CLAIMS

1. A microscopy apparatus for superficial imaging of a sample, the microscopy apparatus comprising:

an objective lens;

a surface illuminator configured to illuminate into the sample at a depth less than or equal to a depth of field of the objective lens;

a stage module configured to receive, adjust and position the sample for repeatable imaging;

optionally an image sensor configured to capture a superficial image of the sample; and

optionally a processor configured to receive the superficial image, estimate a positioning error based on the received superficial image, and correct the positioning error,

wherein the surface illuminator comprises:

a light source configured to emit light to illuminate the sample, the light source arranged adjacent to and on a same side as the objective lens; and

an adjustment mechanism configured to adjust an angle of the light directed at the sample, wherein the adjustment mechanism comprises a leaf-slider mechanism, or one or more flexure mechanisms.

2. A surface illuminator in operable communication with a stage module of a microscopy apparatus for receiving, adjusting and positioning a sample, the surface illuminator comprising:

a light source configured to emit light to illuminate the sample, the light source adapted to be arranged adjacent to and on a same side as an objective lens of the microscopy apparatus; and

an adjustment mechanism configured to adjust an angle of the light directed at the sample, wherein the adjustment mechanism comprises a leaf-slider mechanism, or one or more flexure mechanisms,

wherein the surface illuminator is configured to illuminate into the sample at a depth less than or equal to a depth of field of the objective lens.

3. The microscopy apparatus as claimed in claim 1, or the surface illuminator as claimed in claim 2,

wherein adjustment mechanism further comprises:

a waveguide comprising a fibre-optic cable comprising a light-exiting end arrangeable towards the sample, and

each flexure mechanism is configured to control a pitch angle, a yaw angle, and/or a roll angle of a fibre path of the fibre-optic cable, and/or

each flexure mechanism comprising:

a clamp adapted to rigidly hold the fibre-optic cable towards the light-exiting end;

a base opposite to the clamp;

a flexure segment extending between the clamp and the base; and

an arm extending from the flexure segment, wherein the arm is configured to move towards or away from the base to facilitate deflection of the flexure segment,

preferably the flexure segment is made of a single piece of material, and/or is continuously curved, the flexure segment configured to produce deflection upon actuation of the arm extending from the flexure segment,

preferably each flexure mechanism further comprises:

an angular adjustment member operable to actuate the arm to deflect the flexure segment and adjust an angle of the clamp and consequently, the light directed at the sample, thereby enabling the flexure segment to be pivotably coupled to the light source; and/or

a level adjustment member operable to adjust a level movement of the clamp, and collectively, the light-exiting end of the fibre-optic cable with respect to the sample,

preferably the one or more flexure mechanisms comprises two or more flexure mechanisms arranged orthogonally or angularly apart from one another to provide adjustments along different axes.

4. The microscopy apparatus as claimed in claim 1, or the surface illuminator as claimed in claim 2, wherein the leaf-slider mechanism comprises:

a leaf pivotably coupled to the light source and a leaf support; and

a slider being in contact with the leaf,

wherein the slider is coupled to the leaf via a preload force exerted therebetween, preferably the slider is operable to translate or rotate along the leaf, to consequently adjust a position and/or an orientation of the light source relative to the sample, more preferably the slider comprises an eccentric rotating element having a side cross-section with a circular shape, or an elliptical shape, or a polygonal shape for rotation along the leaf.

5. The microscopy apparatus as claimed in claim 4, or the surface illuminator as claimed in claim 4, wherein the slider comprises one of the following:

- one or more sliding joints arranged spatially apart from one another to form an arbitrary contour for translation along the leaf; or

- a sliding joint with a sloped geometry to form a smooth sloped contour for translation along the leaf; or

- a wavy sliding joint forming an irregular and continuous contour for translation along the leaf, and

wherein the leaf-slider mechanism further comprises a resilient member couplable to the slider, the resilient member extending from the slider in a direction away from the leaf, preferably the resilient member comprises a spring or more preferably, is made of a shape-memory alloy.

6. The microscopy apparatus as claimed in claim 4 or 5, or the surface illuminator as claimed in claim 4 or 5,

wherein the leaf-slider mechanism further comprises an actuator coupleable to the slider and configured to operate the slider.

7. The microscopy apparatus as claimed in claim 4 or 5, or the surface illuminator as claimed in claim 4 or 5, wherein

the adjoining member comprises an inner annulus comprising outwardly extending threads;

the slider comprises an outer annulus comprising inwardly extending threads arranged in an interlocking manner with outwardly extending threads; and

the leaf-slider mechanism further comprises one or more further leaves arranged spatially apart from one another around the inner annulus and the outer annulus.

8. The microscopy apparatus as claimed in claim 1, or the surface illuminator as claimed in claim 2, wherein

the light source is configured to emit the light with an exit angle; and

the adjustment mechanism is configured to adjust the light source away from the sample with an azimuth angle less than or equal to the exit angle.

9. The microscopy apparatus as claimed in claim 3, or the surface illuminator as claimed in claim 3, wherein the waveguide comprises:

one or more input features adapted to receive the light from the light source, the light being parallel to a major plane of the waveguide; and

an exit feature adapted to direct the received light to exit onto the sample at a pre-determined angle; and

optionally, one or more distribution features adapted to change a behaviour of the received light internally to correspondingly change a distribution of the received light being directed to the exit feature, wherein each of the one or more distribution features comprises an angled cut slot configured to facilitate internal reflection of the received light, or an absorbent layer adapted to absorb a portion of the received light,

preferably, the waveguide comprises a single plate of quartz, or polymethyl methacrylate, and/or

the waveguide has curved edges or non-parallel edges.

10. A stage module in operable communication with a surface illuminator of a microscopy apparatus for illuminating into a sample at a depth less than or equal to a depth

of field of an objective lens of the microscopy apparatus, wherein the stage module is configured to receive, adjust and position the sample for repeatable imaging; and

wherein the microscopy apparatus is as claimed in claim 1 or any one of claims 3 to 9.

11. The microscopy apparatus as claimed in claim 1 or any one of claims 3 to 9, or the stage module as claimed in claim 10, wherein the stage module comprises:

a rigid mount, preferably the rigid mount comprising a steel shim stock;

a floating mount arranged spatially apart and alongside the rigid mount, preferably the floating mount comprising a polytetrafluoroethylene shim stock;

a master rail affixed to the rigid mount;

a slave rail coupled to the floating mount;

a carriage plate coupled across the master rail and slave rail; and

one or more pre-tensioner configured to exert a force on the slave rail in a direction substantially perpendicular or non-parallel to an axis of motion of the master rail, thereby allowing a repeatable deflection of the slave rail for each position of the carriage plate along the master rail and slave rail.

12. The microscopy apparatus as claimed in claim 1 or any one of claims 3 to 9, or the stage module as claimed in claim 10, wherein the stage module comprises:

a stage arranged between the sample and the objective lens;

a static plate affixed to an effector arm of the stage;

a replaceable plate configured to receive the sample and arrangeable parallel planarly over the static plate;

at least two compressing mechanisms configured to apply compression pressure between a parallel planar arrangement of the static plate and the replaceable plate; and

a kinetic coupling mechanism configured to couple the static plate and the replaceable plate together under the compression pressure and facilitate repeatable positioning of the sample,

preferably the at least two compressing mechanisms comprise one of the following:

at least two clasping mechanisms, or

at least one clamping mechanism and at least one clasping mechanism,

preferably the kinetic coupling mechanism comprises:

a plurality of mating elements coupled to the static plate and a plurality of complementary elements coupled to the replaceable plate, wherein the plurality of complementary elements is configured to be correspondingly received by the plurality of mating elements,

preferably the plurality of mating elements comprises:

a plurality of rod pairs; or

a plurality of bearings; or

a mixture of rod pairs and bearings; and

preferably the plurality of complementary elements respectively comprises:

a plurality of complementary bearings;

a plurality of complementary rod pairs; or

a mixture of complementary bearings and complementary rod pairs,

preferably the plurality of mating elements is arranged spatially apart from one another, each mating element being positioned proximal to an edge of the static plate;

preferably the plurality of complementary elements is arranged spatially apart from one another, each complementary element being positioned proximal to an edge of the replaceable plate;

preferably the plurality of mating elements and the plurality of complementary elements when mated each is orientated with a first axis extending perpendicularly from a longitudinal axis of the mated mating element and complementary element; and

preferably the at least two compressing mechanisms are arranged spatially across the parallel planar arrangement, along a second axis coinciding with every first axis at a single point, preferably the second axis comprises a centroid axis.

13. A method for superficial imaging of a sample, the method comprising:

illuminating into the sample at a depth less than or equal to a depth of field of an objective lens of a microscopy apparatus;

adjusting and positioning the sample for repeatable imaging; and

optionally capturing a superficial image of the sample, estimating a positioning error based on the captured superficial image, and correcting the positioning error,

wherein illuminating into the sample comprises:

emitting light from a light source to illuminate the sample, the light source arranged adjacent to and on a same side as the objective lens; and

adjusting, by an adjustment mechanism, an angle of the light directed at the sample, the adjustment mechanism comprising a leaf-slider mechanism, or one or more flexure mechanisms.

14. The method as claimed in claim 13, wherein adjusting the angle of the light directed at the sample comprises one of the following:

(i) rigidly holding a fibre-optic cable using a clamp of each flexure mechanism; arranging a light-exiting end of the fibre-optic cable towards the sample; and actuating deflection of a flexure segment of the flexure mechanism to adjust a position and/or an orientation of the light-exiting end, preferably adjusting the angle of the light directed at the sample comprises adjusting the angle of the light along different axes using two or more flexure mechanisms arranged orthogonally apart from one another, or

(ii) operating a slider of the leaf-slider mechanism by translating or rotating the slider along a leaf of the leaf-slider mechanism; or operating the slider by using an actuator coupled to the slider, or

(iii) adjusting the light source away from the sample with an azimuth angle less than or equal to an exit angle of the light emitted from the light source, or

(iv) providing a waveguide comprising one or more input features, an exit feature and optionally, one or more distribution features;

receiving, by the one or more input features, the light from the light source, the light being parallel to a major plane of the waveguide;

directing, by the exit feature, the received light to exit onto the sample at a pre-determined angle; and

optionally, changing, by the one or more distribution features, a behaviour of the received light internally to correspondingly change a distribution of the received light being directed to the exit feature, wherein changing the behaviour of the received light internally comprises facilitating internal reflection of the received light by an angled cut slot of each distribution feature or absorbing a portion of the received light by an absorbent layer of each distribution feature, or

(v) rotating the light along one rotational axis or two different rotational axes.

15. The method as claimed in claim 13 or 14, wherein adjusting and positioning the sample for repeatable imaging comprises one of the following:

(a) adjusting and positioning the sample using a stage module comprising commodity parts mass-manufactured with standard dimensions; and custom-made parts affixed to the commodity parts, wherein the custom-made parts comprise planar parts comprising two-dimensional features, or non-planar parts with lower rigidity as compared to the planar parts, or

(b) using a stage module comprising:

a rigid mount;

a floating mount arranged spatially apart and alongside the rigid mount;

a master rail affixed to the rigid mount;

a slave rail coupled to the floating mount;

a carriage plate coupled across the master rail and slave rail; and

one or more pre-tensioner, and

exerting a force, via the one or more pre-tensioner, on the slave rail in a direction substantially perpendicular or non-parallel to an axis of motion of the master rail, thereby allowing a repeatable deflection of the slave rail for each position of the carriage plate along the master rail and slave rail, or

(c) using a stage module comprising:

a stage arranged between the sample and objective lens;

a static plate affixed to an effector arm of the stage;

a replaceable plate arrangeable parallel planarly over the static plate;

at least two compressing mechanisms; and

a kinetic coupling mechanism,

receiving the sample on the replaceable plate,

applying, by the at least two compressing mechanisms, compression pressure between a parallel planar arrangement of the static plate and the replaceable plate, and coupling, via the kinetic coupling mechanism, the static plate and the replaceable plate together under the compression pressure to facilitate repeatable positioning of the sample,

preferably coupling, via the kinetic coupling mechanism, the static plate and the replaceable plate together under the compression pressure comprises:

providing a plurality of mating elements coupled to the static plate; and

correspondingly receiving a plurality of complementary elements coupled to the replaceable plate with the plurality of mating elements, preferably correspondingly receiving the plurality of complementary elements with the plurality of mating elements comprises mating the plurality of mating elements and the plurality of complementary elements in a manner such that each mated mating element and complementary element is orientated with a first axis extending perpendicularly from a longitudinal axis of the mated mating element and complementary element; and arranging the at least two compressing mechanisms spatially across the parallel planar arrangement, along a second axis coinciding with every first axis at a single point, preferably the second axis comprises a centroid axis, or

(d) translating the stage module along three axes, and rotating the light source.