CLAIMS

What is claimed is:

1. An apparatus comprising:

a membrane for separating a fluid from a compartment, wherein the membrane comprises an opening sized to immobilize a particle about the opening;

one or more electrodes disposed proximate to the membrane;

a counter-electrode, wherein the one or more electrodes and the counter-electrode are configured to generate a non-linear electric field across the one or more electrodes and the counter-electrode; and

a power source for providing an alternating current (AC) across the one or more electrodes and the counter-electrode, thereby generating an oscillating non-linear electric field for immobilizing ~~a~~ the particle suspended in the fluid that flows in a channel between the one or more electrodes and the counter-electrode.

~~2. The apparatus of claim 1, wherein the membrane comprises an opening.~~

~~3~~ 2. The apparatus of claim ~~2~~ 1, wherein the opening allows for mechanical manipulation of the particle that is immobilized and the mechanical manipulation includes probing the particle with a sharp member configured to enter across the membrane from the compartment.

~~4~~ 3. The apparatus of claim 1, wherein the membrane comprises at least one of silicon nitride, silicon oxide, a metal oxide, a carbide, a ceramic, alumina, or a polymer.

~~5~~ 4. The apparatus of claim 1, wherein the membrane has a thickness between about 10 nm to about 1 cm.

~~6~~ 5. The apparatus of claim ~~2~~ 1, wherein the opening has a size between about 10 nm to about 50 μm.

~~7~~ 6. The apparatus of claim ~~2~~ 1, wherein a wall of the opening has a hydrophobic coating or a hydrophilic coating.

~~8~~ 7. The apparatus of claim 1, wherein a surface area of the one or more electrodes is smaller than a surface area of the counter-electrode.

~~9~~ 8. The apparatus of claim 1, wherein the AC across the one or more electrodes and the counter-electrode is supplied at an oscillating frequency of between about 10 Hz and about 10 GHz.

~~10~~ 9. The apparatus of claim 1, wherein the one or more electrodes comprises at least one of a transparent conducting material or a doped semiconducting material.

~~11~~ 10. The apparatus of claim ~~10~~ 9, wherein the transparent conducting material comprises indium tin oxide, graphene, doped graphene, a conducting polymer, or a thin metal layer.

~~12~~ 11. The apparatus of claim 1, wherein the fluid comprises one of an aqueous fluid, an aqueous buffer, an organic solvent, a hydrophobic fluid, or a gas.

~~13~~ 12. The apparatus of claim 1, wherein the particle comprises one of a biological organism, a biological structure, a cell, a living cell, viruses, oil droplets, liposomes, micelles, reverse micelles, protein aggregates, polymers, or surfactant assemblies.

~~14~~ 13. A method for operating an apparatus comprising:

providing a power source;

providing a membrane configured for separating a fluid from a compartment, wherein the membrane comprises an opening sized to immobilize a particle about the opening;

providing one or more electrodes disposed proximate to the membrane;

providing a counter-electrode, wherein the one or more electrodes and the counter-electrode are configured to generate a non-linear electric field across the one or more electrodes and the counter-electrode;

supplying, via the power source, an alternating current (AC) across the one or more electrodes and the counter-electrode, thereby generating an oscillating non-linear electric field; and

immobilizing, via a dielectrophoretic (DEP) force generated by the oscillating non-linear electric field, ~~a~~ the particle suspended in the fluid that flows in a channel between the one or more electrodes and the counter-electrode.

~~15. The method of claim 14, wherein the membrane comprises an opening.~~

~~16~~ 14. The method of claim ~~15~~ 13, further comprising:

manipulating, via the opening, the particle that is immobilized.

~~17~~ 15. The method of claim ~~15~~ 13, further comprising:

probing, via the opening, the particle with a sharp member configured to enter across the membrane from the compartment.

~~18~~ 16. The method of claim ~~15~~ 13, further comprising:

inserting, via the opening, the particle with a sharp member configured to enter across the membrane from the compartment.

~~19~~ 17. An apparatus comprising:

one or more electrodes and a counter-electrode configured for generating a non-linear electric field for immobilizing a particle suspended in a fluid that flows in a channel between the one or more electrodes and the counter-electrode; and

a membrane disposed proximate a surface of the one or more electrodes, the surface of the one or more electrodes distal the counter-electrode, wherein the membrane comprises an opening sized to immobilize the particle about the opening,

wherein the membrane is configured for separating the fluid from a compartment, and ~~has an~~ the opening configured to allow for insertion of a sharp member disposed in the compartment.

~~20~~ 18. The apparatus of claim ~~19~~ 17, wherein the particle comprises one of a biological organism, a biological structure, a cell, a living cell, viruses, oil droplets, liposomes, micelles, reverse micelles, protein aggregates, polymers, or surfactant assemblies.