

[0010] In an embodiment, the present invention provides a microfluidic device comprising a solid support, where the solid support comprises a sample inlet port, at least one microchannel comprising at least one section filled with magnetic beads, a sample outlet port, and a detection module. The detection module includes a detection electrode, a self-assembled monolayer; a binding ligand; and a detection inlet port to receive a sample.

[0011] In another aspect, the present invention provides a method to process a target analyte in a sample. An embodiment includes providing a target analyte labeled with a magnetic label and introducing the analyte to a microfluidic device comprising a solid support. The solid support comprises a sample inlet port, at least one microchannel comprising at least one section with walls comprising magnetic beads, and a sample outlet port. The sample is introduced under conditions whereby the labeled target analyte binds to said walls. In some embodiments, other components of the sample are washed away, or the analyte may be treated.

[0012] In another embodiment, the present invention provides a method to process a target analyte in a sample. A target analyte labeled with a magnetic label is provided and introduced to a microfluidic device comprising a solid support comprising a sample inlet port, at least one microchannel comprising a gradient inducing feature coated with a magnetic material, and a sample outlet port. The sample is introduced under conditions whereby said labeled target analyte is transported toward said gradient inducing feature.

[0013] In another embodiment, the present invention provides a method to process a target analyte in a sample. Target analyte labeled with a magnetic label is provided and introduced to a microfluidic device comprising a solid support. The solid support comprises a sample inlet port, at least one microchannel comprising at least one section filled with magnetic beads, a sample outlet port, and a detection module. The detection module includes a detection electrode, a self-assembled monolayer, a binding ligand, and a detection inlet port to receive a sample. The sample is introduced under conditions whereby the target analyte binds to the channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 depicts one preferred embodiment of the present invention. The depicted microfluidic device comprises a solid support 100 that has a sample inlet port 20, a storage module 30, a labeling chamber 40, a magnetic microchannel 50, a sample outlet port 60, a waste outlet port 70, a releasing chamber 80, a waste storage module 90, and a detection module 105. The various components are in communication with their corresponding components through fluidic microchannels. The embodiment may additionally comprise cell handling modules, reaction modules, separation modules, valves, and pumps.

[0015] FIGS. 2-4 depict a number of preferred embodiments of magnetic microchannels. FIG. 2 depicts a magnetic microchannel 550 with magnetic beads 11 embedded on the outer surface of the channel. The embedded beads can be optionally non-uniform in size. FIG. 3 depicts a magnetic microchannel 551 with magnetic beads 11 coated on the inner surface of the channel. The coated beads can be optionally non-uniform in size. FIG. 4 depicts a magnetic microchannel 552 with magnetic beads 11 packed inside the channel.

[0016] FIG. 5 depicts a cross-sectional view of a magnetic microchannel incorporating saw-toothed ridges according to an embodiment of the present invention.

[0017] FIG. 6 depicts a cross-sectional view of a magnetic microchannel incorporating domed features according to another embodiment of the present invention.

[0018] FIG. 7 depicts a mold for fabricating a magnetic microchannel incorporating a dome structure according to an embodiment of the present invention.

[0019] FIG. 8 is a schematic representation of an anisotropic etched Si structure according to an embodiment of the present invention.

[0020] FIGS. 9 and 10 depict scanning electron microscope (SEM) images of an anisotropic etched Si structure used to mold a plastic substrate according to an embodiment of the present invention.

[0021] FIGS. 11 and 12 depict SEM images of a compression-molded plastic microchannel with ridge microstructures according to an embodiment of the present invention.

[0022] FIGS. 13 and 14 depict SEM images of pit structures of an isotropic etched Si stamper according to an embodiment of the present invention.

[0023] FIGS. 15 and 16 depict SEM images of a channel structure with micro-dome arrays obtained in a compression molding process according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] The present invention provides microfluidic devices that can be used to effect a number of manipulations on a sample to ultimately result in target analyte detection or quantification. The device provides at least one magnetic microchannel that is capable of separating magnetic or magnetically-labeled target analytes from non-magnetic materials. Further, a magnetic microchannel may sort materials according to their magnetic response. Alternatively, magnetic or magnetically-labeled components other than the target analytes can be retained by the magnetic microchannel and are thus removed from the target analytes. The magnetic labeling is achieved by the association of the target analyte or contaminant to a binding ligand conjugated on a magnetic particle. Depending on the specificity of the binding ligand, one can either separate a vast population of analytes sharing a common binding motif, or specifically retain a rare target analyte because of its recognition of a specific ligand on the magnetic particle.

[0025] The magnetic microchannel may comprise matrix elements such as magnetic beads that are either embedded in the substrate surrounding the microchannel or coated on the inner surface of the microchannel. Alternatively, the microchannel may be filled with magnetic beads, and the interstitial spacing among the beads form a relatively uniform channel in which the sample can flow. Upon being exposed to an external magnetic field, the magnetic beads will produce a local high gradient magnetic field within the microchannel. Advantageously, the particles that are embedded in or coated on the surfaces of the microchannels are nonuniform in size, so that a desired local magnetic gradient can be achieved.