As illustrated, contacts **205** and leads **210** are used to allow electrodes **215** in the addressable electrode array to be controlled by a control unit (not shown) adapted to contact, or mate, with the cartridge. Since the resistance across leads **210** represents a large fraction of the total cell resistance during an assay measurement, it is preferable to match the resistance across each lead as closely as possible. As shown in the figure, the length of the leads varies according to the positioning of the electrodes and contacts, however, the width is varied so that the length to width ratio of the leads is kept constant so as to provide a uniform lead resistance (the widths in the figure are not to scale and have been exaggerated for emphasis).

[0139] Utilization of the electrode array for multiple purposes contributes to a miniaturized cartridge-based device since the need for additional components is obviated. According to another aspect of the present invention, the electrode array may advantageously also be used for detecting the presence of fluid, for the detection of trapped air and/or for the identification of sample type. Preferably, an impedance measurement may be used to monitor the state of the cell during the cartridge routine. The measurement may assess whether there is trapped air on or above an electrode during incubation and after the wash step. Additionally, the impedance measurement may also allow usage of the electrode array to distinguish different sample types drawn into the cartridge, e.g., differentiate between samples of urine, saliva, serum, plasma, or whole blood, and make any necessary adjustments that may be needed.

[0140] The advantages associated with utilizing the electrode array to monitor cartridge operations by performing impedance measurements can be many fold. In particular, use of the electrode array in this manner affords a non-destructive measurement to be made since application of low voltage DC or, preferably, AC waveforms can be carried out with no effect on the subsequent ECL measurement. Also, the impedance measurement performed by the electrode array is relatively fast compared to other cartridge operations. Still further, the impedance measurement performed by the electrode array is very precise and can preferably be used in conjunction with other sensors; e.g., pressure, optical, etc.

[0141] At low voltages, the electrodes located in the region where detection is to be made, i.e., the read chamber, behave like a series RC circuit. This has proven to be a suitable model for the development of a fail safe mechanism to ascertain the presence of fluid, the presence of an unwanted bubble or to discriminate between sample specimen in types in the read chamber. In practice, it has been observed that trapped air may reside either on the electrode surface or in the solution bulk. According to the present invention, the location of the air with respect to the electrodes is important. According to one embodiment, a resistance measurement can be utilized to provide an indicator that is sensitive to air trapped in the bulk solution and at the electrode/solution interface. According to another embodiment, a capacitance measurement can be employed to provide an indicator that is primarily sensitive to air trapped at the interface. In yet another alternative embodiment, the electrochemical current during an ECL measurement (e.g., the TPA oxidation current during ECL) may be used to detect trapped air during the ECL measurement, however, this measurement would not provide information related to trapped air during the sample entry and incubation phases and would not allow corrective steps to be taken before the ECL measurement.

[0142] With respect to using a capacitance measurement, the pertinent capacitance is the double layer capacitance. Since the parallel plate capacitance is insignificant at frequencies below about 1 MHz, it is preferably ignored. Each electrode has a double layer capacitance. It is noted that the double layer capacitance is not a true capacitor, as it does exhibit a small frequency dependence. Advantageously the capacitance is primarily affected by changes at the interface (e.g., changes in the effective area of an electrode due to the trapping of an air bubble on the electrode surface), and not by the bulk; the capacitance is therefore preferably used to detect air bubbles at the electrode/solution interfaces. Preferably, the capacitance measurement uses an AC voltage input with a frequency between 10-40,000 Hz, more preferably between 20-2000 Hz, more preferably between 50-400 Hz, most preferably around 200 Hz. Other factors besides trapped air, e.g., errors in the printing of the electrodes, may change the effective area of an electrode and thus the measured capacitance. The measurement of capacitance can be used to check for these factors as well as for bubbles and can be used to trigger error flags if the capacitance values fall out of an acceptable range or, alternatively, to allow for normalization of the reported ECL signal to compensate for the actual electrode area.

[0143] With respect to using a resistance measurement, the pertinent resistances are the solution and lead resistances. It has been observed that the solution resistance will have a small frequency dependence. The resistance is affected by changes in the bulk solution (e.g., by bubbles interfering with the flow of current through bulk solution) and changes at the electrode/solution interface (e.g., trapped air at the interface has the affect of reducing the effective electrode area and therefore increasing the resistance). The solution resistance can also be expected to be very sensitive to the nature of the solution in contact with the electrodes and can also be used to identify the sample.

[0144] The resistive (in-phase) and capacitive (out-of phase) components of the impedance may be measured simultaneously using conventional impedance analyzing circuitry, preferably using a voltage waveform having a frequency at which both components have a significant effect on the impedance and/or a voltage waveform having a plurality of frequencies comprising at least one frequency where the resistance is a significant component of the impedance and at least one frequency where the capacitance is a significant component of the impedance. Alternatively, the resistive and capacitive components may be measured separately, preferably at frequencies that maximize the effect of the component being measured. For example, at high frequencies the effect of surface capacitance is minimized and the impedance is primarily due to solution resistance. In one embodiment of the invention, the solution resistance is measured by applying a voltage waveform having a frequency greater than 2000 Hz, more preferably between 2,000 and 100,000 Hz, most preferably around 20,000 Hz.

[0145] Sample matrix identification can be very important since certain biochemical assays may have varied steps or different post-processing requirements (e.g., the blood samples may be treated different than plasma samples). Tables 3 and 4 list resistance and capacitance values acquired for five different matrices by applying low voltage AC excitation to electrodes within an experimental cartridge. The electrode array comprised screen printed carbon ink electrodes, the exposed surface of which were defined by a pat-