electric field maxima may be generated by applying different voltage potentials (e.g., plus and minus connections) to different (e.g., neighboring) microposts within the array, thereby obviating a ground plane.

[0086] In yet another embodiment, an array of microcoils may be configured to produce both controllable, spatially and/or temporally patterned, electric fields and/or magnetic fields. More specifically, in one implementation discussed further below in Section II, respective independently controllable voltages may be applied across the microcoils of a microcoil array, such that the individual microcoil structures behave essentially like the microposts of the micropost array **210** shown in FIGS. **5**(*a*) and (*b*), namely, by generating electric fields that are capable of interacting with samples contained in the microfluidic system. According to one aspect of this embodiment, respective independently controllable currents also may be applied to the microcoils of the microcoil array, to additionally generate magnetic fields that are capable of interacting with magnetic samples contained in the microfluidic system. These and other types of electric field-based or electric/magnetic field-based implementations may be employed for a variety of applications relating to manipulation, sensing and imaging systems that integrate microelectronics and microfluidics.

[0087] As mentioned above and also shown in **FIG. 1**, the field control components **400** of the hybrid system **100** may include one or more current sources **420** to facilitate the generation of magnetic fields from magnetic field-generating components, according to some embodiments of the invention. Similarly, the field control components may also, or alternatively, include one or more voltage sources **440** to facilitate the generation of electric fields from electric field-generating components, according to other embodiments of the invention.

[0088] In general, whether the field control components **400** include one or more current sources **420**, one or more voltage sources **440**, or both, according to one embodiment the field control components also include various switching or multiplexing components **460** to facilitate the appropriate application of currents and/or voltages to individual field-generating components or groups of field-generating components. In various implementations discussed in greater detail below, the switching or multiplexing components **460** may be configured as a programmable digital switching network (e.g., under control of the one or more processors **600**) such that the output(s) of one or more current and/or voltage sources are applied in a prescribed independently controllable manner to the field-generating components, so as to create the spatially and/or temporally patterned electric and/or magnetic fields that facilitate sample manipulation.

[0089] As also shown in **FIG. 1**, the field control components **400** additionally may include radio frequency (RF) and other detection components **480**, coupled between the field-generating components **200** and the one or more processors **600**, for facilitating one or more of detection, imaging and characterization of samples contained in the microfluidic system **300**, according to various embodiments of the present disclosure. In different aspects, examples of such RF/detection components **480** may include, but are not limited to, oscillators, mixers and/or filters, which are operated (e.g., under control of the one or more processors **600** via the switching or multiplexing components **460**) to both generate RF fields from the field-generating components and measure signals indicating some type of interaction between the generated RF fields and one or more samples of interest. Specific details of exemplary circuit implementations for the RF/detection components **480** are discussed further below in Section III.

[0090] In various aspects, the RF/detection components **480** provide for sample detection, imaging and characterization techniques that are purely based on electromagnetic fields, without requiring chemical elements that may possibly be harmful to samples of interest, or bulky optical microscopes. Nevertheless, it should be appreciated that, according to some techniques involving various concepts disclosed herein, sample detection and imaging may be assisted by chemically treating/targeting specific types of samples.

[0091] In general, as is well known based on Maxwell's Equations, an RF field is capable of interacting with virtually any particle (biological or otherwise) that conducts electricity at the RF signal frequency, or is polarizable electrically or magnetically. Accordingly, in various embodiments of the present disclosure, the interaction between RF electric and/or magnetic fields and samples of interest may be exploited not only to move samples but also to determine the position of the sample (e.g., to facilitate imaging). Moreover, spectral responses arising from the RF field/sample interaction may be used in some cases to identify or characterize different types or classes of samples.

[0092] For example, conducting samples have circulating currents induced by an RF field that in turn produce their own magnetic field, and interact strongly with an applied field. This is the basis of operation of conventional electric motors (e.g., a "squirrel cage" rotor with no electrical contacts). This interaction can be used to move samples and also detect their presence. In one mechanism discussed in greater detail below, magnetic polarization of a sample changes the inductance of a coil (e.g., a microcoil of an array) in proximity to the sample; accordingly, damping of oscillations of the magnetic polarization causes detectable losses in a circuit including the microcoil. In yet another example, electrical polarization of a sample gives rise to the forces responsible for dielectrophoresis (DEP). This polarization can be detected via a change in capacitance between the sample and the electrodes of an electric-field generating device (e.g., a micropost or microcoil with an applied voltage) with no dissipation, or by a change in damping due to the oscillating electric polarization in the sample. The foregoing examples provide various mechanisms by which the location of a sample can be detected, and thus imaged.

[0093] Based on such RF imaging techniques, various implementations of a hybrid system according to the present disclosure may incorporate feedback control mechanisms, whereby samples of interest may be manipulated based on acquired images of the samples. For example, in one embodiment, the hybrid system may be programmably configured (e.g., via the one or more processors **600**) to first obtain an image of a distribution of samples contained in the microfluidic system. Thereafter, based on the imaged distribution, one or more particular samples may be manipulated based on a prescribed algorithm.

[0094] Various concepts disclosed herein relating to RF fields likewise may be employed for identification and