nucleic acid arrays, which are contained in one or a plurality of reaction volumes. By "array" or "biochip" herein is meant a plurality of capture binding ligands, preferably nucleic acids, in an array format; the size of the array will depend on the composition of the array. Most of the discussion therein is directed to the use of nucleic acid arrays with attached capture probes, but this is not meant to limit the scope of the invention, as other types of capture binding ligands (proteins, etc.) can be used. "Array" in this context generally refers to an ordered spacial arrangement, particularly an arrangement of immobilized biomolecules or polymeric anchoring structures. "Addressable array" refers to an array wherein the individual elements have precisely defined X and Y coordinates, so that a given element at a particular position in the array can be identified.

[0241] Nucleic acids arrays are known in the art, and can be classified in a number of ways; both ordered array (e.g. the ability to resolve chemistries at discrete sites), and random arrays are included. Ordered arrays include, but is not limited to, those made using photolithography techniques (Affimetrix GeneChip), spotting techniques (Synteni and others), printing techniques (Hewlett Packard and Rosetta), three dimensional "gel pad" arrays, electrochemical based electrode arrays, etc. The size of the array can vary, with arrays containing from about 2 different capture probes to many thousands can be made, with very large arrays being possible. Generally, depending on the type of array, the array will comprise from two to as many as 100,000, with from about 10 to about 1000 being the most preferred, and about 50 being especially preferred for electrode arrays. Arrays can also be classified as "addressable", which means that the individual elements of the array have precisely defined coordinates, so that a given array element can be pinpointed.

[0242] In a preferred embodiment, the detection module is based on electrochemical or electronic methods and utilizes arrays of electrodes. In general, the detection module is based on work outlined in U.S. Pat. Nos. 5,591,578; 5,824,473; 5,770,369; 5,705,348 and 5,780,234; U.S. Ser. Nos. 09/096,593; 08/911,589; 09/135,183; and 60/105,875; and PCT applications US97/20014 and US98/12082; all of which are hereby incorporated by reference in their entirety. Detection module work is also outlined in WO98/20162, WO98/12430, WO00/16089, WO99/57317, WO01/35100, WO00/62931, WO01/06016, WO01/07665, WO01/54813, and WO01/42508; U.S. Pat. No. 6,232,062; and U.S. Ser. Nos. 09/459,685 and 09/458,533, all of which are hereby incorporated by reference.

[0243] There are two basic mechanisms which can be used in this embodiment. Both utilize detection electrodes with capture binding ligands attached (frequently referred to herein as "capture probes" when the analytes and ligands are nucleic acids). In one embodiment, detection is based on changes in impedance upon binding of the target analyte to the detection electrode. That is, the impedance between two electrodes is measured prior to the introduction of the sample comprising the target analyte, the analyte is introduced, the electrodes are washed if necessary, and then the impedance is measured again. This embodiment provides a significant commercial benefit, as no labels (e.g. electrochemical reporter molecules) are used, thus simplifying the reactions and costs of the system. These systems generally referred to herein as "impedance mode" systems and are generally described in WO98/20162, WO98/12430, WO00/16089, WO99/57317, WO01/35100, WO0/62931, WOO1/06016, WO01/07665, WO01/54813, and WO01/42508; U.S. Pat. No. 6,232,062; and U.S. Ser. Nos. 09/459,685 and 09/458,533, all of which are expressly incorporated by reference, and others of the above-listed applications.

[0244] Alternatively, electrochemical reporter groups (frequently referred to herein as electron transfer moieties (ETMs)) are used. In this embodiment, a target analyte is introduced to the detection module, and is combined with other components to form an assay complex in a variety of ways, as is more fully outlined below. The assay complexes comprise ETMs, which can be attached to the assay complex in a variety of ways, as is more fully described below. Detection proceeds by detecting the presence or absence of the ETMs as an indication of the presence or absence of the target analytes. These systems are generally referred to as "electron transfer mode" and are generally described in WO98/20162, WO98/12430, WO00/16089, WO99/57317, WO01/35100, WO00/62931, WO01/06016, WO01/07665, WO01/54813, and WO01/42508; U.S. Pat. No. 6,232,062; and U.S. Ser. Nos. 09/459,685 and 09/458,533, all of which are hereby incorporated by reference, all of which are expressly incorporated by reference, and others of the above-listed applications.

[0245] Accordingly, the detection modules of the invention comprise electrodes. By "electrode" herein is meant a composition, which, when connected to an electronic device, is able to sense a current or charge and convert it to a signal. Alternatively an electrode can be defined as a composition which can apply a potential to and/or pass electrons to or from species in the solution. Thus, an electrode is an ETM as described herein. Preferred electrodes are known in the art and include, but are not limited to, certain metals and their oxides, including gold; platinum; palladium; silicon; aluminum; metal oxide electrodes including platinum oxide, titanium oxide, tin oxide, indium tin oxide, palladium oxide, silicon oxide, aluminum oxide, molybdenum oxide (Mo_{206}), tungsten oxide (WO_3) and ruthenium oxides; and carbon (including glassy carbon electrodes, graphite and carbon paste). Preferred electrodes include gold, silicon, platinum, carbon and metal oxide electrodes, with gold being particularly preferred.

[0246] In a preferred embodiment, the detection electrodes are formed on a substrate. In addition, the discussion herein is generally directed to the formation of gold electrodes, but as will be appreciated by those in the art, other electrodes can be used as well. The substrate can comprise a wide variety of materials, as will be appreciated by those in the art, with printed circuit board (PCB) materials being particularly preferred. Thus, in general, the suitable substrates include, but are not limited to, fiberglass, teflon, ceramics, glass, silicon, mica, plastic (including acrylics, polystyrene and copolymers of styrene and other materials, polypropylene, polyethylene, polybutylene, polycarbonate, polyurethanes, Teflon™, and derivatives thereof, etc.), GETEK (a blend of polypropylene oxide and fiberglass), etc.

[0247] In general, preferred materials include printed circuit board materials. Circuit board materials are those that comprise an insulating substrate that is coated with a conducting layer and processed using lithography techniques, particularly photolithography techniques, to form the patterns of electrodes and interconnects (sometimes referred to