drawbacks, including the aggregation of particles and inefficiency in mixing of the particles. Further, such techniques may require manual intervention between stages of the process. A technique to improve mixing solutions using magnetic beads is the use of electromagnets surrounding a sample container to create a changing magnetic field.

[0005] However, magnetic particles typically used for capture and isolation of biological molecules are paramagnetic. Paramagnetic beads are responsive to an applied external magnetic field but retain little or no residual magnetism when that field is removed. This low residual magnetism reduces or eliminates clumping of the beads, allowing the beads to remain dispersed and suspended in solution and to be easily transferred through a pipette tip. Paramagnetic beads, however, are generally less responsive to an external magnetic field and therefore are more difficult to effectively mix using an electromagnetic mixer, particularly in viscous solutions such as those used to selectively precipitate and isolate nucleic acids using magnetic beads. Accordingly, a need exists to provide an arrangement of electromagnetic elements that more effectively induces efficient mixing of such magnetic particles.

SUMMARY

[0006] Apparatus, systems, and methods are described herein allow for the processing of sampling devices and fluids using electromagnetic assemblies without the limitations of known techniques. For example, the apparatus, systems, and methods described herein allow for the processing of sampling devices and fluids using electromagnetic assemblies on sample volume without sample loss or magnetic particle loss.

[0006a] In one aspect, there is provided a method for processing fluids, comprising: providing at least one fluid container having a fluid chamber containing a fluid and a plurality of magnetic particles; disposing the at least one fluid container onto a magnetic assembly, the magnetic assembly including a plurality of electromagnets located about the periphery of the fluid chamber, each of the plurality of electromagnets having: (i) an electrically-conductive coil located about a centerline that extends in a z-direction, and (ii) a magnetic lens configured and arranged to direct a magnetic field generated by the conductive coil towards the fluid chamber, wherein at least one of the magnetic lens or the fluid chamber is movable in the z-direction; providing an electrical signal to each of the plurality of electromagnets so as to generate a magnetic field within the fluid chamber, wherein the magnetic field is configured to influence the plurality of magnetic particles; and adjusting the electrical signal to modify the magnetic field within the fluid chamber while moving the at least

one of the magnetic lens or the fluid chamber in the z-direction to further modify the magnetic field within the fluid chamber.

[0006b] In another aspect, there is provided a fluid processing system, comprising: at least one fluid container defining a fluid chamber therein for containing a fluid and a plurality of magnetic particles; a magnetic assembly including a plurality of electromagnets disposed about the periphery of the at least one fluid chamber, each of the plurality of electromagnets having: (i) an electrically-conductive coil located about a centerline that extends in a z-direction, and (ii) a magnetic lens configured and arranged to direct a magnetic field generated by the conductive coil towards the fluid chamber, wherein at least one of the magnetic lens or the fluid chamber is movable in the z-direction; and a control component coupled to the magnetic assembly, the control component configured to: (i) control the magnetic field generated by each of the plurality of electromagnets to generate a plurality of magnetic field gradients within the fluid chamber sufficient to magnetically influence the plurality of magnetic particles within the fluid chamber, and (ii) control the movement of the at least one of the magnetic lens or the fluid chamber in the z-direction while generating the plurality of magnetic field gradients within the fluid chamber.

DESCRIPTION OF THE DRAWINGS

[0007] A description is provided herein below with reference, by way of example, to the following drawings. It will be understood that the drawings are provided as examples only and that all reference to the drawings is made for the purpose of illustration only and are not intended to limit the scope of the disclosure in any way. For convenience, reference numerals can also be repeated (with or without an offset) throughout the figures to indicate analogous components or features.

[0008] FIGS. 1A-1D are schematics of fluid processing systems according to various aspects described herein.

[0009] FIGS. 2A and 2B are schematics illustrative open-well magnetic sample plate according to various aspects described herein.

[0010] FIG. 3 is a schematic illustrative fluid processing system according to various aspects described herein.