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In a holographic microscope apparatus, one key part is the measuring or imaging arrangement used to illuminate a target fluid volume by coherent light, and capture digital image frames by receiving the light propagated across the target fluid. The image data of the digital image frames comprise hologram patterns formed in result of interference of light scattered by the microscopic objects with non-scattered light.

Because the hologram patterns form the basis for detecting and/or determining the microscopic pattern, the reliability of the detection and/or determination may be greatly affected by the operation of the measurement or imaging arrangement. In particular, in the case of a simple arrangement with no specific optics and/or a non-sampling configuration of the arrangement allowing continuous flow-through of the fluid to be analyzed, it is important that in all situations, the measurement or imaging arrangement produces reliable image data. Reliable image data should not be affected, for example, by pressure variations in a pipe as part of which a flow-through type arrangement may be integrated.

Similarly to water quality monitoring, also various other applications exist where foreign microscopic objects in a fluid may be detected and/or analyzed by means of in-line holography microscopy.

SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This

Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter

In an example, a measuring arrangement for in-line holography microscopy is disclosed which may be used for detecting microscopic objects of foreign origin present in a fluid. Such detecting may be utilized, for example, for monitoring water quality in water supply, distribution, or use systems and networks wherein the microscopic objects may be, for example, impurity particles and/or microbes. Alternatively, the fluid may be some other liquid or gas.

"In-line holography microscopy" refers to analysis and measurement procedures where one or more digital image frames of a sample volume, illuminated by coherent light, are captured, the digital image frame(s) comprising hologram patterns resulting from microscopic objects of foreign origin present in the sample volume. However, "in-line holography microscopy" also covers analysis and measurement procedures where no complete reconstruction of the sample volume is calculated or generated on the basis of the digital image frame(s) comprise hologram patterns, but determinations concerning the content of the sample volume are made on the basis of the captured digital image frame(s).

The apparatus may comprise an illuminating arrangement configured to emit coherent light; a cuvette defining an inner volume for receiving a fluid possibly comprising microscopic objects of foreign origin, the cuvette being arranged to receive the coherent light and let it, after propagating across the cuvette, exit therefrom through opposite entrance and exit openings,

respectively, the entrance opening being closed by an entrance window whereby the possible microscopic objects present in the fluid scatter part of the light, the scattered and non-scattered light interfering so as to form interference fringes behind the microscopic objects; an image sensor comprising a light sensitive cell, the image sensor being arranged to capture a hologram digital image frame by receiving the light propagated across the cuvette; and an exit window arranged to close the exit opening of the cuvette.

Advantageously, the image sensor may be mounted in the arrangement in direct contact with the cuvette.

According to a first aspect, the present disclosure refers to a measuring arrangement for in-line holography microscopy, comprising: an illuminating arrangement configured to emit coherent light; a cuvette defining an inner volume for receiving a fluid possibly comprising microscopic objects of foreign origin, the cuvette being arranged to receive the coherent light and let it, after propagating across the cuvette, exit therefrom through opposite entrance and exit openings, respectively, the entrance opening being closed by an entrance window, whereby the possible microscopic objects present in the fluid scatter part of the light, the scattered and non-scattered light interfering so as to form interference fringes behind the microscopic objects; an image sensor comprising a light sensitive cell, the image sensor being arranged to capture a hologram digital image frame by receiving the light propagated across the cuvette; and an exit window arranged to close the exit opening of the cuvette; characterized in that the image sensor is mounted in direct contact with the cuvette, wherein

the exit window is mounted to the cuvette, and the image sensor comprises a protective window positioned in front of the light sensitive cell, the protective window being mounted to the exit window; and wherein the cuvette is of flow-through type configured to be connected to an external piping to allow flow of the fluid from the external piping through it continuously during the measurements.

According to a second aspect, the present disclosure refers to an apparatus comprising a measuring arrangement as defined in the first aspect, and a computing arrangement connected to the measuring arrangement to receive image data of the hologram digital image frame, and to detect the presence of the microscopic objects on the basis of hologram patterns formed by the interference fringes in the image data of the hologram digital image frame.

Many of the attendant features will be more readily appreciated as the same becomes better understood by reference to the following detailed description considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present description will be better understood from the following detailed description read in light of the accompanying drawings, wherein:

FIGs. 1 to 3 illustrate, as schematic drawings, measuring arrangements for detecting microscopic objects of foreign origin present in a fluid; and

FIG. 4 illustrates, as a schematic block diagram, an apparatus for detecting microscopic objects of foreign origin present in a fluid.

defining the inner volume thereof. Defining the inner volume means that the one or more walls limit or surround a cross-section of the inner volume throughout a perimeter thereof. In other words, the one or more walls and/or some other appropriate structure of the cuvette completely encircles the entire inner volume at least at one cross-section thereof, thereby preventing escaping of the fluid to be measured from the inner volume in directions in the plane of such cross-section.

A cuvette may be of sampling type, in which case a discrete sample volume may be contained in such inner volume. Alternatively, a cuvette may be of flow-through type allowing the fluid to be measured or analyzed to flow continuously through the cuvette during the measurements. In some embodiments, a cuvette may be configured to serve alternatively as a sampling type cuvette or as a flow-through cuvette.

The cuvette comprises an entrance opening 150 closed by an entrance window 151, so positioned relative to the illuminating arrangement that when in use, the cuvette receives the coherent light emitted by the illuminating arrangement through the entrance window.

The cuvette has also an exit opening 153 closed by an exit window 152 mounted to the cuvette wall and forming a part of the cuvette, opposite to the entrance window, through which the cuvette lets light received into the cuvette, after propagating across the cuvette, exit therefrom.

“Mounting” refers to attaching or fixing, releasably or non-releasably, a component, element, or module to another structure. Mounting may be made, for example, by glue or any other appropriate type of adhesive.

CLAIMS

1. A measuring arrangement for in-line holography microscopy, comprising:

an illuminating arrangement configured to emit coherent light;

a cuvette defining an inner volume for receiving a fluid possibly comprising microscopic objects of foreign origin, the cuvette being arranged to receive the coherent light and let it, after propagating across the cuvette, exit therefrom through opposite entrance and exit openings, respectively, the entrance opening being closed by an entrance window, whereby the possible microscopic objects present in the fluid scatter part of the light, the scattered and non-scattered light interfering so as to form interference fringes behind the microscopic objects;

an image sensor comprising a light sensitive cell, the image sensor being arranged to capture a hologram digital image frame by receiving the light propagated across the cuvette; and

an exit window arranged to close the exit opening of the cuvette;

c h a r a c t e r i z e d in that the image sensor is mounted in direct contact with the cuvette, wherein the exit window is mounted to the cuvette, and the image sensor comprises a protective window positioned in front of the light sensitive cell, the protective window being mounted to the exit window; and wherein the cuvette is of flow-through type configured to be connected to an external piping to allow flow of the fluid from the external piping through it continuously during the measurements.

2. An apparatus comprising a measuring arrangement as defined in claim 1, and a computing arrangement

connected to the measuring arrangement to receive image data of the hologram digital image frame, and to detect the presence of the microscopic objects on the basis of hologram patterns formed by the interference fringes in the image data of the hologram digital image frame.