Microbeads for Sampling and Mixing in a Complex Sample

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Detection of low concentrations of bacteria, viral particles and parasites in food samples is a challenging process [1]. The separation of the target from the food matrix is a key step that needs to be carried out with highly specific capture of the target onto a mobile phase. This can subsequently be separated and concentrated for detection with florescent, electrochemical or quantum dot labeling. The capture of the target can be more effectively carried out with efficient mixing.

Microfluidics provides exciting possibilities for miniaturized biosensors allowing for highly parallel and high throughput tests to be performed in miniaturized "lab-on-a-chip" packaging with a great deal of control utilizing the low Reynolds number flows. However, laminar flow makes mixing of fluid difficult. Passive mixers stretch and fold fluids, shortening diffusion lengths or use herring-bone features in a channel to achieve mixing [2]. These mixers require either complicated 3-D fabrication, relatively long mixing lengths or both. Active mixers exert time-dependent disturbances.

We present a simple microfluidic system capable of controlled transport of rotating paramagnetic beads among soft magnetic patterns. Low aspect ratio super-paramagnetic NiFe discs (150 nm tall, diameter 3 µm) are patterned onto a silicon wafer. A PDMS channel is bonded onto the wafer to create the microfluidic channel. An external permanent magnet attached to a motor provides a magnetic field, which can be rotated at different speeds while magnetizing the NiFe disks in the channel. Paramagnetic microbeads (Dynabeads MyOne® & M-280, Invitrogen) introduced into the channel with a syringe pump are trapped at the poles of the now magnetized soft magnetic discs. Rotation of the external permanent magnet will also rotate the induced magnetic poles in the soft magnetic discs which will in turn rotate the trapped microbeads (Figure 1).

The individually controlled bead transport with synchronized circulating motion provide strong interact between the particles and the fluid flow, which is good for sampling in microchannels. The effective transport of the beads also facilitates the uniform distribution of beads among the soft magnetic patterns, which is important to many biological total-analyses on a chip (see Figure 2).

We have already demonstrated the capacity to capture particles from flow with rotating M-280 beads in this device (Figure 3). Future work will investigate the effects of device geometry by optimizing the flow rate and bead rotation speed in order to capture particles of different sizes efficiently. For example, altering the channel height to allow for higher throughput with taller NiFe features and varying the spacing between the NiFe pillars. The long term objective of this work is to develop a practical compact portable pre-concentration and pathogen purification system for complex mixtures important for food and environmental safety that can be applied to a wide range of assays.

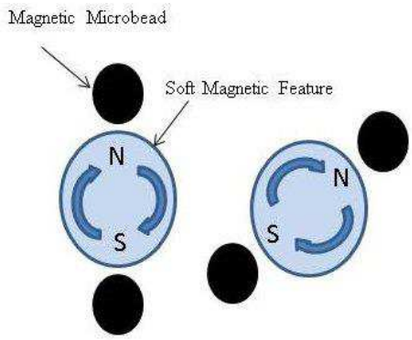

Figure 1: Magnetic attraction between paramagnetic beads and induced magnetic poles. As the external permanent magnet rotates, the induced poles within the soft magnetic features also rotate, pulling the magnetic microbead.

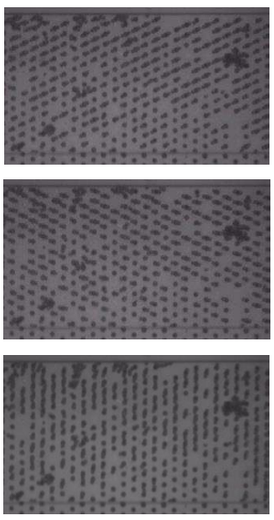

Figure 2: M-280 (2.8 micron diameter) magnetic microbeads are trapped at magnetized NiFe discs (3 micron in diameter, 150 nm tall) in a microfluidic channel. The rotation of the M-280 beads is caused by the rotation of the external permanent magnet.

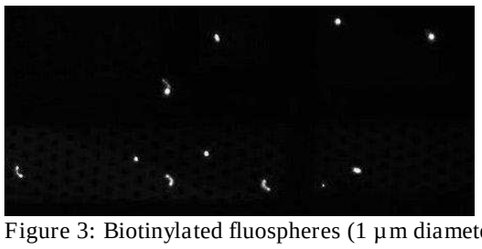

Figure 3: Biotinylated fluospheres (1 µm diameter) were flown (linear velocity 24 cm/min) into a channel (150 µm wide, 6.5 µm tall) and captured by rotating streptavidin coated M-280 beads (2.8 µm diameter). In the image, M-280 beads were rotating at 2500 rpm (linear velocity 2.3 cm/min). Bound fluospheres show up as streaklines due to the exposure time needed to detect fluorescence.

REFERENCES

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