

binds to a magnetic signal affinity complex to form a coded magnetic signal binding complex. Typically the affinity agent of the magnetic signal affinity complex is complementary to the code. In this example, the affinity agent of the magnetic signal affinity complex is a polynucleotide complementary to the code polynucleotide. The microcoil array is activated to move the coded magnetic signal binding complex to one or multiple detection zones comprising a second affinity surface. Typically different areas of the detection zone or the different detection zones contain unique affinity agents to the codes. The affinity agents of the second affinity surface are complementary to and bind the code. The detection element then detects the coded magnetic signal binding complex in the detection zone using electrical sensing methods, optical sensing methods, or enzymatic methods, such as amplifying the affinity agent (if it is a polynucleotide) on the magnetic signal affinity complex.

[0136] FIG. 9 illustrates the general signal generation scheme for enzymatic signal amplification. In the left compartment (i.e., a sample zone), the sample is applied to a mixture of reagents containing i) magnetic particles coated with a first affinity agent, ii) signal particles coated with a second affinity agent and catalytic element, such as alkaline phosphatase (AP), luciferase, or horse radish peroxidase (HRP), that can amplify signals, and iii) proper buffer solution. After formation of sandwich complexes in the left compartment, the complexes are transported through a (micro or milli) channel to the middle compartment where it is "washed" via aggregation-de-aggregation by activating the vibration element. The complexes are then transported to the right compartment (i.e., the detection zone), where the reaction substrate is stored. The enzymatic reaction generates luminescence, fluorescence or color change. Luminescence or fluorescence yield is quantified by photon counting while color change is quantified by UV-Vis absorption.

[0137] FIG. 10 illustrates the preparation of a signal particle. Core signal particle is surface-coated with a functionalized polymer, such as poly (acrylic acids). The affinity agent and/or catalytic element are bioconjugated through either non-covalent or covalent interactions onto the surface of the signal particle. The core particle can be any nanoparticle including gold, silver, silica, CdS, CdSe, Eu^{3+} -coated polymer, etc. The core particle can also be organic particles.

[0138] FIG. 11 illustrates an example of chemiluminescent optical signal generation and detection. In this example, the catalytic element is alkaline phosphatase (AP) and the substrate is Lumigen APS-5. AP acts on the substrate generating a radical intermediate which traps oxygen to form an oxetane intermediate with high energy. Breaking up of the oxetane four-membered ring generates light, which can be detected by photon counting.

[0139] FIG. 12 illustrates an example of chemiluminescent optical signal generation and detection. In this example, the catalytic element is horseradish peroxidase (HRP) and the substrate is Lumigen TMA-6. In the presence of hydrogen peroxide, HRP acts on the substrate generating an oxetane intermediate with high energy. Breaking up of the oxetane four-membered ring generates light, which can be detected by photon counting.

[0140] FIG. 13 illustrates an example of absorption optical signal generation and detection. In this example, the catalytic element is horseradish peroxidase (HRP) and the substrate is 3,5,3',5'-tetramethylbenzidine (TMB) with an absorption maximum of 285 nm. In the presence of hydrogen peroxide,

HRP acts on the substrate generating a yellow diimine product with absorption of 450 nm. The absorption can be detected by UV-Vis.

[0141] FIG. 14 illustrates an example of fluorescent optical signal generation and detection. In this example, the catalytic element is horseradish peroxidase (HRP) and the substrate is Amplex Red. In the presence of hydrogen peroxide, HRP acts on the substrate generating resorufin, which is excited at 530 nm-571 nm and its fluorescence emission at 590 nm-600 nm is detected.

[0142] FIG. 15 illustrates an example of fluorescent optical signal generation and detection using a combination of HRP and glucose oxidase. In this example, the catalytic element is horseradish peroxidase (HRP), the substrate is Amplex Red, and other reagents including glucose oxidase and glucose. Contrary to FIG. 14, the hydrogen peroxide is generated from glucose oxidase reaction with glucose. HRP acts on the substrate generating resorufin, which is excited at 530 nm-571 nm and its fluorescence emission at 590 nm-600 nm is detected. Alternatively, if the catalytic element is glucose oxidase, the substrate will be glucose and other agents include HRP and Amplex Red.

[0143] In order to cover all possible detection schemes, Table 1 (above) summarizes these different detection methodologies.

[0144] FIG. 16 illustrates an embodiment of the particle (or molecule) transport device of the invention, showing major components which are (1) a fluidic network, e.g., a biochip, (2) an electromagnetic array, (3) a circuitry board; and (4) computer. The fluidic network comprises a plurality of fluidic zones, each fluidic zone being connected to the adjacent zone by a diffusion barrier, and an integrated circuitry component, and optionally has a vibration element functionally coupled to the fluidic network. The array of magnetic microcoils functionally is coupled to the fluidic network, wherein the microcoils are programmably activatable to generate a magnetic field in proximity to each microcoil. The electromagnetic array can concentrate or transport magnetic particles, but dispersion of magnetic particles is preferably done by the vibrational device, which could be integrated in the fluidic network. A detection element (not shown in FIG. 16) could be functionally coupled to the fluidic network.

[0145] The circuitry board shown in FIG. 16 contains the circuitry to control the elements (core/coil) of the electromagnetic array. The circuitry board is connected, either hard-wired or by wireless connection, to a computer or any other device for controlling the switches of the circuitry board in a preferred sequence. The computer or any processing unit could include an embedded computer processor and/or could be capable of integrated computing.

[0146] Particle transport in the fluidic device is achieved by using the magnetic array and magnetic particles. Magnetic particles are commercially available. For clinical diagnostic applications, the particles could be conjugated with affinity binding partners (e.g. nucleic acid probes or antibodies); they could also be used together with other nanoparticles which can serve as either signal source or as carriers of signal sources. Magnetic particles and other reagents are placed in the fluidic device (e.g., biochip) containing multiple zones wherein liquid transport is not needed, and thus mechanism to generate fluid movement force is avoided.

[0147] To facilitate biomolecule detection, aggregated or concentrated particles in the fluidic zones may need to be dispersed or resuspended in solution locally within a fluidic