current to a coil adjacent the device. The oscillating current creates an oscillating magnetic field through the center of the coil which results in vibratory motion and rotation of the magnetic particles in the cartridge and mixing of the fluid components. In addition to sensors for monitoring temperature, the cartridge may contain sensors to monitor the progress of one or more of the operations of the device. For example, optical sensors and pressure sensors may be incorporated into one or more regions to monitor the progress of the various reactions, or within flow channels to monitor the progress of fluids or detect characteristics of the fluids, e.g., pH, temperature, electrical conductance, capacitance, fluorescence, viscosity, (chemi)luminescence, color, and the like.

[0131] The cartridge will typically include temperature sensors and controllers. For example, a heating element or temperature control block may be disposed adjacent the external surface of a chemically interactive region to transfer heat to the region. In this case, preferred cartridges include a thin external wall for regions in which thermal control is desired. This thin wall may be a thin cover element, e.g.; polycarbonate sheet, or high temperature tape, i.e. silicone adhesive on Kapton® tape (commercially available from, e.g., 3M Corp). In one embodiment, the cartridge may comprise two or more components that are fabricated separately, and then bonded together. Some surfaces of the components ultimately become the interior of the fluid flow regions or channels.

[0132] On such surfaces, conductive layers may be deposited. These could be one of several metals, for example gold, chrome, platinum, silver, carbon, copper or other metals, deposited by standard thin film deposition techniques such as plating, evaporation or sputtering. Another method for deposition of such conductive materials is via thick film technology. In this method, conductive pastes or inks are deposited by screen printing, and then baked to drive off solvents and leave behind the final conductor. Finally, thin films of carbon are commonly used for low cost conductive materials. These can also be screen printed and baked at low temperatures to form conductive layers.

[0133] Any of the above methods are useful for allowing conduction of electrical signals from the external environment, through the fluid seal area, and into the interior of the cartridge. These conductors can be made very thin, limited only by the necessary conductivity. In the case of a cartridge, the thickness of the conductors may be on the order of 0.0254 mm.

[0134] Electrical signals through such conductors may be used in a number of ways, both as inputs to the cartridge and as outputs from it. Some signals involve making a circuit, part of which is the fluid itself within the cartridge. In one embodiment, such a circuit is used simply to sense the presence or absence of the fluid. Two conductive terminals are routed to regions within the fluid channel, close to one another but not connected to each other. External electronics monitors the impedance between these conductors, by, for example, applying a small voltage between them and monitoring the current flow. When no fluid is present, the impedance will be very high. However, when fluid passes this point in the channel, the fluid will bridge the gap between the two terminals. Since the fluids typically used in biological and chemical applications are at least mildly conductive, this fluid will cause the impedance in the circuit to decrease dramatically. This decrease in impedance can be sensed by the electronics, and decisions made based on this input. By placing several such circuits along the length of any fluid channel, the external electronics may be used to monitor the fluid velocity, thus monitoring the progress of the intended fluidic processing.

[0135] Electrodes in contact with the fluid might also be used for monitoring specific characteristics of the fluid. Capacitance, fluid conductivity, fluid pH, capacitance, reaction region humidity (e.g. in paper based cartridges) are all examples of specific fluid parameters that might be monitored by electronic means. Specific electrode configurations are also possible to allow electrochemical detection of reaction products.

[0136] Another example is the use of such electrical connections into the fluid for manipulation of biomolecules such as DNA. Such molecules can be moved through fluids by DC electrophoresis. In this case, one electrode makes contact with the fluid as a counter electrode. Many other electrodes can be biased with respect to the counter electrode to attract charged molecules. For example, some macromolecules such as DNA are negatively charged. By biasing electrodes positively with respect to the counter electrode, these macromolecules can be attracted to the positive electrodes. This may be useful for isolating such molecules from other fluidic components, or for attracting such molecules to specific reaction regions within the cartridge.

[0137] Another electronic technique useful for movement and isolation of biomolecules is AC dielectrophoresis. In this case, two or more electrodes are typically configured close to one another, and in a physical configuration which yields non-uniform electric fields. AC fields at frequencies up to tens of MHz are known to induce electrical polarization of such molecules, causing them to move, or be attracted to, regions where they may be isolated or further processed. Molecules also have unique signatures, i.e. particular molecules respond to a particular frequency of excitation. Thus specific molecules can be isolated from the fluidic sample by tuning of the frequency of the AC excitation. By using traveling wave excitation along a series of electrodes, these specific molecules can be moved from place to place.

[0138] Another application of an electrical connection is that of driving an electrolysis reaction to realize fluid movement.

[0139] Electrical connections to a fluid reservoir could be used to realize an electrolytic pump (e-pump). In such a device, current is passed through a reservoir of electrolyte. This current causes gas evolution as the electrolyte solvent is decomposed into gases such as oxygen and hydrogen. These gases build up localized pressure and can serve as a motive source. This pressure can be transmitted to the process fluid within the cartridge through, e.g. a flexible membrane, thus realizing fluid motion of the fluid to be processed.

[0140] FIGS. **5**A and **5**B show one such electrolytic pump **25**. As shown in the plan view of FIG. **5**A, the pump **25** includes electrodes **27** having a star shape to assure that a current path is always available even after bubbles begin to form inside of the reservoir **29**. A sealing ring **4** entraps electrolyte within the reservoir **29**. As shown in the schematic side view of FIG. **5**B, fluid **39** is contained within a pouch **35** having an expandable membrane **37**. The fluid contacts electrodes **27** and decomposes when electric current is applied to the electrodes. The decomposing fluid creates a pressure build-up within the pouch **35**. As the pouch expands due to increased pressure, the pouch biases against a liquid reagent pouch (not shown), thus forcing the liquid reagent contained within the liquid pouch to be released. By controlling the