a keyboard), a pointing device, a joystick, a gamepad, an audio input device (e.g., a microphone, a voice response system, etc.), a cursor control device (e.g., a mouse), a touchpad, an optical scanner, a video capture device (e.g., a still camera, a video camera), a touchscreen, and any combinations thereof. Input device **1932** may be interfaced to bus **1912** via any of a variety of interfaces (not shown) including, but not limited to, a serial interface, a parallel interface, a game port, a USB interface, a FIREWIRE interface, a direct interface to bus **1912**, and any combinations thereof. Input device **1932** may include a touch screen interface that may be a part of or separate from display **1936**, discussed further below. Input device **1932** may be utilized as a user selection device for selecting one or more graphical representations in a graphical interface as described above.

(83) A user may also input commands and/or other information to computer system **1900** via storage device **1924** (e.g., a removable disk drive, a flash drive, etc.) and/or network interface device **1940**. A network interface device, such as network interface device **1940**, may be utilized for connecting computer system **1900** to one or more of a variety of networks, such as network **1944**, and one or more remote devices **19419** connected thereto. Examples of a network interface device include, but are not limited to, a network interface card (e.g., a mobile network interface card, a LAN card), a modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (e.g., the Internet, an enterprise network), a local area network (e.g., a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network, a data network associated with a telephone/voice provider (e.g., a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. A network, such as network **1944**, may employ a wired and/or a wireless mode of communication. In general, any network topology may be used. Information (e.g., data, software **1920**, etc.) may be communicated to and/or from computer system **1900** via network interface device **1940**.

(84) Computer system **1900** may further include a video display adapter **1952** for communicating a displayable image to a display device, such as display device **1936**. Examples of a display device include, but are not limited to, a liquid crystal display (LCD), a cathode ray tube (CRT), a plasma display, a light emitting diode (LED) display, and any combinations thereof. Display adapter **1952**

and display device **1936** may be utilized in combination with processor **1904** to provide graphical representations of aspects of the present disclosure. In addition to a display device, computer system **1900** may include one or more other peripheral output devices including, but not limited to, an audio speaker, a printer, and any combinations thereof. Such peripheral output devices may be connected to bus **1912** via a peripheral interface **1956**. Examples of a peripheral interface include, but are not limited to, a serial port, a USB connection, a FIREWIRE connection, a parallel connection, and any combinations thereof.
(85) The foregoing has been a detailed description of illustrative embodiments of the invention. Various modifications and additions can be made without departing from the spirit and scope of this invention. Features of each of the various embodiments described above may be combined with features of other described embodiments as appropriate in order to provide a multiplicity of feature combinations in associated new embodiments. Furthermore, while the foregoing describes a number of separate embodiments, what has been described herein is merely illustrative of the application of the principles of the present invention. Additionally, although particular methods herein may be illustrated and/or described as being performed in a specific order, the ordering is highly variable within ordinary skill to achieve methods, apparatuses, and software according to the present disclosure. Accordingly, this description is meant to be taken only by way of example, and not to otherwise limit the scope of this invention.
(86) Exemplary embodiments have been disclosed above and illustrated in the accompanying drawings. It will be understood by those skilled in the art that various changes, omissions and additions may be made to that which is specifically disclosed herein without departing from the spirit and scope of the present invention.

Claims

1. An apparatus for performing analyte detection, wherein the apparatus comprises: a microfluidic cartridge; at least a fluid located within the microfluidic cartridge; an optoelectronic reader device, the optoelectronic reader device comprising: a mechanical housing; a microfluidic subassembly located within the mechanical housing comprising: a microfluidic pump, the microfluidic pump configured to route a flow of the at least a fluid, wherein the at least a fluid contains an analyte; and at least a reservoir configured to contain the at least a fluid; an optics subassembly located within the mechanical housing, the optics subassembly comprising: an optical device having at least one light source directed at the at least a fluid; a silica planar-waveguide beam splitter configured for multiplexed diagnostics, wherein the waveguide beam splitter is configured to split the at least one light source into a plurality of light beams having differing power outputs; a photonic chip: a silicon-nitride waveguide based unbalanced Mach-Zehnder interferometer on the photonic chip: an array of photodiodes wire-bonded to a carrier: a printed-circuit board (PCB) fiber-coupled to a ribbon cable: a first multi-fiber push-on (MPO) connector connected to the printed-circuit board wherein the first MPO connecter comprises a male mechanical transfer (MT) ferrule; and a sensor device configured to sense the at least a fluid and detect at least an optical property of the analyte, wherein the sensor device comprises a photodetector wherein the photodetector comprises: a wavelength demultiplexer configured to separate a plurality of wavelengths of light from a shared optical path; a receiving pocket located on the mechanical housing, wherein the receiving pocket is configured to receive the microfluidic cartridge and wherein the receiving pocket comprises an MPO adapter connected to the first MPO connector and wherein the MPO adapter accepts a second MPO connector comprising a female MT ferrule that accepts the male MT ferrule; a limit sensor configured to detect a receipt of the microfluidic cartridge; and a motor sub-assembly comprising at least a motor and a plunger grabbing mechanism, wherein the plunger grabbing mechanism is located within the receiving pocket and adjacent to the first MPO connector and wherein the motor is used to drive the plunger grabbing mechanism; and a portable device, wherein the portable

device is configured for point of care diagnostics.
2. The apparatus of claim 1, the apparatus further comprising a computing device, the computing device comprising: at least a processor; and a memory communicatively connected to the processor, the memory containing instructions configuring the processor to: receive an analyte datum from the optoelectronic reader device; and transmit the analyte datum.
3. The apparatus of claim 2, wherein transmitting the analyte datum comprises transmitting the analyte datum to a database.
4. The apparatus of claim 1, wherein the mechanical housing comprises: a flat facet located on the mechanical housing configured to constrain the optoelectronic reader device.
5. The apparatus of claim 1, wherein the photodetector is configured to collect a receiving light from the optical device.
6. The apparatus of claim 5, the receiving light comprising an evanescent wave.
7. The apparatus of claim 1, the apparatus further comprising a battery.
8. The apparatus of claim 1, the optics subassembly further comprising a waveguide device, wherein the waveguide device is configured to guide the at least one light source.
9. The apparatus of claim 1, the plurality of light beams individually emitted at more than one analyte, wherein at least one of the plurality of light beams is exposed to the at least a fluid.
10. The apparatus of claim 1, the optics subassembly further comprising an optical frequency discriminator, the optical frequency discriminator configured to interpolate a change in resonance wavelength.
11. A method for analyte detection, the method comprising: receiving a microfluidic cartridge, wherein at least a fluid is located within the microfluidic cartridge; receiving an optoelectronic reader device, the optoelectronic reader device comprising: a mechanical housing; a microfluidic subassembly located within the mechanical housing comprising: a microfluidic pump, the microfluidic pump configured to route a flow of the at least a fluid, wherein the at least a fluid contains an analyte; and at least a reservoir configured to contain the at least a fluid; an optics subassembly located within the mechanical housing, the optics subassembly comprising: an optical device having at least one light source directed at the at least a fluid; a silica planar-waveguide beam splitter configured for multiplexed diagnostics, wherein the waveguide beam splitter is configured to split the at least one light source into a plurality of light beams having differing power outputs; a photonic chip: a silicon-nitride waveguide based unbalanced Mach-Zehnder interferometer on the photonic chip: an array of photodiodes wire-bonded to a carrier: a printed-circuit board (PCB) fiber-coupled to a ribbon cable: a first multi-fiber push-on (MPO) connector connected to the printed-circuit board wherein the first MPO connecter comprises a male mechanical transfer (MT) ferrule; and a sensor device configured to sense the at least a fluid and detect at least an optical property; a receiving pocket located on the mechanical housing, wherein the receiving pocket is configured to receive the microfluidic cartridge and wherein the receiving pocket comprises an MPO adapter connected to the first MPO connector and wherein the MPO adapter accepts a second MPO connector comprising a female MT ferrule that accepts the male MT ferrule; a limit sensor configured to detect a receipt of the microfluidic cartridge; and a motor sub-assembly comprising at least a motor and a plunger grabbing mechanism, wherein the plunger grabbing mechanism is located within the receiving pocket and adjacent to the first MPO connector and wherein the motor is used to drive the plunger grabbing mechanism; and grabbing, using the motor sub-assembly, the microfluidic cartridge as a function of the plunger grabbing mechanism and the at least a motor; flowing, using the microfluidic subassembly, the at least a fluid from the microfluidic cartridge through the at least a reservoir; and emitting, using the optical device, the at least one light source onto the fluid; and sensing, using the sensor device, the optical property of the at least a fluid, wherein the optoelectronic reader device is a portable device configured for point of care diagnostics, wherein the sensor device comprises a photodetector wherein the photodetector comprises: a wavelength demultiplexer configured to separate a plurality of

wavelengths of light from a shared optical path.
12. The method of claim 11, wherein the photodetector is configured to collect a receiving light from the optical device.
13. The method of claim 12, the receiving light furthering comprising an evanescent wave.
14. The method of claim 11, wherein the plurality of light beams is individually emitted at more than one analyte and wherein at least one of the plurality of light beams is exposed to the at least a fluid.
15. The method of claim 11, wherein sensing the optical property of the at least a fluid further comprises sensing a plurality of optical properties of the at least a fluid.
16. The method of claim 11, the optics subassembly further comprising an optical frequency discriminator, the optical frequency discriminator configured to interpolate a change in resonance wavelength.