approaches increase throughput, the approach introduces undesired complexity in design and use. Moreover, concentrating cells or particles into a single small volume for higher resolution approaches becomes problematic.

[0012] Accordingly, there is a need in the industry to provide methods, systems and devices for high-throughput sorting and isolation of target cells or particles into smaller volumes relative to a starting sample size. The present disclosure and various embodiments describe herein address this need by the application of various techniques, including field based concentration of particles (including but not limited to non-contact acoustic concentration approaches), laminar flipping flow geometries, and/or particle traps for separating, concentrating and/or trapping particles (including cells) for interrogation and/or further analysis.

SUMMARY OF THE INVENTION

[0013] The present disclosure provides embodiments that are directed to devices, systems and methods for the concentration of particles, the devices comprising: a flow channel adapted to receive a fluid sample moving in a first direction within flow streams; a field generator configured to focus particles within the fluid sample into a focused stream at a first flow rate; one or more additional flow channels; a branch, wherein the branch is configured to be in fluid communication with the flow channel and the one or more additional flow channels, wherein the branch and the one or more additional flow channels are configured to direct the fluid sample into the one or more additional flow channels and to flip the particles in the focused stream to a second direction at a second flow rate, and wherein the first flow rate is greater than the second flow rate; and an analysis region, wherein the analysis region is positioned within the one or more additional flow channels to allow analysis of the particles flipped to the second direction, and wherein the branch and the one or more additional flow channels are configured to concentrate the particles in the analysis region.

The method for concentrating particles according to the present disclosure comprises flowing a fluid sample in a flow channel in a first direction within flow streams, wherein the fluid sample comprises particles; applying a field to focus the particles in the fluid sample into a focused stream at a first flow rate; flipping the particles in the focused stream to a second direction at a second flow rate, wherein the first flow rate is greater than the second flow rate; and concentrating particles flipped to the second direction in an analysis region.

[0014] Certain embodiments of the devices, systems and methods described herein have additional aspects, including a fluid source configured to be in fluid communication with the flow channel; a fluid source that comprises one or more pumps; and/or a controller configured to control the fluid source. Additionally, the field generator can be an acoustic

CLAIMS

1. A device for concentration of particles, comprising:

a flow channel adapted to receive a fluid sample moving in a first direction within flow streams;

a field generator configured to focus particles within the fluid sample into a focused stream at a first flow rate;

one or more additional flow channels;

a branch, wherein the branch is configured to be in fluid communication with the flow channel and the one or more additional flow channels, wherein the branch and the one or more additional flow channels are configured to direct the fluid sample into the one or more additional flow channels and to flip the particles in the focused stream to a second direction at a second flow rate, and wherein the first flow rate is greater than the second flow rate; and

an analysis region, wherein the analysis region is positioned within the one or more additional flow channels to allow analysis of the particles flipped to the second direction, and wherein the branch and the one or more additional flow channels are configured to concentrate the particles in the analysis region.

2. The device of claim 1, wherein the field generator is an acoustic field generator configured to provide an acoustic wave within the flow channel.

3. The device of claim 2, wherein the acoustic field generator is configured to generate a pressure node within the flow channel such that the particles accumulate in the pressure node.

4. The device of claim 1, wherein the one more additional flow channels comprise a first additional flow channel and a second additional flow channel.

5. The device of claim 1, wherein the branch and the one or more additional flow channels are configured to accumulate the particles flipped to the second direction on a channel wall within the analysis region.

6. The device of claim 1, further comprising a detector, wherein the detector is configured to interrogate the particles within the analysis region.

7. The device of claim 1, further comprising a second field generator, wherein the second field generator is positioned and configured to affect particles in the one or more additional flow channels.

8. The device of claim 1, further comprising a trap, wherein the trap is configured to constrain particles within the analysis region.

9. The device of claim 1, further comprising one or more selection filters.

10. The device of claim 1, further comprising an initial stage, wherein the initial stage is positioned upstream of the flow channel, wherein the initial stage comprises an initial flow channel and an initial field generator, wherein the initial flow channel is adapted to receive the fluid sample, and wherein the initial field generator is configured to focus the particles within the fluid sample.

11. The device of claim 10, wherein the initial field generator is configured to focus a first plurality of particles along a center-line of the initial flow channel while a second plurality of particles is not focused along the center-line of the initial flow channel.

12. A method for concentrating particles, comprising:

flowing a fluid sample in a flow channel in a first direction within flow streams, wherein the fluid sample comprises particles;

applying a field to focus the particles in the fluid sample into a focused stream at a first flow rate;

flipping the particles in the focused stream to a second direction at a second flow rate, wherein the first flow rate is greater than the second flow rate; and

concentrating particles flipped to the second direction in an analysis region.

13. The method of claim 12, wherein flipping the particles comprises flowing the particles through a branch into one or more additional flow channels.

14. The method of claim 12, wherein the field is an acoustic field and provides an acoustic wave within the flow channel.

15. The method of claim 13, wherein the one more additional flow channels comprise a first additional flow channel and a second additional flow channel.

16. The method of claim 12, further comprising:
interrogating the particles within the analysis region with a detector.

17. The method of claim 12, further comprising:
applying a second field to the particles after the particles have been flipped.

18. The method of claim 12, further comprising:
constraining particles within the analysis region with a trap.

19. The method of claim 13, further comprising:
filtering a first plurality of particles in the one or more additional flow channels.

20. The method of claim 12, further comprising:

concentrating the particles in an initial flow channel before the fluid sample is flowed into the flow channel, wherein the initial flow channel is upstream of the flow channel.