CLAIMS

1. An illumination optical system which illuminates an irradiated plane with illumination light provided from a light source, the illumination optical system comprising:

a spatial light modulator which is arranged in an optical path of the illumination optical system and cooperates with part of the illumination optical system to form a desired light intensity distribution at a pupil position of the illumination optical system or a position optically conjugated with the pupil position;

a detection unit which detects the light intensity distribution of the illumination light at a position in an optical path extending from the light source to the spatial light modulator, with the detection unit including a light receiving surface which receives some of the illumination light; and

a control unit which controls the spatial light modulator based on the light intensity distribution detected by the detection unit.

2. The illumination optical system according to claim 1, wherein:

the illumination light includes a plurality of light pulses;

the light receiving surface of the detection unit receives the light intensity distribution of the illumination light formed based on the light pulses, every one or more light pulses; and

the control unit controls the spatial light modulator based on a plurality of the light intensity distributions of the illumination light detected for every one or more light pulses.

3. The illumination optical system according to claim 1 or 2, further comprising:

an information acquisition unit which acquires information on the light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position; and

wherein the control unit corrects the controlling executed by the control unit based on the light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position that is acquired by the information acquisition unit.

4. The illumination optical system according to claim 3, further comprising:

an optical path branching member which is arranged in an optical path between the spatial light modulator and the irradiated plane, with the optical path branching member branching off some of the illumination light from the optical path and guiding the branched off light to the information acquisition unit.

5. The illumination optical system according to claim 3, wherein the information acquisition unit acquires information on the light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position based on the illumination light that has passed through the irradiated plane.

6. The illumination optical system according to any one of claims 1 to 5, wherein the spatial light modulator includes:

a first spatial light modulator which cooperates with the part of the illumination optical system to form a first light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position; and

a second spatial light modulator which cooperates with the part of the illumination optical system to form a second light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position.

7. The illumination optical system according to claim 6, further comprising:

a divisional light guide member which is arranged in an optical path between the light source and the spatial light modulator, with the divisional light guide member dividing the illumination light from the light source and guiding the divided light to the first and second spatial light modulators.

8. The illumination optical system according to claim 7, wherein the detection unit detects the light intensity distribution of the illumination light at a position in an optical path extending from the light source to the divisional light guide member.

9. The illumination optical system according to any one of claims 1 to 8, wherein:

the detection unit detects a position on the light receiving surface at which the illumination light falls; and

the control unit controls the spatial light modulator based on the position on the light receiving surface at which the illumination light falls.

10. The illumination optical system according to any one of claims 1 to 9, wherein:

the detection unit includes an incidence angle detection unit which detects incidence angle of the illumination light entering the spatial light modulator; and

the control unit controls the spatial light modulator based on the incidence angle detected by the incidence angle detection unit.

11. The illumination optical system according to any one of claims 1 to 10, wherein:

the spatial light modulator includes a plurality of two-dimensionally arranged elements; and

the plurality of two-dimensionally arranged elements are controllable independently from each other to perform spatial optical modulation on incident light before emitting the light.

12. The illumination optical system according to claim 11, wherein:

the plurality of elements each include a reflection surface; and

the reflection surfaces of the plurality of elements are controllable independently from each other to perform spatial optical modulation on incident light before emitting the light.

13. The illumination optical system according to claim 12, wherein orientations of the reflection surfaces are controllable independently from each other.

14. An exposure apparatus which transfers a predetermined pattern onto a photosensitive substrate, the

exposure apparatus comprising:

the illumination optical system according to any one of claims 1 to 13 which illuminates the pattern that is arranged on an irradiated plane.

15. A method for manufacturing a device comprising:

exposing a predetermined pattern onto a photosensitive substrate using the exposure apparatus according to claim 14;

developing the photosensitive substrate onto which the pattern has been transferred to form a mask layer shaped in correspondence with the pattern on a surface of the photosensitive substrate; and

processing the surface of the photosensitive substrate through the mask layer.

CLAIMS

1. An illumination optical system which illuminates an irradiated plane with illumination light provided from a light source, the illumination optical system comprising:

a spatial light modulator which is arranged in an optical path of the illumination optical system, the spatial light modulator having a plurality of elements two-dimensionally arranged and controllable independently from each other to set traveling directions of respective light beams from the plurality of elements to predetermined traveling directions respectively;

a distribution forming optical system which respectively guides the respective light beams having gone through the plurality of elements of the spatial light modulator onto a pupil plane of the illumination optical system, to form a predetermined light intensity distribution onto the pupil plane;

a detection unit which includes a light receiving surface which receives some of the illumination light, the detection unit detecting the light intensity distribution of the illumination light at a position in an optical path extending from the light source to the spatial light modulator; and

a control unit which controls the traveling directions of the respective light beams from the plurality of elements based on the light intensity distribution detected by the detection unit of the spatial light modulator, to form a desirable light intensity distribution as the light intensity distribution on the pupil plane.

2. The illumination optical system according to claim 1, further comprising:

an information acquisition unit which acquires information on the light intensity distribution at a pupil position of the illumination optical system or a position optically conjugated with the pupil position; and

wherein the control unit corrects the controlling executed by the control unit, based on the light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position that is acquired by the information acquisition unit.

3. The illumination optical system according to claim 2, further comprising:

an optical path branching member which is arranged in an optical path of the illumination optical system between the spatial light modulator and the irradiated plane, the optical path branching member branching off part of the illumination light from the optical path and guiding the branched off light to the information acquisition unit.

4. The illumination optical system according to claim 2, wherein the information acquisition unit acquires information on the light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position, based on the illumination light that has passed through the irradiated plane.

5. The illumination optical system according to any one of claims 1 to 4, wherein:

the detection unit detects a position on the light receiving surface at which the illumination light reaches; and

the control unit controls the spatial light modulator based on the position on the light receiving surface at which the illumination light reaches.

6. The illumination optical system according to any one of claims 1 to 5, wherein:

the detection unit includes an incidence angle detection unit which detects incidence angle of the illumination light entering the spatial light modulator; and

the control unit controls the spatial light modulator based on the incidence angle detected by the incidence angle detection unit.

7. The illumination optical system according to any one of claims 1 to 6, wherein:

the distribution forming optical system includes, in the order from the spatial light modulator side, an afocal optical system, an optical system for optical Fourier transmission, and an optical integrator.

8. The illumination optical system according to any one of claims 1 to 7, wherein:

the illumination light includes a plurality of pulses,

the receiving surface of the detection unit receives the light intensity distribution of the illumination light, formed based on one or more pulses, every one or more pulses out of the plurality of pulses, and

the control unit controls the spatial light modulator based on a plurality of light intensity distributions of the illumination light each of which is detected every one or more pulses.

9. The illumination optical system according to any one

of claims 1 to 8, wherein the spatial light modulator includes:

a first spatial light modulator which cooperates with part of the illumination optical system to form a first light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position; and

a second spatial light modulator which cooperates with part of the illumination optical system to form a second light intensity distribution at the pupil position of the illumination optical system or the position optically conjugated with the pupil position.

10. The illumination optical system according to claim 9, further comprising:

a divisional light guide member which is arranged in an optical path between the light source and the spatial light modulator, the divisional light guide member dividing the illumination light from the light source and guiding the divided light to the first and second spatial light modulators.

11. The illumination optical system according to claim 7, wherein the detection unit detects the light intensity distribution of the illumination light at a position in an optical path extending from the light source to the divisional light guide member.

12. The illumination optical system according to claim 11, wherein:

each of the plurality of elements includes a reflection surface.

13. The illumination optical system according to claim 12, wherein postures of the reflection surfaces are controllable independently from each other.

14. An exposure apparatus which transfers a predetermined pattern onto a photosensitive substrate, the exposure apparatus comprising:

the illumination optical system according to any one of claims 1 to 13 which illuminates the pattern arranged on an irradiated plane.

15. A method for manufacturing a device comprising:

an exposure step of exposing a predetermined pattern onto a photosensitive substrate using the exposure apparatus according to claim 14;

a development step of developing the photosensitive substrate onto which the pattern has been transferred to form a mask layer shaped in correspondence with the pattern on a surface of the photosensitive substrate; and

a processing step of processing the surface of the photosensitive substrate through the mask layer.