CLAIMS

1. An inspection system (1.3; 12) operative to inspect a medical container containing a liquid, the inspection system (1.3; 12) comprising:

a sample holder (1.4; 2.1; 12.1) operative to hold the medical container along an axis (2.2; 6.11);

at least one optical system (1.5; 2.5, 2.8; 3; 4; 5; 6; 7; 11; 12.3, 12.4, 12.5) having:

at least one light source (3.2; 4.6; 5.2; 6.3; 7.2; 11) operative to output light incident onto the medical container; and

at least one detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4; 11) operative to detect return light from the medical container, wherein the at least one detector comprises a first detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4) comprising an opto-electrical transducer having a plurality of pixels; and

an evaluation system (1.7) coupled to the at least one optical detector and operative to detect and/or determine characteristics of a particle in the medical container based at least on an output of the at least one detector;

at least one actuator (1.6; 2.6, 2.7; 12.6) operative to move the at least one light source (3.2; 4.6; 5.2; 6.3; 7.2; 11) and/or the at least one detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4; 11) around the axis (2.2; 6.11) while the sample holder (1.4; 2.1; 12.1) holds the medical container in a rotationally and translationally fixed manner;

wherein:

the at least one light source comprises a first light source (3.2; 4.6; 5.2; 6.3; 7.2) operative to output a light sheet, and

the first detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4) comprises a tilt objective (6.7; 7.4).

2. The inspection system (1.3; 12) of claim 1, wherein the at least one actuator (1.6; 2.6, 2.7; 12.6) is operative to move the at least one light source and the at least one detector along a path that is curved around the axis (2.2; 6.11),

optionally wherein one, several, or all of the following applies or apply:

at least a segment of the path extends in a plane perpendicular to the axis (2.2; 6.11);

the path comprises an elliptical arc;

the path comprises a circular arc;

the at least one actuator (1.6; 2.6, 2.7; 12.6) is operative to concurrently change a position and an orientation of the at least one light source (3.2; 4.6; 5.2; 6.3; 7.2; 11) to keep the illumination light incident onto the medical container and/or the axis (2.2; 6.11);

the at least one actuator is operative to concurrently change a position and an orientation of the at least one detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4; 11) to cause the return light to be incident onto the at least one detector.

3. The inspection system (1.3; 12) of claim 1 or claim 2, further comprising a frame (2.3) on which the at least one optical system is supported, wherein the sample holder (1.4; 2.1; 12.1) is arranged in a fixed location relative to the frame (2.4), and wherein the at least one actuator (1.6; 2.6, 2.7; 12.6) is operative to move the at least one light source and/or the at least one detector relative to the frame (2.3).

4. The inspection system (1.3; 12) of any one of the preceding claims, wherein

the at least one actuator (1.6; 2.6, 2.7; 12.6) comprises a first actuator (1.6; 2.6, 2.7; 12.6) operative to move the first light source (3.2; 4.6; 5.2; 6.3; 7.2) around the axis (2.2; 6.11);

optionally wherein the first actuator (1.6; 2.6, 2.7; 12.6) is operative to move the first light source (3.2; 4.6; 5.2; 6.3; 7.2) around the axis (2.2; 6.11) such that the light sheet remains incident upon the axis (2.2; 6.11) as the first light source (3.2; 4.6; 5.2; 6.3; 7.2) is moved around the axis (2.2; 6.11).

5. The inspection system (1.3; 12) of claim 4, wherein the first detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4) is operative to provide a first detector output responsive to the return light during illumination of the medical container with the light sheet, optionally wherein the first detector comprises a Scheimpflug camera.

6. The inspection system (1.3; 12) of claim 5, wherein the evaluation system (1.7) is operative to at least one of:

detect, based at least on the first detector output, the particle when the particle is located in the light sheet;

determine, based at least on the first detector output, that the particle is located in an interior of the medical container;

discriminate, based at least on the first detector output, the particle from a bubble in a liquid within the medical container;

discriminate, based at least on the first detector output, the particle from an impurity within a container wall of the medical container;

determine, based at least on the first detector output for several different angular positions of the first light source and/or the first detector around the axis (2.2; 6.11), information on a morphology of the particle, optionally a three-dimensional surface shape of the particle;

determine, based at least on the first detector output, information on a size of the particle, optionally a three-dimensional size of the particle.

7. The inspection system (1.3; 12) of any one of the preceding claims, wherein the at least one light source comprises a second light source (11) operative to output a Raman probe beam and the at least one detector comprises a second detector (11) coupled to a Raman spectrometer.

8. The inspection system (1.3; 12) of claim 7 when dependent on claim 6,

wherein the at least one actuator comprises a second actuator (2.7) operative to move both the second light source (11) and the second detector (11), wherein the second actuator has more degrees of freedom than the first actuator, optionally wherein the first actuator (2.6; 12.6) has one degree of freedom and the second actuator (2.7) has at least two degrees of freedom (5.41, 5.42) and/or optionally wherein the second actuator comprises a multi-axis robotic arm or a multi-axis (5.41, 5.42) linear displacement actuator, and/or

the inspection system (1.3; 12) comprises a control device operative to control the second actuator (2.7) based at least on the first detector output.

9. The inspection system (1.3; 12) of claim 7 or claim 8, wherein the evaluation system (1.7) is operative to determine chemical characteristics of the particle based at least on a second detector output provided by the second detector or a Raman spectrum provided by the Raman spectrometer.

10. A manufacturing system (1), comprising:

a filling device (1.1) operative to fill at least one liquid into a medical container;

a closure device (1.2) operative to close the medical container with the at least one liquid contained therein; and

the inspection system (1.3; 12) according to any one of the preceding claims operative to inspect the closed medical container for particulate matter.

11. An inspection method of inspecting a medical container containing a liquid, the inspection method comprising:

positioning, by a sample holder (1.4; 2.1; 12.1), the medical container along an axis (2.2; 6.11);

irradiating, by at least one light source, the medical container with light;

detecting, by at least one detector, return light from the medical container, the return light being detected in response to irradiating the medical container with the light;

detecting and/or determining characteristics of a particle, by an evaluation system, based at least on an output of the at least one detector, wherein the at least one detector comprises a first detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4) comprising an opto-electrical transducer having a plurality of pixels; and

moving the at least one light source and/or the at least one detector around the axis (2.2; 6.11) while the sample holder (1.4; 2.1; 12.1) holds the medical container in a rotationally and translationally fixed manner,

wherein:

the at least one light source comprises a first light source (3.2; 4.6; 5.2; 6.3; 7.2) operative to output a light sheet, and

the first detector (3.4; 4.6; 5.3; 6.6, 6.7; 7.3, 7.4) comprises a tilt objective (6.7; 7.4).

12. The inspection method of claim 11, which is performed by the inspection system (1.3; 12) according to any one of claims 1 to 9 or the manufacturing system according to claim 10.

13. A manufacturing method, comprising:

filling a liquid into a medical container;

closing the medical container with the liquid contained therein; and

performing the inspection method according to claims 11 or 12 to inspect the closed medical container for particulate matter.