Technology Offer

Precision Microscopy: Detector for Changes in Direction of a Light Beam

Ref.-No.: 0105-5623-BC

The invention relates to a new method for light beam angle detection that is based on interferometry. High precision and sensitivity for slight changes of the beam direction can be achieved with this method.

For high precision light microscopy, the light beam must be aligned accurately, and the beam direction stability must be ensured in order to maintain a sufficient imaging resolution over longer periods of time. In standard microscopy environments even small temperature changes can result in significant deviations of the beam angle.

The invention solves this problem by using interferometry. The beam of interest is divided into two parts and focused onto a camera sensor. As the two beams can interfere with each other, a corresponding pattern can be monitored. This pattern is highly sensitive to beam angle variations and hence they can be measured precisely by this cheap and robust setup.

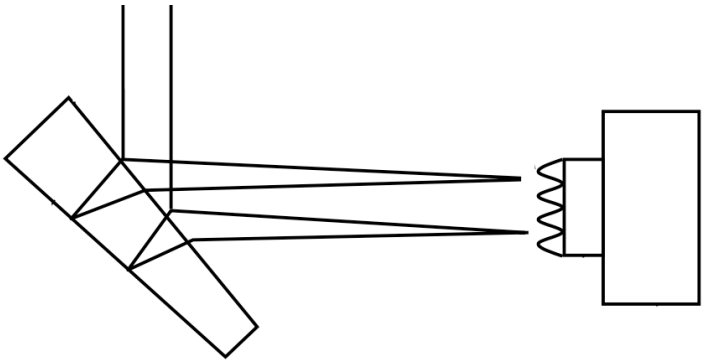

Fig.1: Simplified beam paths of a possible implementation of the invention using a Shear-Interferometer

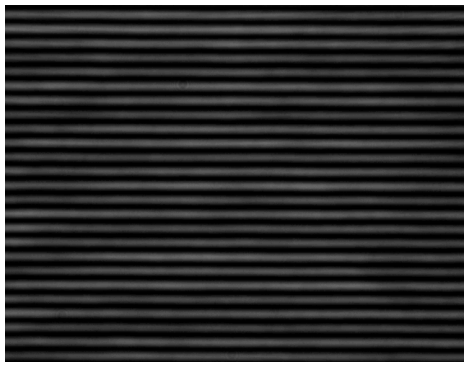

Fig.2: Interference pattern

Advantages

- Angle measurement accuracy of up to pico-rad
- Cheap and simple to implement
- Reliable
- Different camera types usable
- Possible sensitivity in two directions
- Extendible for absolute spot position monitoring

Application

- Applicable to all types of high precision microscopes

Background

In order to reach a position accuracy of 1 nm in a microscope, the angle of the light beam must be set with a precision of 1µrad, which makes the detection of deviations essential.
Current solutions for this problem are often based on using a segmented photosensor to monitor relative changes on each segment. As its measurements also depend on the beam intensity and shape, the setup needs careful calibration, and its accuracy is strictly limited by the detector resolution.

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Technology

A new method based on interferometry has been developed to solve the problem of accurately monitoring the beam angle in microscopes.
The Invention can be exemplarily implemented, as shown in figure 3, into a laser-scanning microscope (12), where the light beam (2, 14) is provided by a laser (13) and focused by the objective (15). The focal point can be moved across the sample (17) by the scanner (16). To monitor the beam angle, the invention (1) investigates the light provided by a beam splitter (21) and focusses it onto a shear-interferometer (18) with a parallel glass plate (19). As the focal plane (22) is located behind the interferometer, the front (23) and back (24) of the plate are reflecting the light, generating parallel beams (4, 5) and forming separate focal points (25, 26). From these points, spherical waves propagate towards the photodetector (7) of the camera (8) and interfere with each other, resulting in a periodic pattern (6). The image data (10) are evaluated by a computer (11).
A variation of the angle of the initial laser beam (14) directly results in a shift of the interreference pattern (6) perpendicular to the propagation direction (9). The distance of the shift is proportional to the change of the beam angle and can be calibrated. As the initial beam (2) in the apparatus (1) is collimated and focused internally, the interference pattern is insensitive to lateral movements of the beam, while being highly sensitive to its direction.
The presented method can be easily implemented on various ways into different types of microscopes as well as developed around other types of interferometry. It can be adapted for two dimensions as well as absolute spot position measurements.

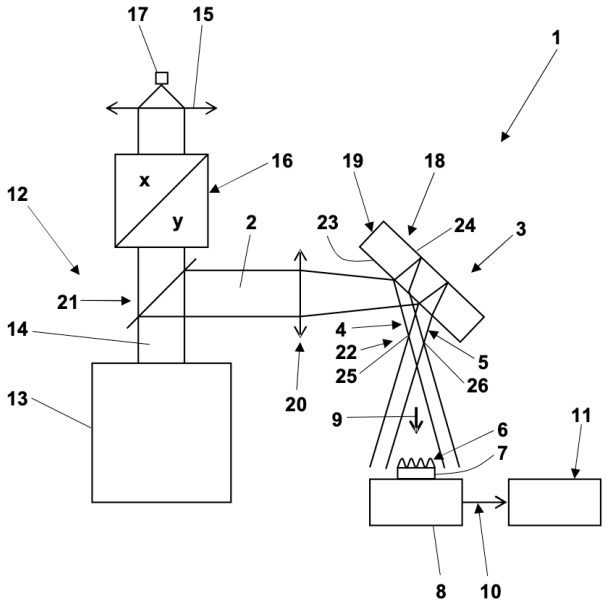

Fig. 3: Example of an implementation, according to the invention, of a shear-interferometer into a laser-scanning microscope.

Patent Information

PCT *(WO2020083744A1)*, EPO *(EP3871021A1)*, USPTO *(US20210239452A1)*

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