According to a first aspect of the invention, there is provided an optical reader for analyzing biological samples arranged the wells of a microplate, the optical reader including a horizontal reading plane for receiving a microplate comprising a plurality of wells, an illuminating arrangement comprising a light source and being arranged to illuminate the samples in the wells of the microplate, an imaging device arranged to receive light from the microplate, a beam splitter, which is arranged to direct part of the light from the illuminating arrangement towards the reading plane and to direct part of the light received from the microplate to the imaging device, and a lens system comprising at least one lens and being arranged between the beam splitter and the reading plane to focus the light received from the illuminating arrangement to a sample and to focus an image of the sample to the imaging device. The optical reader is configured to transmit from the illuminating arrangement to the lens system only light having a specific polarization, and the optical reader comprises a polarizer that is arranged between the lens system and the imaging device and configured to block polarized light reflected from the surfaces of the lens system, and wherein the illuminating arrangement comprises an integrating chamber and the lens system comprises an aperture, through which the light from the beam splitter is directed to a well of the microplate, and the diameter of the aperture is at most the same as the diameter of the well.

According to a second aspect of the invention, there is provided a method for analyzing biological samples arranged the wells of a microplate, the method including the steps of producing polarized or unpolarized light by means of an illuminating arrangement, directing part of the produced light by means of a beam splitter towards a sample in a well of a microplate, in case of unpolarized light, polarizing the light received from the beam splitter, directing light with a specific polarization by means of a lens system to the sample, passing at least part of the light reflected from the microplate and the sample and/or emitted by the sample through the lens system, directing part of the light received from the microplate and the lens system by means of the beam splitter towards an imaging device, and forming an image of the sample by means of the imaging device. Polarized light reflected from the surfaces of the lens system are blocked by means of a polarizer arranged between the lens system and the imaging device, and wherein the light is directed towards the beam splitter from an integrating chamber and the light from the beam splitter is directed to a well of the microplate through an aperture of the lens system, the diameter of the aperture being at most the same as the diameter of the well.

By directing the light from the illuminating arrangement via the beam splitter and the lens system to the well of the microplate, it is possible to form a uniform and bright spot on the bottom of the well. Stray light around the well can be significantly reduced, which increases the contrast of the image. However, as the illumination beam goes through the lens system, stray light is formed on each lens

Claims

1. An optical reader for analyzing biological samples arranged in the wells ~~(2)~~ of a microplate ~~(1)~~, the optical reader comprising

- a horizontal reading plane ~~(3)~~ for receiving a microplate ~~(1)~~ comprising a plurality of wells ~~(2)~~,
- an illuminating arrangement ~~(4)~~ comprising a light source ~~(5)~~ and being configured to illuminate the samples in the wells ~~(2)~~ of the microplate ~~(1)~~,
- an imaging device ~~(6)~~ arranged to receive light from the microplate ~~(1)~~,
- a beam splitter ~~(7)~~, which is arranged to direct part of the light from the illuminating arrangement ~~(4)~~ towards the reading plane ~~(3)~~ and to direct part of the light received from the microplate ~~(1)~~ to the imaging device ~~(6)~~, and
- a lens system ~~(8)~~ comprising at least one lens ~~(16)~~ and being arranged between the beam splitter ~~(7)~~ and the reading plane ~~(3)~~ to focus the light received from the illuminating arrangement ~~(4)~~ to a sample and to focus an image of the sample to the imaging device ~~(6)~~,

wherein the optical reader is configured to transmit from the illuminating arrangement ~~(4)~~ to the lens system ~~(8)~~ only light having a specific polarization, and the optical reader comprises a polarizer ~~(10, 19)~~ that is arranged between the lens system ~~(8)~~ and the imaging device ~~(6)~~ and configured to block polarized light reflected from the surfaces of the lens system ~~(8)~~, and
wherein the illuminating arrangement comprises an integrating chamber and the lens system comprises an aperture, through which the light from the beam splitter is directed to a well of the microplate, and the diameter of the aperture is at most the same as the diameter of the well.

2. ~~An~~The optical reader according to claim 1, wherein the illuminating arrangement ~~(4)~~ is configured to illuminate the samples in the wells ~~(2)~~ of the microplate ~~(1)~~ with light having a first polarization direction, and the~~a~~ polarizer ~~(10)~~ between the lens system and the imaging device has~~ving~~ a second polarization direction that is perpendicular to the first polarization direction, and the polarizer is arranged between the beam splitter ~~(7)~~ and the imaging device ~~(6)~~.

3. ~~An~~The optical reader according to claim 2, wherein the light source ~~(5)~~ is arranged to produce unpolarized light and the illuminating arrangement ~~(4)~~ comprises a further polarizer ~~(9)~~ arranged between the light source ~~(5)~~ and the beam splitter ~~(7)~~.

4. AnThe optical reader according to claim 1, wherein athe polarizer between the lens system and the imaging device is a circular polarizer (19) that is arranged between the beam splitter (7) and the lens system (8).

5. AnThe optical reader according to claim 4, wherein the angle (α) between the normal (23) of the surface of the circular polarizer (19) and the longitudinal axis (22) of the lens system (6) is in the range of 5–15 degrees.

6. AnThe optical reader according to any of the preceding claims, wherein the imaging device (6) comprises a camera sensor (6a).

7. An optical reader according to any of the preceding claims, wherein the illuminating arrangement (4) comprises an integrating chamber (13).

8.7. AnThe optical reader according to any of the preceding claims, wherein the illuminating arrangement (4) comprises at least one LED (14) for producing the light used for illuminating the samples.

9.8. AnThe optical reader according to any of the preceding claims, wherein the imaging device (6) is arranged above the beam splitter (7).

10.9. AnThe optical reader according to any of the preceding claims, wherein the optical reader comprises a reference detector (11) arranged to measure the intensity of light produced by the illuminating arrangement (4) and passed through the beam splitter (7).

11.10. AnThe optical reader according to any of the preceding claims, wherein the optical reader comprises a first filter (12) that is arranged between the illuminating arrangement (4) and the beam splitter (7) and configured to pass through light only in one or more first predetermined wavelength ranges, and a second filter (18) that is arranged between the beam splitter (7) and the imaging device (6) and configured to pass through light only in one or more second predetermined wavelength ranges.

12. An optical reader according to any of the preceding claims, wherein the lens system (8) comprises an aperture (17), through which the light from the beam splitter (7) is directed to a well (2) of the microplate (1), and the diameter of the aperture (17) is at most the same as the diameter of the well (2).

13.11. A method of analyzing biological samples arranged in the wells (2) of a microplate (1), which is arranged in a horizontal reading plane (3), the method comprising the steps of

- producing polarized or unpolarized light by means of an illuminating arrangement ~~(4)~~,
- directing part of the produced light by means of a beam splitter ~~(7)~~ towards a sample in a well ~~(2)~~ of a microplate ~~(1)~~,
- in case of unpolarized light, polarizing the light received from the beam splitter ~~(7)~~,
- directing light with a specific polarization by means of a lens system ~~(8)~~ to the sample,
- passing at least part of the light reflected from the microplate ~~(1)~~ and the sample and/or emitted by the sample through the lens system ~~(8)~~,
- directing part of the light received from the microplate ~~(1)~~ and the lens system ~~(8)~~ by means of the beam splitter ~~(7)~~ towards an imaging device ~~(6)~~, and
- forming an image of the sample by means of the imaging device ~~(6)~~,

wherein polarized light reflected from the surfaces of the lens system ~~(8)~~ are blocked by means of a polarizer ~~(10, 19)~~ arranged between the lens system ~~(8)~~ and the imaging device ~~(6)~~, and

wherein the light is directed towards the beam splitter from an integrating chamber and the light from the beam splitter is directed to a well of the microplate through an aperture of the lens system, the diameter of the aperture being at most the same as the diameter of the well.

~~14.~~12. ~~A~~The method according to claim ~~13~~11, wherein light with a first polarization direction is produced by means of the illuminating arrangement ~~(4)~~, the polarizer has a second polarization direction that is perpendicular to the first polarization direction, and light received from the lens system ~~(8)~~ and the beam splitter ~~(7)~~ is polarized by means of ~~a~~ the polarizer ~~(10) having a second polarization direction that is perpendicular to the first polarization direction~~.

~~15.~~13. ~~A~~The method according to claim ~~14~~12, wherein polarized light is produced in the illuminating arrangement ~~(4)~~ by producing unpolarized light and passing it through a further polarizer ~~(9)~~ arranged between the light source and the beam splitter.

~~16.~~14. ~~A~~The method according to claim ~~13~~11, wherein the polarizer arranged between the lens system and the imaging device is a circular polarizer arranged between the beam splitter and the lens system and the light received from the beam splitter ~~(7)~~ is polarized by means of ~~a~~ the circular polarizer ~~(19) that is arranged between the beam splitter (7) and the lens system (8)~~.

~~17.~~15. ~~A~~The method according to any of claims ~~13~~11–~~16~~14, wherein unpolarized light is produced by means of at least one LED ~~(14)~~.

~~18. A method according to any of claims 13–17, wherein unpolarized light is directed towards the beam splitter (7) from an integrating chamber (13).~~

~~19.~~16. ~~A~~The method according to any of claims ~~13~~11–~~18~~15, wherein the light from the illuminating arrangement ~~(4)~~ is reflected to the sample by the beam splitter ~~(7)~~.

~~20.~~17. ~~A~~The method according to claim ~~19~~16, wherein the intensity of light produced by the illuminating arrangement ~~(4)~~ and passing the beam splitter ~~(7)~~ is measured.

~~21.~~18. ~~A~~The method according to any of claims ~~13~~11–~~20~~17, wherein the samples are arranged in a microplate ~~(1)~~, where the walls of the wells ~~(2)~~ are black.

~~22.~~19. ~~A~~The method according to any of claims ~~13~~11–~~21~~18, wherein the samples are arranged in a microplate ~~(1)~~, where the bottoms of the wells ~~(2)~~ are white.