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Electric Field Devices for the Manipulation, Directed Assembly, Isolation and Detection of BioDerivatized Nanoparticles

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One of the grand challenges in nanotechnology is the development of fabrication technologies that will lead to cost effective nanomanufacturing processes. In addition to the more classical top-down processes such as photolithography, so-called bottom-up processes are being developed for carrying out self-assembly of molecules and nanostructures into higher-order materials and devices. To this end, considerable efforts have been carried out on Layer-by-Layer (LBL) self-assembly processes as a way to make three dimensional structures. However, limitations of both passive and active LBL self-assembly processes provide considerable incentive to continue the development of better paradigms for this type of nanofabrication. Over the past decade, electronic microarray devices have been used to carry out the parallel addressing and selective binding of charged biomolecules such as DNA, RNA, biotin/streptavidin, and antibodies; as well as quantum dots, metallic and polymeric nanoparticles, cells and even micron sized semiconductor devices. More recently, an electronic microarray process has been developed for the rapid and highly parallel assisted self-assembly of protein and DNA derivatized nanoparticles into multi-layer structures. This process allows 3D structures with more than forty alternating nanoparticle layers to be completed in less than one hour. Electric field assisted self-assembly represents an example of combining some of the best aspects of "top-down" and "bottom-up" technologies into viable process for the hierarchical assembly and integration of nanocomponents into 3D structures. Such a process may be useful for fabrication of bio/chemsensor devices, in-vivo therapeutic/drug delivery devices; as well as for many nanoelectronic, nanophotonic, energy conversion (fuel cells, photovoltaics, and batteries) and nanocomposite material applications.

In cancer research and clinical diagnostics, it is a significant challenge to *directly* isolate and identify rare cancer cells and potential cancer markers such as high molecular weight DNA nanoparticulates and immunocomplexes in blood, plasma and other clinically relevant samples. The advent of bio/nanotechnology has now led to numerous drug delivery approaches that involve encapsulation of drugs and imaging agents within nanovesicles and nanoparticles, which will also have to be identified and separated from blood and plasma. AC electrokinetic techniques such as dielectrophoresis (DEP) offer a particularly attractive mechanism for the separation of cells, biomarkers and drug delivery nanovesicles. Unfortunately, present DEP systems require significant dilution of the blood or plasma, thus making the technology less suitable for clinical sample preparation and diagnostic applications. Electronic DEP microarray systems have now been developed which allow separation and detection of cells, microspheres and DNA nanoparticles to be carried out under higher ionic strength conditions that more closely approach blood and plasma.