

11

slightly larger than the experimental value measured during the course of the present invention. Deviations from the experimental values obtained using hydrodynamic drag equation are most likely due to the frictional force resulting from the normal force, F_z , pulling the bead into the silicon nitride membrane surface. The force as a function of displacement from the center of the tip indicates that the size of the field gradient is comparable to the size of the particle, and the field outside the particle decreases rapidly. This localization of the magnetic trapping field allows for constant displacement measurements to be made, which is in contrast to typical magnetic tweezers that function as force clamps. While the set-up tested produced forces comparable to optical tweezers, it is possible to tailor the tip-particle geometry and magnetic material used to increase the force acting on the particle to forces typical of current magnetic tweezers apparatus ($\sim 10^2$ pN).

The magnetic material coating the side walls of the cone comprising the tip produces sufficient magnetic field gradients to attract more than one particle at a time. This is an undesirable attribute that can be resolved by implementing the traps to separate the particles. Particles less than 5 μm in diameter that are stuck together may be split up by dragging the particles over the center of a PERMALLOY™ element, where the particle furthest away from the tip will remain with the PERMALLOY™ element, while the other continues to track the field gradient of the tip.

FIG. 13 depicts a magnetic random access molecular manipulator according to one embodiment of the present invention (Note: will change description of FIG. 13 on page 8 in same manner). In FIG. 13 a micro fluidic chamber 40 that includes an array of magnetic traps 1 according to the present invention is positioned on a magnetic random access memory chip 41 that can be used to individually switch the magnetic traps 1 "ON" and "OFF" by passing current pulses through the magnetic traps or through wires 43 that are configured to address each of the magnetic traps 1. The micro fluidic chamber 40 includes a support 44 for the magnetic traps 1 which can be a fluid permeable support such as a membrane that provides a fluid barrier between the micro fluidic chamber 40 and the underlying electronics package. The micro fluidic chamber 40 can also include a suitable structure 45 that forms a flow area 46 to contain or direct the transfer of a fluid within the micro fluidic chamber 40. Such a structure 45 can be a silicon substrate, membrane or any suitable structure. With reference to FIG. 13 is noted that the present invention allows for the controlled movement of magnetic particles without a fluid flow channel. For example, an open surface provided with the array of magnetic traps 1 and the magnetic random access memory chip 41 of FIG. 13 (or any suitable control of the individual traps) would allow one to selectively turn "OFF" a magnet trap holding a particle and turn "ON" adjacent magnetic traps in sequence to move the particle around as desired. This eliminates the need for the type of fluid flow that is the basis of micro flow channel technology.

Although the present invention has been described with reference to particular means, materials and embodiments, from the foregoing description, one skilled in the art can easily ascertain the essential characteristics of the present invention and various changes and modifications can be made to adapt the various uses and characteristics without departing from the spirit and scope of the present invention as described above and in the attached claims.

What is claimed is:

1. A microfluidic platform for selectively manipulating magnetic particles, said microfluidic platform comprising:
a membrane;

12

at least one selectively generateable magnetic field; and
a plurality of spin valve magnetic traps attached to the membrane, the plurality of spin valve magnetic traps each configured to produce a local magnetic field when temporarily subjected to a magnetic field of sufficient strength to change the magnetization state of the spin valve trap between off and on states, said produced local magnetic field being capable of attracting and indefinitely retaining magnetic particles proximate the spin valve magnetic traps, said plurality of spin valve magnetic traps further being selectively switchable between the on state, in which the local magnetic fields are produced and the magnetic particles are magnetically attracted and retained proximate the spin valve magnetic traps, and an off state, in which no local magnetic fields are produced and the magnetic particles are not attracted or retained proximate the spin valve magnetic traps, and wherein the on state is further characterized by the persistence of the local magnetic field after the at least one selectively generateable magnetic field is discontinued.

2. The microfluidic platform for selectively manipulating magnetic particles according to claim 1, wherein the plurality of spin valve magnetic traps comprise a high moment low remnant field material.

3. The microfluidic platform for selectively manipulating magnetic particles according to claim 1, wherein the high moment low remnant field material is a nickel-iron alloy.

4. The microfluidic platform for selectively manipulating magnetic particles according to claim 1, wherein the plurality of spin valve magnetic traps each comprise a multilayered spin-valve structure comprising two discrete magnetic layers of a material that together can selectively have either parallel or anti-parallel magnetic moments when subjected to the magnetic field to produce the local magnetic fields near the individual spin valve magnetic traps that is capable of attracting and restraining and subsequently releasing the magnetic particles by the spin valve magnetic traps.

5. The microfluidic platform for selectively manipulating magnetic particles according to claim 1, wherein the plurality of spin valve magnetic traps each comprise a multilayered spin-valve structure having two discrete magnetic layers encased in a multiple layer structure that together can selectively have either parallel or anti-parallel magnetic moments when subjected to the magnetic field to produce in total the local magnetic fields near the individual spin valve magnetic traps that are capable of attracting and restraining and subsequently releasing the magnetic particles by the spin valve magnetic traps.

6. The microfluidic platform for selectively manipulating magnetic particles according to claim 1, wherein the plurality of spin valve magnetic traps each comprises a multilayered spin-valve structure having the following sequence of layers: a layer of tantalum, a layer of nickel-iron alloy, a layer of cobalt, a layer of copper, a layer of cobalt, a layer of nickel-iron alloy, a layer of IrMn and a layer of tantalum, wherein the layers of the nickel-iron alloy can selectively have either parallel or anti-parallel magnetic moments when subjected to the magnetic field to produce in total the local magnetic fields near the individual spin valve magnetic traps that are capable of attracting and restraining and subsequently releasing the magnetic particles by the spin valve magnetic traps.

7. The microfluidic platform for selectively manipulating magnetic particles according to claim 1, wherein the plurality of spin valve magnetic traps are arranged in an array and are sized to attract and restrain individual cells, molecules, or polymers that are magnetically tagged.