CLAIMS

1.- A method for the isolation of at least one first particle (2) of a given type by means of a microfluidic system (1), which comprises a feeding assembly (8) and a microfluidic circuit (4) having: at least one inlet (5); at least one first outlet (6); and at least one microfluidic channel (7), which is designed to fluidically connect the inlet (5) and the first outlet (6);

the microfluidic channel (7) comprises at least one first segment (15), at least one second segment (16), which is arranged downstream of the first segment (15), and at least one third segment (17), which is arranged downstream of the second segment (16);

the method comprises a feeding step, during which the feeding assembly (8) feeds a sample, comprising at least one first particle (2) and at least one second particle (3) of a type different from the first particle (2), from the inlet (5) to the first outlet (6) along the microfluidic channel (7); and

a trapping step, during which the first particle (2) is trapped in and prevented from escaping from the second segment (16), while letting the second particle (3), which reaches at least the third segment (17), pass through the second segment (16);

the microfluidic system (1) comprises a movement device (26), which is configured to directly exert a ~~(~~selective~~)~~ force upon said first particle (2) of a given type;

the method further comprises a selection step, which is subsequent to the trapping step and during which the movement device (26) directly exerts a force upon the first particle (2) so as to substantially selectively move the first particle (2), relative to at least part of a further content of the microfluidic channel (7), along at least one part of a given path (P) from the second segment (16) downstream of the second segment (16) itself; the given path (P) extends inside said microfluidic circuit (4);

wherein the microfluidic system (1) comprises a collection area (25), which is fluidically connected to the microfluidic channel

(7); during the selection step, the movement device (26) moves the first particle (2) substantially selectively from the microfluidic channel (7) (in particular, from the second segment (16)) to the collection area (25).

2.- The method according to claim 1, wherein, during the selection step, the movement device (26) directly exerts said force upon the first particle (2) so as to substantially selectively move the first particle (2) relative to the second particle (3) along at least said part of said given path (P) from the second segment (16) downstream of the second segment (16) itself.

3.- The method according to claim 1 or 2, wherein the sample comprises at least one third particle (3'); during the trapping step, the third particle (3') is trapped in the second segment (16); during the selection step, the movement device (26) directly exerts said force upon the first particle (2) so as to move the first particle (2) substantially selectively relative to the third particle (3') along at least said part of said given path (P) from the second segment (16) downstream of the second segment (16) itself.

4.- The method according to any one of the preceding claims, wherein the selection step comprises a detection sub-step, which is at least partially subsequent to the trapping step and during which information concerning the content of the second segment (16) is collected in order to identify at least said first particle (2); for example, during the selection step, said first particle (2) is distinguished from said third particle (3').

5.- The method according to any one of the preceding claims, wherein during the trapping step, the first particle (2) is trapped by means of a trapping system chosen in the group consisting of: a vortex created in the second segment (16), a dielectrophoretic force exerted at the second segment (16), a

magnetic force exerted at the second segment (16), and a combination thereof.

6.- The method according to any one of the preceding claims, wherein the first segment (15) has a first inner cross-section; the second segment (16) has a second inner cross-section having a sudden size increase (AI) relative to the first inner cross-section (16); the first particle (2) is trapped by means of a vortex created in the second segment (16).

7.- The method according to any one of the preceding claims, and comprising a recovery step, during which the first particle (2) is conveyed from the collection area (25) out of the microfluidic circuit (4), for example through a second outlet (27); for example, during the recovery step, the fluid present in the collection area (25) is moved so as to force the first particle (2) through the second outlet (27); for example, the first particle (2) is larger than the second particle (3).

8.- The method according to any one of the preceding claims, wherein, during the selection step a plurality of first particles (2) are moved to the collection area (25) so as to obtain a group of first particles (2) in the collection area (25); for example, during the recovery step, the first particles (2) are moved away from the collection area (25) (for example, they are conveyed from the collection area (25) out of the microfluidic circuit (4)) one at a time.

9.- The method according to any one of the preceding claims and comprising a washing step, during which the feeding assembly (8) conveys a washing liquid through the microfluidic channel (7) so that the second particle (3) is forced out of the of given path (P), for example through the first outlet (6), whereas the first particle (2) is kept in the second segment (16); for example, the selection step is subsequent to the washing step; for example, the washing step is at least partially subsequent

to the trapping step; for example, during the selection step, the fluid present in the channel (7) is not moved (the fluid is substantially still).

10.- The method according to any one of the preceding claims, wherein the sample has a plurality of first particles (2) and a plurality of second particles (3); the microfluidic system (1) has a plurality of second segments (16); during the trapping step, at least part of the first particles (2) is trapped by vortexes created in the second segments (16) and at least part of the second particles (3) passes through the second segments (16); during the selection step, the movement device (26) moves at least part of the first particles (2) from the second segments (16), for example to the collection area (25); for example, during the washing step, at least part of the second particles (3) is forced out of the microfluidic circuit (4) (for example, through the first outlet (6)), whereas at least part of the first particles (2) is kept in the second segment (16).

11.- The method according to any one of the preceding claims and comprising a detection sub-step, which is at least partially subsequent to the trapping step and at least partially prior to the selection step and during which the first particle (2) is identified by capturing at least one image; for example, the first particle (2) is identified by assessing one or more morphological and/or fluorescence features thereof.

12.- The method according to any one of the preceding claims, wherein, during the selection step, the first particle (2) is moved by means of a system chosen in the group consisting of: dielectrophoresis, optical tweezers, opto-electronic tweezers, light-induced dielectrophoresis, magnetophoresis, acoustophoresis, and a combination thereof.

13.- The method according to any one of the preceding claims, wherein the first particle (2) is a circulating tumour cell; the

second particle (3) is chosen in the group consisting of: erythrocytes, lymphocytes, and a combination thereof.

14.- The method according to any one of the preceding claims and comprising a marking step, which is at least partially prior to the selection step (for example, is at least partially prior to the detection sub-step) and during which one between the first particle (2) and the second particle (3) is marked with a selective marker.

15.- The method according to any one of the preceding claims, wherein the sample comprises (in particular, mainly consists of) a substantially liquid base in which the first particle (2) and at least the second particle (3) are distributed; the method comprises an adjustment step, during which the temperature of the sample is changed so as to change the viscosity of said liquid base.

16.- A microfluidic system for the isolation of at least one first particle (2) of a given type; the microfluidic system (1) comprises a microfluidic circuit (4) provided with: at least one inlet (5); at least one first outlet (6); at least one microfluidic channel (7), which is configured to fluidically connect the inlet (5) and the first outlet (6); and a feeding assembly, which is configured to feed a sample along the microfluidic channel (7);

the sample comprises the first particle (2) and at least one second particle (3) of a different type from the first particle (2);

the microfluidic channel (7) comprises at least one first segment (15), at least one second segment (16), which is arranged downstream of the first segment (15), and at least one third segment (17), which is arranged downstream of the second segment (16);

the microfluidic system (1) further comprises a trapping system, which is configured to trap the first particle (2) in the

microfluidic channel (7), while letting the second particle (3), which reaches at least the third segment (17), go through; and a movement device (26), which is configured to directly exert a ~~(~~selective~~)~~ force upon said first particle (2) so as to move the first particle (2) along at least one part of a given path (P) from the second segment (16) downstream of the second segment (16); the given path (P) extends inside said microfluidic circuit (4);

wherein the microfluidic system (1) comprises a collection area (25), which is fluidically connected to the microfluidic channel (7); the movement device (26) is designed to move the first particle (2) substantially selectively from the microfluidic channel (7) to the collection area (25).

17.- The microfluidic system according to claim 16, wherein the trapping system is chosen in the group consisting of: the second segment (16) shaped so as to generate, as a consequence of a fluid flow flowing through the microfluidic channel (7), a vortex arranged at the second segment (16) and is configured to trap the first particle (2); a device configured to exert a dielectrophoretic force at the second segment (16); a device configured to exert a magnetic force at the second segment (16); and a combination thereof.

18.- The microfluidic system according to claim 16 or 17, wherein the first segment (15) has a first inner cross-section; the second segment (16) has a second inner cross-section with an equivalent diameter with a sudden increase (AI) of at least 80 µm relative to the first inner cross-section, and at least one third segment (17), which is arranged downstream of the second segment (16); the microfluidic channel (7) (for example, the second segment (16)) is configured to generate, as a consequence of a fluid flow flowing through the microfluidic channel (7), a vortex, which is arranged at the second segment (16) and is designed to trap the first particle (2).

19.- The microfluidic system according to claim 18, wherein the second inner cross-section has a sudden size increase (AI) of the equivalent diameter ranging from approximately 80 μm to approximately 800 μm relative to the first inner cross-section; for example, the first and the third segment (15, 17) have a width ranging from 20 μm to 200 μm and a height ranging from 20 μm to 500 μm; for example, the second segment has a length ranging from 200 μm to 2 mm.

20.- The microfluidic system according to any one of the claims from 16 to 19, wherein the movement device (26) comprises a particle moving system chosen in the group consisting of: dielectrophoresis, optical tweezers, opto-electronic tweezers, light-induced dielectrophoresis, magnetophoresis, acoustophoresis, and a combination thereof.

21.- The microfluidic system according to any one of the claims from 16 to 20, wherein the movement device (26) is configured to directly exert the (selective) force upon said first particle (2) of a given type in order to move the first particle (2) along the given path (P) from the second segment (16) to the collection area (25), which is arranged downstream of the microfluidic channel (7).

22.- The microfluidic system according to claim 21, wherein the collection area (25) comprises a waiting area (29) and a recovery area (30); the movement device (16) being configured to transfer the first particle (2) from the microfluidic channel (7) (for example, from the second segment (16)) to the waiting area (29) and, subsequently, from the waiting area (29) to the recovery area (30); the microfluidic system (1) further comprising a conveying assembly (28), which is configured to feed a fluid towards the recovery area (30) so as to convey the first particle (2) out of the microfluidic circuit (4) through a second outlet (27) of the microfluidic circuit (4).

23.- The microfluidic system according to any one of the claims from 16 to 22 and comprising at least one detection device to capture images of at least part of the microfluidic circuit (4), for example at least of the second segment (16), the given path (P) and the collection area (25).

24.- The microfluidic system according to any one of the claims from 16 to 23, wherein the microfluidic circuit (4) comprises a second outlet (27); the microfluidic system (1) comprises a conveying assembly (28), which is configured to convey the first particle (2) from the collection area (25), through the second outlet (27), out of the microfluidic circuit (4).

25.- The microfluidic system according to any one of the claims from 16 to 24, wherein the first, the second and the third segment (15, 16, 17) have respective cross-sections substantially having the shape of quadrilateral parallelogram.

26.- The microfluidic system according to any one of the claims from 16 to 25, wherein the second segment (16) is delimited by a rear surface (19) arranged at the end of the first segment (16) and transverse to the microfluidic channel (7) as well as having an inclination of at least 45° (for example, it is substantially perpendicular) relative to a feeding direction (D) of the first particle (2) along the first segment (15).

27.- The microfluidic system according to one of the claims from 16 to 26, wherein the microfluidic circuit (4) comprises a plurality of microfluidic channels (7), each having at least one respective first segment (15), at least one respective second segment (16) and at least one respective third segment (17).

28.- The microfluidic system according to any one of the claims from 16 to 27, wherein the feeding assembly (8) comprises a washing device (10), which is configured to feed a washing liquid through the microfluidic channel (7) towards the first outlet

(6).

29.- The microfluidic system according to any one of the claims from 16 to 28, wherein the sample comprises at least one further particle (2'); the microfluidic channel (7) comprises at least one fourth segment (16'), which is arranged downstream of the second segment (16);
the trapping system (1) is configured to trap said first particle (2) in the second microfluidic segment (16), while letting said second particle (3) and said further particle (2') go through, and to trap said further particle (2') in the fourth segment (16'); for example, the trapping system comprises said fourth segment (16'), which is shaped so as to generate, as a consequence of a fluid flow flowing through the microfluidic channel (7), a vortex arranged at said fourth segment (16') and designed to trap the further particle (2').