CLAIMS

1. An illumination optical apparatus which illuminates an object having a pattern with illumination light, the apparatus comprising:

an optical integrator arranged in an optical path of the illumination light;

a spatial light modulator comprising a plurality of reflection surfaces which are arranged along a predetermined surface and disposed in the optical path on an incidence side of the optical integrator so as to reflect the illumination light, an orientation of each of the plurality of reflection surfaces being controllable individually so that at least part of the illumination light from the spatial light modulator passes through an area on a illumination pupil of the illumination optical apparatus via the optical integrator, the area being away from an optical axis of the illumination optical apparatus;

an optical element arranged in the optical path on an incidence side of the spatial light modulator, which improves an evenness of a light intensity distribution of the illumination light on the plurality of reflection surfaces; and

a polarization element arranged in the optical path between the optical element and the optical integrator, which changes a polarization state of the illumination light,

wherein the spatial light modulator sets orientations of the plurality of reflection surfaces so that a first part of the illumination light passes through a first area of the area and a second part of the illumination light passes through a second area of the area, the first area being different from the second area, the first part of the illumination light being incident on a first part of the plurality of reflection surfaces, the second part of the illumination light being incident on a second part of the plurality of reflection surfaces, and

wherein the polarization element changes the polarization state of

the illumination light so that the first part of the illumination light is substantially linearly polarized light having a first polarization direction in the first area and the second part of the illumination light is substantially linearly polarized light having a second polarization direction in the second area, the second polarization direction being different from the first polarization direction.

2. The illumination optical apparatus according to claim 1, wherein

the first and second polarization directions are substantially coincident with a circumferential direction around the optical axis on the illumination pupil.

3. The illumination optical apparatus according to claim 1, wherein

the polarization element comprises a first polarization member arranged in an optical path of the first part of the illumination light so as to rotate a polarization direction of the first part of the illumination light which is incident on the first polarization member in a linearly polarization state having a single polarization direction.

4. The illumination optical apparatus according to claim 3, wherein

the polarization element comprises a second polarization member arranged in an optical path of the second part of the illumination light so as to rotate a polarization direction of the second part of the illumination light, the second polarization member being different from the first polarization member.

5. The illumination optical apparatus according to claim 1, wherein

the polarization element includes at least one of a half wave plate and an optical rotator other than the half wave plate.

6. The illumination optical apparatus according to claim 1, wherein

the polarization element is arranged in the optical path as replaceable.

7. The illumination optical apparatus according to claim 6, wherein

the polarization element is replaceable with a glass member having the same path length with the polarization element.

8. The illumination optical apparatus according to claim 1, wherein

the area including the first and second areas has a multi-polar shape or an annular shape around the optical axis.

9. The illumination optical apparatus according to claim 8, wherein

the first area includes two areas spaced in a first direction, the second area includes two areas spaced in a second direction different from the first direction, and the optical axis in the illumination pupil is located between the two areas spaced in the first direction and located between the two areas spaced in the second direction.

10. The illumination optical apparatus according to claim 1, wherein

the illumination pupil is located on or near a rear focal plane of the optical integrator.

11. The illumination optical apparatus according to claim 1, further comprising

a lens system arranged in the optical path between the spatial light modulator and the optical integrator, a pupil plane of the lens system being located at or near a position optically conjugate with an entrance surface of the optical integrator.

12. An exposure apparatus which exposes a substrate with light from a pattern on a mask, the exposure apparatus comprising:

a stage which holds the substrate;

an illumination optical apparatus according to claim 1, which illuminates the pattern; and

a projection optical system which projects an image of the pattern illuminated by the illumination optical apparatus onto the substrate held by the

stage.

13. The exposure apparatus according to claim 12, wherein

the projection optical system projects the image onto the substrate through liquid disposed in an optical path between the projection optical system and the substrate.

14. An exposure method which exposes a substrate with light from a pattern on a mask, the exposure method comprising:

holding the substrate by a stage;

illuminating the pattern by an illumination optical apparatus according to claim 1; and

projecting an image of the pattern illuminated by the illumination optical apparatus onto the substrate held by the stage through a projection optical system.

15. The exposure method according to claim 14, wherein

the image is projected onto the substrate through liquid disposed in an optical path between the projection optical system and the substrate.

16. A device manufacturing method comprising:

exposing a substrate with light from a pattern by use of an exposure apparatus according to claim 12; and

developing the substrate having been exposed with the light.

17. A device manufacturing method, comprising:

exposing a substrate with light from a pattern by use of the exposure method according to claim 14; and

developing the substrate having been exposed with the light.