

Claims

[Claim 1] A defect detection device, which is configured to detect a defect having at least an inclined surface portion in a semiconductor product or a workpiece, which is a part of the semiconductor product, the defect detection device comprising an inspection mechanism, the inspection mechanism comprising:

an illumination unit configured to irradiate the workpiece with bright-field illumination light having a numerical aperture smaller than a numerical aperture of an observation optical system; and

an image pickup device configured to observe an observation site of the workpiece irradiated with the bright-field illumination light by the illumination unit,

wherein a defect on an observation image formed by reflected light from the workpiece, which is obtained by the bright-field illumination light being emitted from the illumination unit having the numerical aperture smaller than the numerical aperture of the observation optical system, and being output from an out-of-focus position defocused from an in-focus position in an optical axis direction, is enlarged as compared to a defect on an observation image formed by reflected light from the in-focus position, and

wherein the image pick up device is configured to observe the reflected light from the workpiece, which is the output from the out-of-focus position to inspect the enlarged defect.

[Claim 2] The defect detection device according to claim 1, further comprising a positioning device configured to perform position detection of the workpiece, wherein the positioning device comprises the inspection mechanism.

[Claim 3] The defect detection device according to claim 1 or 2, further comprising a workpiece placement portion, which is configured to position the workpiece placed thereon, and to inspect a defect in the workpiece.

[Claim 4] The defect detection device according to any one of claims 1 to 3, further comprising a varying unit configured to vary the numerical aperture of the illumination unit.

[Claim 5] The defect detection device according to any one of claims 1 to 3, wherein the illumination unit comprises an inspection light source and a positioning light source, and is configured to switch between the inspection light source and the positioning light source to switch a numerical aperture on an illumination side.

[Claim 6] The defect detection device according to any one of claims 1 to 5, wherein the reflected light is output from two different positions comprising at least the out-of-focus position among the in-focus position and the out-of-focus position.

[Claim 7] The defect detection device according to claim 6, wherein the inspection mechanism is configured to perform the inspection based on reflected light output from an out-of-focus position on a side close to the image pickup device and reflected light output from an out-of-focus position on a side away from the image pickup device, with the in-focus position being a boundary between the out-of-focus positions.

[Claim 8] The defect detection device according to any one of claims 1 to 7, wherein the workpiece is arranged at the out-of-focus position to cause the reflected light from the workpiece to be output from the out-of-focus position displaced from the in-focus position in the optical axis direction.

[Claim 9] The defect detection device according to any one of claims 1 to 8,

wherein the inspection mechanism comprises a defocusing unit configured to cause the reflected light from the workpiece to be output from the out-of-focus position displaced from the in-focus position in the optical axis direction, and

wherein the defocusing unit comprises any one of a unit configured to cause the workpiece and an optical system to relatively move in the optical axis direction, a unit configured to change the optical system, a unit that uses a plurality of optical systems

and a plurality of light-receiving elements having different in-focus positions, and a unit configured to change an illumination wavelength or an observation wavelength.

[Claim 10] The defect detection device according to any one of claims 1 to 9, wherein the defect detection device is configured to perform inspection at a position defocused by 100 μm or more from the in-focus position in the observation optical system.

[Claim 11] The defect detection device, which is configured to detect a defect having at least an inclined surface portion in a semiconductor product or a workpiece, which is a part of the semiconductor product,

the defect detection device comprising:

an inspection mechanism comprising:

an illumination unit configured to irradiate the workpiece with bright-field illumination light; and

an image pickup device, which forms an observation optical system, and is configured to observe an observation site of the workpiece irradiated with the bright-field illumination light by the illumination unit; and

a detection portion configured to detect an inclination angle and a defect width of a surface portion based on a defocus amount and a separation width between one inclined surface portion and another inclined surface portion of the defect,

wherein the inspection mechanism is configured to observe

reflected light from the workpiece, which is output from an out-of-focus position defocused from an in-focus position in an optical axis direction, and emphasize a defect on an observation image formed by reflected light from the out-of-focus position as compared to a defect on an observation image formed by reflected light from the in-focus position.

[Claim 12] The defect detection device according to any one of claims 1 to 11,

wherein the workpiece has a multilayer structure, and

wherein light that is reflected or scattered from a layer to be inspected to enter the image pickup device has a wavelength at which an intensity of the light is higher than an intensity of light from another layer.

[Claim 13] The defect detection device according to claim 12,

wherein the workpiece comprises a variable density layer having a variable density pattern derived from a semiconductor manufacturing process and a coating layer, which covers the variable density pattern of the variable density layer, and

wherein illumination light emitted from the illumination unit has a wavelength at which an intensity of light that is reflected or scattered from the coating layer to enter the image pickup device is higher than an intensity of light that is reflected from at least the variable density layer to enter the image pickup device, to

thereby reduce influence of the variable density pattern of the variable density layer.

[Claim 14] The defect detection device according to claim 13, wherein the coating layer comprises an organic substance layer.

[Claim 15] The defect detection device according to any one of claims 1 to 14, wherein, of the illumination light from the illumination unit, illumination light to be observed has a wavelength of 450 nm or less, or a wavelength of 1,000 nm or more.

[Claim 16] The defect detection device according to any one of claims 1 to 15, further comprising a table on which the workpiece is placed, wherein a workpiece placement portion of the table is formed of a porous material configured to attract the workpiece through suction to hold the workpiece.

[Claim 17] The defect detection device according to any one of claims 1 to 15, further comprising a table on which the workpiece is placed, wherein a workpiece placement portion of the table is formed of an electrostatic chuck structure configured to attract the workpiece through static electricity to hold the workpiece.

[Claim 18] A defect detection method for detecting a defect having at least an inclined surface portion in a semiconductor product

or a workpiece, which is a part of the semiconductor product,
the method comprising:

irradiating the workpiece with bright-field illumination light having a numerical aperture smaller than a numerical aperture of an observation optical system to cause reflected light from the workpiece to be output from an out-of-focus position defocused from an in-focus position in an optical axis direction so as to enlarge a defect on an observation image formed by reflected light from the out-of-focus position as compared to a defect on an observation image formed by reflected light from the in-focus position;

observing the reflected light from the workpiece, which is output from the out-of-focus position to inspect the enlarged defect.

[Claim 19] A defect detection method for detecting a defect having at least an inclined surface portion in a semiconductor product or a workpiece, which is a part of the semiconductor product,
the method comprising:

placing the workpiece on a table having a workpiece placement portion formed of a porous material;

sucking the workpiece through a pore of the porous material to cause the workpiece to be adsorbed to the table;

irradiating the workpiece with bright-field illumination light having a numerical aperture smaller than a numerical aperture of an observation optical system to cause reflected light from the workpiece to be output from an out-of-focus position defocused from

an in-focus position in an optical axis direction so as to enlarge a defect on an observation image formed by reflected light from the out-of-focus position as compared to a defect on an observation image formed by reflected light from the in-focus position; and

observing the reflected light from the workpiece, which is output from the out-of-focus position to inspect the enlarged defect.

[Claim 20] A defect detection method for detecting a defect having at least an inclined surface portion in a semiconductor product or a workpiece, which is a part of the semiconductor product,

the method comprising:

placing the workpiece on a table having a workpiece placement portion formed of an electrostatic chuck structure;

attracting the workpiece through static electricity to cause the table to hold the workpiece;

irradiating the workpiece with bright-field illumination light having a numerical aperture smaller than a numerical aperture of an observation optical system to cause reflected light from the workpiece to be output from an out-of-focus position defocused from an in-focus position in an optical axis direction so as to enlarge a defect on an observation image formed by reflected light from the out-of-focus position as compared to a defect on an observation image formed by reflected light from the in-focus position; and

observing the reflected light from the workpiece, which is output from the out-of-focus position to inspect the enlarged defect.

[Claim 21] The defect detection method according to any one of claims 18 to 20, wherein the defect detection method allows a defect in the workpiece to be inspected at a position at which positioning of the workpiece is performed.

[Claim 22] The defect detection method according to any one of claims 18 to 20, wherein a light source is switched between an inspection light source and a positioning light source to switch a numerical aperture on an illumination side.

[Claim 23] The defect detection method according to claim 19 or 20, further comprising a step of pressing the workpiece against the table.

[Claim 24] A die bonder, comprising:

a bonding portion, which is configured to pick up an individual piece serving as a workpiece at a pickup position, convey the individual piece that has been picked up to a bonding position, and to subject the workpiece to bonding at the bonding position; and

the defect detection device of any one of claims 1 to 17.

[Claim 20] A semiconductor manufacturing method, comprising an inspection step using the defect detection method of any one of

claims 18 to 20, and further comprising at least any one of a dicing step of cutting a wafer into an individual piece or a mold sealing step of sealing a semiconductor chip formed into an individual piece with resin.

[Claim 26] A semiconductor device manufacturing method for manufacturing a semiconductor device comprising an individual piece assembly formed of a plurality of individual pieces,

the semiconductor device manufacturing method comprising subjecting at least any one of a target object comprising one individual piece or an assembly of a predetermined number of individual pieces or another individual piece to be assembled to the target object, to inspection through use of the defect detection method of any one of claims 18 to 20.