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 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 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.

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.

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

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

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

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.

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.

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.

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

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.

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.

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, the particle suspended in the fluid that flows in a channel between the one or more electrodes and the counter-electrode.

14. The method of claim 13, further comprising:

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

15. The method of claim 13, further comprising:

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

16. The method of claim 13, further comprising:

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

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 the opening configured to allow for insertion of a sharp member disposed in the compartment.

18. The apparatus of claim 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.