CLAIMS:

1. A microfluidic sensor for sensing biological particles including a particle concentration device for performing concentration of particles in three dimensions, the sensor device comprising:

a substrate bearing a microfluidic channel or chamber for carrying a conductive fluid bearing said particles for concentration, wherein said channel has:

first and second electrodes spaced apart on said channel or chamber for defining an electric field therebetween; and

a sensing surface on an inner surface of said channel or chamber for contact with said fluid to selectively sense said particles; and

wherein said particle concentration device comprises means for applying an ac voltage across said electrodes to flow said particles past said sensing surface and to concentrate said particles in three dimensions adjacent to or away from said sensing surface.

2. A microfluidic sensor as claimed in claim 1 wherein said substrate defines a lateral plane of said sensor, and wherein said particle concentration device is configured to concentrate said particles in a direction perpendicular to said lateral plane.

3. A microfluidic sensor as claimed in claim 2 wherein said channel or chamber has upper and lower surfaces spaced apart in said direction perpendicular to said lateral plane, said upper surface being further from said substrate than said lower surface and wherein one or both of said electrodes is disposed on or adjacent said upper surface.

4. A microfluidic sensor as claimed in any preceding claim wherein said surface is adjacent to or opposite a said electrode.

5 A microfluidic sensor as claimed in any preceding claim wherein said electrodes are disposed on the same side of said channel or chamber and wherein a gap between said electrodes is the same as a distance from a said electrode to said sensing surface, to within 50% of said distance from a said electrode to said sensing surface.

6. A microfluidic sensor as claimed in any preceding claim wherein said particles have a mean maximum dimension in the range of 0.5 to 200 μm.

7. A microfluidic sensor as claimed in claim 6 wherein said fluid is an aqueous fluid and wherein a said particle comprises a droplet of oil in said aqueous fluid, said droplet of oil including a biological entity.

8. A microfluidic sensor as claimed in any preceding claim wherein said sensing surface comprises a polymer sensing surface configured to provide an antibody/antigen-based surface sensing reaction.

9. A microfluidic sensor as claimed in any preceding claim wherein said means for applying said ac voltage comprises means to apply a said voltage at a frequency of greater than 100KHz, preferably greater than 1MHz.

10 A microfluidic sensor as claimed in any preceding claim wherein said sensing surface is configured to provide an optically detectable sensing reaction, wherein said sensing surface is provided over one of said electrodes, and wherein said one of said electrodes is substantially transparent.

11. A microfluidic sensor as claimed in any preceding claim wherein said sensing surface comprises a hologram.

12. A microfluidic sensor for sensing biological particles including a particle concentration device for performing concentration of particles in three dimensions, the sensor device comprising:

a substrate bearing a microfluidic channel or chamber for carrying a conductive fluid bearing said particles for concentration, wherein said channel has:

first and second electrodes spaced apart on said channel or chamber for defining an electric field therebetween; and

a sensing surface on an inner surface of said channel or chamber for contact with said fluid to selectively sense said particles; and

wherein said particle concentration device comprises means for applying an ac voltage across said electrodes to flow said particles past said sensing surface and to concentrate said particles in three dimensions adjacent to or away from said sensing surface; and

wherein said sensing surface is configured to provide an optically detectable sensing reaction, wherein said sensing surface is provided over one of said electrodes, and wherein said one of said electrodes is substantially transparent.

13. A method of using 3D particle concentration for particle sensing in a microfluidic device including a conductive fluid bearing said particles, the method comprising:

applying an ac voltage across a pair of electrodes in channel or chamber of said microfluidic device including a conductive fluid bearing said particles to perform, simultaneously:

i) electrohydrodynamic generation of a convection current flow in said fluid; and

ii) 3D concentration of said particles in said fluid by dielectrophoretic attraction or repulsion of said particles to or from a region of increased electric field generated by said ac voltage across said electrodes; and

wherein said convection current flow and 3D concentration increase a concentration of said particles towards a sensing surface of said sensor.

14. A method as claimed in claim 13 wherein said sensing surface is disposed away from said electrodes in a convective flow path of said fluid, and wherein said ac voltage is selected to repel said particles in said fluid away from said electrodes.

15. A method as claimed in claim 13 wherein said sensing surface comprises an optically responding surface adjacent a transparent one of said electrodes, and wherein said ac voltage is selected to attract said particles in said fluid away from said electrodes.

16. A method as claimed in claims 13, 14 or 15 wherein said particles comprise droplets of oil in an aqueous said fluid.

17. A method as claimed in claim 13, 14 or 15 wherein said particles comprise biological entities having a mean maximum dimension of greater than 0.5 μm.

18. A method as claimed in any one of claims 13 to 17 wherein a gap between said electrodes is equal to a distance from a said electrode to said sensing surface to within +/- 50% of said distance from a said electrode to said sensing surface.

19. A system for using 3D particle concentration for particle sensing in a microfluidic device including a conductive fluid bearing said particles, the system comprising:

means for applying an ac voltage across a pair of electrodes in channel or chamber of said microfluidic device including a conductive fluid bearing said particles to perform, simultaneously:

i) electrohydrodynamic generation of a convection current flow in said fluid; and

ii) 3D concentration of said particles in said fluid by dielectrophoretic attraction or repulsion of said particles to or from a region of increased electric field generated by said ac voltage across said electrodes; and

wherein said convection current flow and 3D concentration increase a concentration of said particles towards a sensing surface of said sensor.

CLAIMS:

1. A microfluidic sensor for sensing biological particles including a particle concentration device for performing concentration of particles in three dimensions, the sensor device comprising:

a substrate bearing a microfluidic channel or chamber for carrying a conductive fluid bearing said particles for concentration, wherein said channel has:

first and second electrodes spaced apart on said channel or chamber for defining an electric field therebetween; and

a sensing surface on an inner surface of said channel or chamber for contact with said fluid to selectively sense said particles; and

wherein said particle concentration device comprises means for applying an ac voltage across said electrodes to flow said particles past said sensing surface and to concentrate said particles in three dimensions adjacent to or away from said sensing surface.

2. A microfluidic sensor as claimed in claim 1 wherein said substrate defines a lateral plane of said sensor, and wherein said particle concentration device is configured to concentrate said particles in a direction perpendicular to said lateral plane.

3. A microfluidic sensor as claimed in claim 2 wherein said channel or chamber has upper and lower surfaces spaced apart in said direction perpendicular to said lateral plane, said upper surface being further from said substrate than said lower surface and wherein one or both of said electrodes is disposed on or adjacent said upper surface.

4. A microfluidic sensor as claimed in any preceding claim wherein said surface is adjacent to or opposite a said electrode.

5 A microfluidic sensor as claimed in any preceding claim wherein said electrodes are disposed on the same side of said channel or chamber and wherein a gap between said electrodes is the same as a distance from a said electrode to said sensing surface, to within 50% of said distance from a said electrode to said sensing surface.

6. A microfluidic sensor as claimed in any preceding claim wherein said particles have a mean maximum dimension in the range of 0.5 to 200 μm.

7. A microfluidic sensor as claimed in claim 6 wherein said fluid is an aqueous fluid and wherein a said particle comprises a droplet of oil in said aqueous fluid, said droplet of oil including a biological entity.

8. A microfluidic sensor as claimed in any preceding claim wherein said sensing surface comprises a polymer sensing surface configured to provide an antibody/antigen-based surface sensing reaction.

9. A microfluidic sensor as claimed in any preceding claim wherein said means for applying said ac voltage comprises means to apply a said voltage at a frequency of greater than 100KHz, preferably greater than 1MHz.

10 A microfluidic sensor as claimed in any preceding claim wherein said sensing surface is configured to provide an optically detectable sensing reaction, wherein said sensing surface is provided over one of said electrodes, and wherein said one of said electrodes is substantially transparent.

11. A microfluidic sensor as claimed in any preceding claim wherein said sensing surface comprises a hologram.

12. A microfluidic sensor as claimed in any preceding claim, wherein said means for applying an ac voltage across said electrodes is configured to perform simultaneously:

i) electrohydrodynamic generation of a convection current flow in said fluid; and

ii) 3D concentration of said particles in said fluid by dielectrophoretic attraction or repulsion of said particles to or from a region of increased electric field generated by said ac voltage across said electrodes; and

wherein said convection current flow and 3D concentration increase a concentration of said particles towards said sensing surface of said sensor.

13. A method of using 3D particle concentration for particle sensing in a microfluidic device including a conductive fluid bearing said particles, the method comprising:

applying an ac voltage across a pair of electrodes in channel or chamber of said microfluidic device including a conductive fluid bearing said particles to perform, simultaneously:

i) electrohydrodynamic generation of a convection current flow in said fluid; and

ii) 3D concentration of said particles in said fluid by dielectrophoretic attraction or repulsion of said particles to or from a region of increased electric field generated by said ac voltage across said electrodes; and

wherein said convection current flow and 3D concentration increase a concentration of said particles towards a sensing surface of said sensor.

14. A method as claimed in claim 13 wherein said sensing surface is disposed away from said electrodes in a convective flow path of said fluid, and wherein said ac voltage is selected to repel said particles in said fluid away from said electrodes.

15. A method as claimed in claim 13 wherein said sensing surface comprises an optically responding surface adjacent a transparent one of said electrodes, and wherein said ac voltage is selected to attract said particles in said fluid away from said electrodes.

16. A method as claimed in claims 13, 14 or 15 wherein said particles comprise droplets of oil in an aqueous said fluid.

17. A method as claimed in claim 13, 14 or 15 wherein said particles comprise biological entities having a mean maximum dimension of greater than 0.5 μm.

18. A method as claimed in any one of claims 13 to 17 wherein a gap between said electrodes is equal to a distance from a said electrode to said sensing surface to within +/- 50% of said distance from a said electrode to said sensing surface.

19. A system for using 3D particle concentration for particle sensing in a microfluidic device including a conductive fluid bearing said particles, the system comprising:

means for applying an ac voltage across a pair of electrodes in channel or chamber of said microfluidic device including a conductive fluid bearing said particles to perform, simultaneously:

i) electrohydrodynamic generation of a convection current flow in said fluid; and

ii) 3D concentration of said particles in said fluid by dielectrophoretic attraction or repulsion of said particles to or from a region of increased electric field generated by said ac voltage across said electrodes; and

wherein said convection current flow and 3D concentration increase a concentration of said particles towards a sensing surface of said sensor.

20. A microfluidic sensor for sensing biological particles including a particle concentration device for performing concentration of particles in three dimensions, the sensor device comprising:

a substrate bearing a microfluidic channel or chamber for carrying a conductive fluid bearing said particles for concentration, wherein said channel has:

first and second electrodes spaced apart on said channel or chamber for defining an electric field therebetween; and

a sensing surface on an inner surface of said channel or chamber for contact with said fluid to selectively sense said particles; and

wherein said particle concentration device comprises means for applying an ac voltage across said electrodes to flow said particles past said sensing surface and to concentrate said particles in three dimensions adjacent to or away from said sensing surface; and

wherein said sensing surface is configured to provide an optically detectable sensing reaction, wherein said sensing surface is provided over one of said electrodes, and wherein said one of said electrodes is substantially transparent.