

parts, such as valves or pumps, due to the unique transport properties of the electrowetting system.

[0107] The electrowetting technology integrates well with the electrochemical detection of target analytes as the addition of electrodes for detection and the lack of any optical requirements allows for superior and less expensive results. Suitable electrochemical detection systems are described in U.S. Pat. Nos. 4,887,455; 5,591,578; 5,705,348; 5,770,365; 5,807,701; 5,824,473; 5,882,497; 6,013,170; 6,013,459; 6,033,601; 6,063,573; 6,090,933; 6,096,273; 6,180,064; 6,190,858; 6,192,351; 6,221,583; 6,232,062; 6,236,951; 6,248,229; 6,264,825; 6,265,155; 6,290,839; 6,361,958; 6,376,232; 6,431,016; 6,432,723; 6,479,240; 6,495,323; 6,518,024; 6,541,617; 6,596,483; 6,600,026; 6,602,400; 6,627,412; 6,642,046; 6,655,010; 6,686,150; 6,740,518; 6,753,143; 6,761,816; 6,824,669; 6,833,267; 6,875,619; 6,942,771; 6,951,759; 6,960,467; 6,977,151; 7,014,992; 7,018,523; 7,045,285; 7,056,669; 7,087,148; 7,090,804; 7,125,668; 7,160,678; 7,172,897; 7,267,939; 7,312,087; 7,381,525; 7,381,533; 7,384,749; 7,393,645; 7,514,228; 7,534,331; 7,560,237; 7,566,534; 7,579,145; 7,582,419; 7,595,153; 7,601,507; 7,655,129; 7,713,711; 7,759,073; 7,820,391; 7,863,035; 7,935,481; 8,012,743; 8,114,661 and U.S. Pub. No. 2012/0181186, all of which are expressly incorporated herein by reference. Specific reference is made to the structure and synthesis of the ETMs, the different assay methods and assay components (particularly the structure and synthesis of label probes), the methods of making the PCB component and detection electrodes, etc.

[0108] Accordingly, the processed target analyte drops are transported to a detection zone on the substrate, where they are specifically captured on individual detection electrodes, using systems described in numerous patents above with specific reference to U.S. Pat. No. 7,935,418, hereby expressly incorporated by reference and more fully described below. This detection system relies on the use of label probes (in the case of nucleic acids) containing electrochemically active labels, such that the presence of the target analyte results in a positive signal, allowing detection of the pathogen, disease state, etc.

[0109] The cartridge is then inserted into an apparatus, more fully described below, that receives the cartridge(s) and detects the presence or absence of the labels at each electrode, allowing the detection of the target analytes of interest, and reporting on the disease state, etc.

[0110] A particular utility of the present system is the ease and rapidity of this integrated system. For example, there are no more than 2 operations required before introduction of the sample to the system, which allows for both ease of use and no requirement for highly trained lab personnel. A significant benefit to the present system is also the speed from sample to answer, which is generally no more than about 45-90 minutes from sample introduction to reporting of assay results, with most results being reported in roughly 60-70 minutes or less. This represents a significant advantage to both labs and doctors relying on quick analyses for diagnosis and start of appropriate treatments. In addition, as outlined below, the ability of running not only multiple tests which are highly multiplexed on a single cartridge but the ability to analyze multiple cartridges in a completely random access way is a significant advantage in a clinical lab setting. A further advantage of the present system is that it can be used for point-of-care (POC) diagnostics. Each bay can be autonomously operated with minimal user operations, power requirements, and easy port-

ability. A single bay can run multiple cartridge and assay combinations. Furthermore, some of the components (e.g., heaters and sensors) can be incorporated into the cartridge at minimal cost, thus allowing for easy and rapid assay development without altering the bay structure.

[0111] It should be noted that any and all components of the apparatus, biochip cartridge, methods, etc., can be individually included or excluded in each composition or method. That is, biochip cartridges without liquid reagents can be made, without heaters, etc.

[0112] Accordingly, the present invention is directed to integrated biochip systems that allow for the detection of target analytes from samples.

Samples

[0113] The invention provides apparatus (also referred to herein as “devices” or “systems”) for the detection of target analytes in samples to diagnose disease, infection by pathogens (e.g. bacteria, virus, fungi, etc.). As will be appreciated by those in the art, the sample solution may comprise any number of things, including, but not limited to, bodily fluids (including, but not limited to, blood, urine, serum, plasma, cerebrospinal fluid, lymph, saliva, nasopharyngeal samples, anal and vaginal secretions, feces, tissue samples including tissues suspected of containing cancerous cells, perspiration and semen of virtually any organism, with mammalian samples being preferred and human samples being particularly preferred); environmental samples (including, but not limited to, air, agricultural, water and soil samples, environmental swabs and other collection kits); biological warfare agent samples; food and beverage samples; research samples (i.e. in the case of nucleic acids, the sample may be the products of an amplification reaction, including both target and signal amplification as is generally described in PCT/US99/01705, such as PCR amplification reaction); purified samples, such as purified genomic DNA, RNA, proteins, etc.; raw samples (bacteria, virus, genomic DNA, etc.); as will be appreciated by those in the art, virtually any experimental manipulation may have been done on the sample.

[0114] The biochip cartridges of the invention are used to detect target analytes in patient samples. By “target analyte” or “analyte” or grammatical equivalents herein is meant any molecule or compound to be detected and that can bind to a binding species, defined below. Suitable analytes include, but not limited to, small chemical molecules such as environmental or clinical chemical or pollutant or biomolecule, including, but not limited to, pesticides, insecticides, toxins, therapeutic and abused drugs, hormones, antibiotics, antibodies, organic materials, etc. Suitable biomolecules include, but are not limited to, proteins (including enzymes, immunoglobulins and glycoproteins), nucleic acids, lipids, lectins, carbohydrates, hormones, whole cells (including prokaryotic (such as pathogenic bacteria) and eukaryotic cells, including mammalian tumor cells), viruses, spores, etc.

[0115] In one embodiment, the target analyte is a protein (“target protein”). As will be appreciated by those in the art, there are a large number of possible proteinaceous target analytes that may be detected using the present invention. By “proteins” or grammatical equivalents herein is meant proteins, oligopeptides and peptides, derivatives and analogs, including proteins containing non-naturally occurring amino acids and amino acid analogs, and peptidomimetic structures. The side chains may be in either the (R) or the (S) configuration. In a preferred embodiment, the amino acids are in the