

manipulations and can also be split into two smaller daughter droplets (FIG. 1D) to physically isolate and drive a specific sample type to an analysis or immuno-capture site. That is, once the droplet containing sample is extracted, the droplet can be subjected to forces (e.g., electrical) to further spatially separate the sample molecules or particles within the droplet. Then the droplet can be further subdivided, for example by being pulled apart into two droplets, to render this spatial separation permanent. Alternatively, a uniform droplet can be split and divided repeatedly to create multiple identical droplets to allow parallel analysis.

[0022] Droplet extraction from a liquid column was demonstrated using the test chip design shown in FIG. 3A. In the design the channel or column **40** is a CE column powered by CE electrodes **42** (powered by traces **52**) which draw a sample from a sample reservoir **44** through the column **40**. The length of the column from the reservoir **44** to the electrodes **42** is between two and three centimeters. The actual channel through which liquid flows is approximately 100 μm wide and 80 μm in height. Spacers **46** support a layer of glass (or similar transparent material) above the device to create the upper bounds of the channel. Two T-shaped EWOD electrodes **48** are provided to extract a droplet from an extraction point **22** (a 1.5 mm long opening in the walls of the column) located where the column **40** passes between the two EWOD electrodes **48**. The EWOD electrodes are powered by a plurality of traces **54**. All the traces lead to square connection pads **56** (20 pads total) which interconnect with a connector (not shown) to power and control the device.

[0023] FIG. 3B is a photograph of the actual fabricated chip at approximately life size. FIG. 3B shows a photomicrograph of the extraction point **22**. The side walls **60** of the column end at either side of the EWOD electrodes **48** leaving the 100 μm wide fluid channel **58** to cross the electrodes **48** without side walls. In this photomicrograph, the EWOD electrodes **48** are drawing liquid out of the channel **58** forming menisci **62** on either side.

[0024] FIG. 4A shows a large reservoir water droplet **64** which will supply the refill droplet. The EWOD electrode array **48** runs from left to right. FIG. 4B shows a meniscus **66** (to the right) outlining a refill droplet **68** being pulled from the reservoir droplet **64**. Note the channel **58** crossing the EWOD electrodes **48** at the far right. FIG. 4C shows the necking as the refill droplet **68** is pinched off from the reservoir droplet as the droplet **68** is driven towards the right and the channel **58**. FIG. 4D shows the fully formed refill droplet **68** moving towards the separation channel **58**. FIG. 4E shows a droplet **70** being extracted from the right side of the channel opening (while the refill droplet **68** moves in from the left side). FIG. 4F shows the necking of the extracted droplet **70** pulled from the separation channel **20**. FIG. 4G shows the extracted drop **70** fully separated while FIG. 4H shows the extracted droplet **70** driven farther to the right end of the EWOD electrode **48**.

[0025] Surprisingly, a break or physical wall opening does not interfere with liquid channel functions such as separation. For example, CE separation was successfully conducted in the test chip channel of the type shown in FIG. 3 (100 μm

wide) with a mid-channel opening 1.5 mm in length. In that experiment a mixture of red colored Carboxyl Modified Latex (CML) beads (10 μm diameter) and white colored Amino Sulfate coated beads (10 μm diameter) were pipetted into the channel input reservoir. Then an approximately 80V potential was applied to the CE electrodes located at opposite ends of the channel. There was clear separation of red and white beads into distinct bands within the channel due to surface charge differences of the beads. The band of red beads arrived first at the extraction point where it was extracted following the steps shown in FIG. 4. At the extraction point the band of white beads reached the earlier arriving red beads. As anticipated remixing of the two bead populations was prevented by the droplet extraction-refill droplet process demonstrating that 1) the order of separation can be preserved and that 2) the CE separation continues to function normally despite the presence of the extraction point opening.

[0026] The following claims are thus to be understood to include what is specifically illustrated and described above, what is conceptually equivalent, what can be obviously substituted and also what essentially incorporates the essential idea of the invention. Those skilled in the art will appreciate that various adaptations and modifications of the just-described preferred embodiment can be configured without departing from the scope of the invention. The illustrated embodiment has been set forth only for the purposes of example and that should not be taken as limiting the invention. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

What is claimed is:

1. A method for extracting a droplet from fluid within a microfluidic column or channel comprising the steps of:
 - providing an extraction point on the column or channel;
 - providing a refill droplet;
 - extracting fluid from the column or channel at the extraction point by means of surface phenomena; and
 - creating an extracted droplet by simultaneously allowing the refill droplet to enter the column or channel adjacent the extraction point to replace the extracted fluid.
2. The method according to claim 1, wherein the column or channel is bounded by a physical wall and the extraction point includes a physical opening in the wall.
3. A microfluidic device comprising:
 - a separation channel or column;
 - an extraction point on the column or channel;
 - means for providing a refill droplet adjacent the extraction point; and
 - means for extracting fluid from the column or channel at the extraction point using surface phenomena, whereby an extracted drop can be created by allowing the refill droplet to enter the column or channel to replace extracted fluid.
4. The device according to claim 3, wherein the column or channel is bounded by a physical wall and the extraction point includes a physical opening in the wall.

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