

Optical component measurement system and method for measuring at least one component

Description

Background

Semiconductor components are used in many technical fields, such as, for example, in semiconductor electronics, photovoltaics, the production of optical detectors and radiation sources (for example, a light-emitting diode). Due to the diverse usage of semiconductor components, ever higher demands are made on semiconductor component manufacturers, especially in respect of quality. Defects or imperfections in or on semiconductor components are undesirable, as they can lead to imperfect functionality of the semiconductor component. Semiconductor components are accordingly inspected during manufacture for defects and imperfections. One possible option for inspecting the semiconductor components is to image the semiconductor components using an optical system in the micrometer range.

A conventional construction of the optical system has a small depth of field, however. If a surface to be imaged of the semiconductor component to be inspected is tilted towards an image sensor surface of an image sensor of the optical system, the semiconductor component cannot be imaged entirely sharply in one image. Furthermore, optical components installed in the optical system have a large mass for the most part. The adjusting process is accordingly sluggish or the optical system begins to oscillate on variation of a focus by adjusting the components, which significantly impairs the image quality. It is consequently necessary to wait until the oscillations have been damped to record an image. In ongoing production/inspection of semiconductor components such an increased image recording time results in a lower throughput of semiconductor components.

Prior art

DE 10 2008 018 586 A1 relates to an optical detection device for detecting at least one surface of a component. The component is directed by means of a retaining element at a camera device and a first surface of the component is irradiated by a light source with first light beams in the short-wave range. The detection device further comprises a second light source, which radiates second light beams in the long-wave range onto a second surface of the component, wherein the second surface lies opposite the first surface of the component. The light beams reflected at the surfaces are received by means of a camera device. JP 2016 128 781 teaches a device for inspecting an electronic component. The device comprises first and second imaging means, which record images of different regions of the electronic component, wherein the regions are two different regions of a rectangular parallelepiped.

An instrument with a shaft is known from DE 10 2011 089 055 A1, wherein an image sensor and a lens that is adjustable linearly by an actuator are arranged at one shaft end. The lens is attached to a runner, which is adjustable in a cylindrical sliding tube along the adjusting direction. The actuator comprises two coils, which are arranged around the sliding tube. The actuator is constructed simply and is easy to assemble. In addition, it can be sterilised easily, for example using an autoclave.

A camera module with an image sensor and a lens group is known from US 2015/0168679 A1. The lens group can be adjusted by an adjusting device relative to the sensor. The adjusting device comprises in this case a mount for the lens group, wherein the mount is connected to the image sensor via springs. Due to this design the camera module has particularly low sensitivity with regard to vibrations. A comparable device in this respect is also known from US 2014/0368724 A1.

A lens adjusting device such as can be used for a camera module of a mobile telephone, for example, is known from US 2011/0176046. The device comprises an image sensor and a lens, which can be adjusted relative to the image sensor via an adjusting unit. Here the lens group is connected to the image sensor via springs. The device can be designed to be particularly small.

Underlying object

The object underlying the present application is to provide an efficient optical component measurement system for measuring a component.

5

Proposed solution

An optical component measurement system for measuring at least one surface of at least one component is proposed. A seat is designed to position the component in front of a camera device in order to measure a first surface of the component using the camera device. The camera device comprises an image sensor, which is designed to receive light reflected at the first surface of the component. The optical component measurement system further comprises a first optically active element, which is arranged in a beam path of the reflected light to the image sensor, and an adjusting device for the first optically active element. The adjusting device comprises a mount for the first optically active element. The mount is attached to an inner side of a hollow

10

15

cylindrical tube and a longitudinal centre line of the tube is oriented coaxially to an optical axis of the first optically active element. The mount is elastically flexible at least in a longitudinal direction of the tube. The adjusting device further comprises a first actuator for adjusting a relative distance between the optically active element and the image sensor, in order to move the optically active element relative to the image sensor along the optical axis.

Due to the elastically flexible mount it is possible to hold only the first optically active element without a corresponding thread or a holder of the optically active element that is adjustable in length. If the optically active element is an achromat, the lens pair (consisting, for example, of a crown glass lens and a flint glass lens) of the achromat can be held by the mount. The holder of the lens pair is thus superfluous and the mass to be moved of the optically active element as well as the overall mass of the optical component measurement system is reduced. Due to the smaller mass of the optically active element with the mount, a position of the optically active element can be adjusted with comparatively less applied force. The smaller mass permits a lower-inertia activation of the optically active element; a focal plane of the component can thus be readjusted quickly.

The elastically flexible mount can have a material containing rubber or a helical spring or be formed as a bellows. Alternatively, the mount can be formed as a cup spring, wherein the cup spring has an opening in its wick axis, in which the first optically active element is received.

Disruptions such as oscillations of external sources on the optically active element can thus be strongly damped or even avoided. Measurements carried out with the optical component measurement system are thus less sensitive to interference.

Furthermore, the elastically flexible mount is infinitely extensible or contractable

due to its elastic properties, so that a precise adjustment of the position of the first optically active element is enabled.

In a real production environment the component may occasionally not be aligned precisely to the optics. In such cases it is not possible to image the component entirely sharply with sufficient depth of field. Using the optical component measurement system presented here a series of several image recordings can be carried out quickly.

Due to the satisfactory and swift adjustability of the optical component measurement system, measurements of components can be carried out faster and more precisely, so that a higher throughput is achieved.

Variants and configurations

The image sensor can be a CCD chip. In other variants the image sensor can be a CMOS chip or an image sensor sensitive to certain wavelength ranges, such as a microbolometer array or a pyroelectric array.

The tube can have a low permeability. In one variant the tube has a paramagnetic material. The tube can also have at least aluminium or plastic.

The coil can be in contact with the tube or be arranged at a distance from this. A position of the coil can be offset on the optical axis with regard to the position of the mount.

The mount has a first end region in which the mount is attached to the tube. The mount further has a second end region on which the first optically active element is held. In a resting state a position of the first end region of the mount can coincide with a position of an end of the coil with reference to the

optical axis. In another variant the position of the first end region of the mount can lie inside or outside the coil with reference to the optical axis. Alternatively or in addition, the second end region of the mount can lie inside or outside the coil in relation to the optical axis.

5

The mount of the first actuator can be surrounded by a coil, at least in sections. A control device is designed to control an electric current supplied to the coil to generate a magnetic field. The mount also has a yoke containing soft iron or a permanently magnetic yoke as a component that contains soft iron or is permanently magnetic and that is designed to move the mount along the longitudinal centre line of the tube as a function of the electric current supplied to the coil.

10

Due to this construction, wear or abrasion of the means for adjusting the relative distance is reduced. Furthermore, precise adjustment of the relative distance is made possible by the force on the mount generated by the magnetic field.

15

If the mount with the yoke containing soft iron is arranged at an end of the coil, the force acts on the mount in the direction of the coil centre. If the magnetic field is reduced and then turned off, no further force acts on the mount. The mount then assumes its initial position once again.

20

If the mount has a permanently magnetic yoke, the mount can be extended in two directions according to a flow direction of the electric current through the coil and the alignment of the north and south pole of the permanently magnetic component. A targeted adjustment of the relative distance in both directions is facilitated accordingly with a permanently magnetic component.

25

The seat can be designed to position the component in front of the camera device in such a way that the focal plane of the component is projected at

30

least partially onto an image sensor surface of the image sensor.

The optical component measurement system can further comprise a second actuator controlled by the control device for adjusting the image sensor in order to move the image sensor along the optical axis relative to the first optically active element.

The second actuator can comprise at least one piezoactuator or a finely moving, linearly operating axis system. The finely moving, linearly operating axis system can be a system consisting of connecting rods.

It is possible by means of the second actuator to move the image sensor on the optical axis and to project the focal plane onto the image sensor surface of the image sensor. Rapid focusing of the optics onto the component is thus made possible.

A certain portion of the component can thus already be imaged sharply in the image in a first recording of the component by means of the image sensor.

The optical component measurement system can further comprise a light source, which is designed to transmit light onto the surface of the component. The light source is designed to transmit light with a predetermined wavelength or a certain wavelength range onto the surface of the component. The light emitted by the light source can be visible light with a wavelength in the range of approx. 380 nm to 780 nm, infrared light and/or polarised light. In addition, the image sensor can have a sensitivity in infrared or for polarised light.

As an option the control device can be designed to adjust the relative distance between the first optically active element and the image sensor by controlling the first and/or the second actuator to project a focal plane of the

reflected light onto the image sensor surface of the image sensor facing the reflected light.

By controlling the first and/or the second actuator a fast and precise adjustment of the relative distance between the first optically active element and the image sensor can take place, so that the focal plane is projected onto the image sensor surface of the image sensor.

An image processing function of the optical component measurement system can be designed to record a first image of the component by means of the image sensor. The image sensor supplies the first image to the image processing function. Based on the first image produced, the image processing function determines whether the focal plane of the reflected light is projected substantially completely onto the image sensor surface of the image sensor. If the focal plane of the reflected light is not projected substantially completely onto the image sensor surface of the image sensor, the image processing function is designed to determine a first image region of a first plurality of image regions of the first image in which a first sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor.

The image processing function is further designed to determine a second image region of the first plurality of image regions of the first image in which a second sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor. The image processing function is further designed to supply a control command to the control device. The control device is designed to control the first and/or the second actuator based on the control command in order to adjust the relative distance between the optically active element and the image sensor. Here the second sub-region of the focal plane of the reflected light is adjusted so that the focal plane of the reflected light is projected onto the image sensor

surface of the image sensor.

The image processing function is further designed to record a second image of the component by means of the image sensor. In the second image the image processing function determines a third image region of a second plurality of image regions of the second image in which the first sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor. The image processing function further determines a fourth image region of the second plurality of image regions of the second image in which the second sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor.

If the component cannot be imaged sharply in one image, it is possible by the process described above to produce at least two recordings of the component in which an image region sharply images a portion of the component in each case. Furthermore, recognised blurred image regions are imaged sharply in a next image, so that an inspection of the complete component is made possible.

In a first alternative, an image processing function can be designed to record a first image by means of the image sensor, which supplies the first image to the image processing function. The image processing function is further designed to supply a control command to the control device to control the first and/or the second actuator in order to adjust the relative distance between the first optically active element and the image sensor by a predetermined path length. The image processing function is further designed to record a second image by means of the image sensor, wherein the image sensor supplies the second image to the image processing function.

The image processing function can supply the control command to the first and/or the second actuator following a predetermined time period after the recording of the first image.

The predetermined path length can be dependent on optical properties of the first and/or the second optically active element and/or dimensions of the surface of the component. The predetermined path length can preferably be predetermined as a function of the depth of field, so that the predetermined path length is smaller than, equal to or greater than the depth of field.

In the case of a predetermined path length that is smaller than or equal to the depth of field, the surface of the component can be inspected completely for defects through individual sharply imaging image regions of the recorded images. If the predetermined path length is greater than the depth of field, predetermined surface regions of the component can be inspected for defects. Other surface regions are accordingly not inspected for defects. An inspection of the surface regions for defects can thus be carried out with less computing effort and/or within a shorter time.

In a second alternative, an image processing function can be designed to record a first image by means of the image sensor, which supplies the first image to the image processing function. The image processing function is further designed to supply a control command to the control device to control the first and/or the second actuator in order to adjust the relative distance between the first optically active element and the image sensor during the recording of the first image at a predetermined velocity. Furthermore, the image processing function is designed to record a second image by means of the image sensor, which supplies the second image to the image processing function. The second image is recorded after the first image or after a predetermined period of time after the first image was recorded, and while the relative distance between the first optically active element and the image sensor is adjusted. In another alternative the second image is recorded after a predetermined length variation of the relative distance between the image sensor and the first optically active element.

The image processing function can be designed to supply another control command to the first and/or second actuator following the recording of the second image in order to stop the adjustment of the relative distance between the image sensor and the first optically active element.

The predetermined velocity can be dependent on the optical properties of the first and/or the second optically active element, the dimensions of the surface of the component, masses of the first and/or the second optically active element and/or of the image sensor as well as the response behaviour of these due to the first and/or second actuator.

The predetermined velocity can be selected such that the relative distance between the image sensor and the first optically active element is not adjusted further than the depth of field while an image is recorded. Thus a recorded image is recorded sufficiently sharply in spite of a simultaneous adjustment of the relative distance between the image sensor and the first optically active element. Due to the ongoing adjustment of the relative distance between the image sensor and the first optically active element, the image sensor and/or the first optically active element do not have to be stopped and then accelerated again. That has the advantage that oscillations arising due to the acceleration and stopping of the image sensor and/or of the first optically active element are avoided. Another advantage is that a time for inspecting the component for defects is minimised, as the image sensor and/or the first optically active element only have to be accelerated and stopped once.

The image processing function of the first and the second alternative can be designed to determine, after the recording of the first image or after the recording of the second image, a first image region of a first plurality of image regions of the first image. In the first image region a first sub-region of the

focal plane of the reflected light is projected onto the image sensor surface of the image sensor. In addition or alternatively, the image processing function determines a second image region of the first plurality of image regions of the first image in which a second sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor.

Furthermore, in addition or alternatively after the recording of the second image, the image processing function can determine a third image region of a second plurality of image regions of the second image. In the third image region the first sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor. In addition or alternatively, the image processing function also determines a fourth image region of the second plurality of image regions of the second image, in which the second sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor.

The image processing function can further be designed to supply a control command to the control device to control the first and/or the second actuator following the recording of the second image, in order to adjust the relative distance between the image sensor and the first optically active element to its initial length after the recording of the second image.

The first and second image region of the first image can each image a portion of the component that substantially corresponds to the portion of the component in the third and fourth image region of the second image. The first and the second image region of the first image completely image the component.

The first plurality of image regions of the first image can correspond to the second plurality of image regions of the second image.

The first and second image region of the first image and/or the third and fourth image region of the second image can be image regions connecting to one another. Alternatively, the first and the second image region of the first image and the third and fourth image region of the second image can overlap at least partially.

The first sub-region of the focal plane in the first image and the second sub-region of the focal plane in the second image can be projected within a predetermined depth of field onto the image sensor surface of the image sensor. The second sub-region of the focal plane in the first image and the first sub-region of the focal plane in the second image are then projected outside the predetermined depth of field onto the image sensor surface of the image sensor.

The image processing function can be designed to cut the first image region out of the first image and the fourth image region out of the second image. The image processing function is further designed to join the cut-out first and fourth image regions together to produce a third image.

Due to the creation of a third image, only one image has to be inspected by the image processing function and not two when inspecting the component for imperfections or defects, so that a time for inspecting the image and a computing effort are reduced.

The image processing function can further be designed to determine on the basis of the first image region of the first image and/or the fourth image region of the second image and/or the third image whether the component has at least one imperfection. If the image processing function ascertains at least one imperfection, the image processing function is designed to supply imperfection information about the component.

The optical component measurement system can comprise a position detection sensor, which is designed to determine a position and/or location of the first optically active element and/or of the image sensor surface of the image sensor. The position detection sensor is further designed to supply information about the position and/or location of the optically active element and/or of the image sensor surface of the image sensor to the control device, which controls the first and/or second actuator based on the information supplied. The position detection sensor can be an optical or an (electro-) mechanical position detection sensor.

The position detection sensor can be mounted on the inner side of the tube. In another variant the position detection sensor can be integrated into the image sensor. The mount has a pattern on a surface region that faces the image sensor. The image sensor is designed to recognise the pattern on the surface region and to determine the position and/or location of the optically active element based on the recognised surface region.

Due to the information supplied, it is possible for the control device to position the first optically active element and/or the image sensor precisely to project a focal plane of the reflected light onto the image sensor surface of the image sensor.

The camera device can comprise a second optically active element between the first optically active element and the image sensor in the beam path. An optical axis of the second optically active element is oriented coaxially to the optical axis of the first optically active element.

The first optically active element can be an achromat or an apochromat and/or the second optically active element can be a converging lens.

A refractive index of light increases continuously from red to blue and thus

the focal length of a lens decreases. To compensate for or correct this imaging error, the achromat is used.

Furthermore, an optical component measurement system is proposed for measuring at least one surface of at least one component. A seat is designed to position the component in front of a camera device in order to measure a first surface of the component using the camera device. The camera device comprises an image sensor, which is designed to receive light reflected at the first surface of the component. The optical component measurement system further comprises a first optically active element, which is arranged in the beam path of the reflected light to the image sensor, and an adjusting device for the first optically active element. The adjusting device comprises a mount for the first optically active element. The mount is attached to an inner side of a hollow cylindrical tube by means of a linear guide and a longitudinal centre line of the tube is oriented coaxially to an optical axis of the first optically active element. The linear guide is designed to guide the mount parallel to the optical axis. The adjusting device further comprises a first actuator for adjusting a relative distance between the image sensor and the first optically active element in order to move the first optically active element relative to the image sensor.

An adjusting device for an optically active element is also proposed that comprises a mount for the first optically active element. The mount is attached to an inner side of a hollow cylindrical tube and a longitudinal centre line of the tube is oriented coaxially to an optical axis of the first optically active element. The mount is elastically flexible at least in a longitudinal direction of the tube. The adjusting device further comprises a first actuator for adjusting the mount in order to move the first optically active element relative to the tube along the optical axis.

Furthermore, an adjusting device for an optically active element is proposed

that comprises a mount for the first optically active element. The mount is attached to an inner side of a hollow cylindrical tube by means of a linear guide and a longitudinal centre line of the tube is oriented coaxially to an optical axis of the first optically active element. The linear guide is designed to guide the mount parallel to the optical axis. The adjusting device further comprises a first actuator for adjusting the mount in order to move the first optically active element relative to the tube along the optical axis.

In addition, a method is proposed for measuring at least one surface of at least one component, with the following steps: orientation of the component to a camera device; measurement, by means of the camera device, of a first surface of the component; receiving, by means of an image sensor of the camera device, of light reflected at the first surface of the component; holding of a first optically active element in the beam path of the reflected light by means of a mount that is elastically flexible in a longitudinal direction, wherein the longitudinal direction is oriented parallel to an optical axis of the optically active element; adjustment of a relative distance between the image sensor and the first optically active element in order to move the first optically active element relative to the image sensor along the optical axis.

The method can further comprise the following steps: adjustment of the relative distance between the image sensor and the first optically active element in order to move the image sensor relative to the first optically active element along the optical axis; and, as an option, adjustment of the relative distance between the image sensor and the first optically active element to project a focal plane of the reflected light onto an image sensor surface of the image sensor that faces the reflected light.

The method can further comprise the following step: illumination of the first surface of the component with light. The light can be light of a certain wavelength or of a certain wavelength range.

The method can further comprise the following steps: recording of a first image; determining, based on the first image, whether the focal plane of the reflected light is projected substantially completely onto the image sensor surface of the image sensor; and if the focal plane of the reflected light is not projected substantially completely onto the image sensor surface of the image sensor, then determining a first image region of a first plurality of image regions of the first image in which a first sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor; determining a second image region of the plurality of image regions of the first image in which a second sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor; adjusting the relative distance between the image sensor and the first optically active element in order to project the second sub-region of the focal plane of the reflected light onto the image sensor surface of the image sensor; recording of a second image; determination of a third image region of a second plurality of image regions of the second image in which the first sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor; determination of a fourth image region of the second plurality of image regions of the second image in which the second sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor.

In a first alternative the method can comprise the following steps: recording of a first image; adjusting the relative distance between the image sensor and the first optically active element by a predetermined path length; recording of a second image.

In a second alternative the method can comprise the following steps: recording of a first image; adjusting the relative distance between the image sensor and the first optically active element during the recording of the first

image at a predetermined velocity; recording of a second image after the first image was recorded or after a predetermined period of time after the first image was recorded and during the adjustment of the relative distance between the image sensor and the first optically active element.

5

10

15

The methods according to the first and the second alternative can further comprise the following steps: determination of a first image region of a first plurality of image regions of the first image, in which a first sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor; and/or determination of a second image region of the plurality of image regions of the first image, in which a second sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor; and/or determination of a third image region of a second plurality of image regions of the second image, in which the first sub-region of the focal plane of the reflected light is not projected onto the image sensor surface of the image sensor; and/or determination of a fourth image region of the second plurality of image regions of the second image, in which the second sub-region of the focal plane of the reflected light is projected onto the image sensor surface of the image sensor.

20

The method can further comprise the following steps: cutting of the first image region out of the first image and of the fourth image region out of the second image; and joining together of the cut-out first and fourth image regions to produce a third image.

25

30

The method can further comprise the following steps: determining on the basis of the first image region of the first image and/or the fourth image region of the second image and/or the third image whether the component has at least one imperfection; and if the component has at least one imperfection, then supplying imperfection information about the component.

Even if some of the aspects described above were described in relation to the methods, these aspects can also apply to the devices. In just the same way, the aspects described above in relation to the devices can apply in a corresponding manner to the method.

5

Brief description of the figures

Further aims, features, advantages and application options result from the following description of exemplary embodiments, which are not to be understood to be restrictive, with reference to the associated drawings. Here all features described and/or depicted show by themselves or in any combination the subject matter disclosed here, even independently of their grouping in the claims or their back references. The dimensions and proportions of the components shown in the figures are not necessarily to scale in this case; they may diverge from what is illustrated here in embodiments to be implemented.

15

Fig. 1 shows a schematic lateral plan view of an adjusting device for an optically active element;

20

Figs. 2 and 3 show schematic plan views of exemplary embodiments of a mount of the adjusting device;

25

Fig. 4 shows a schematic lateral plan view of an optical component measurement system for measuring at least one surface of at least one component;

Figs. 5 and 6 show schematically various image recordings with image regions of different sharpness;

30

Fig. 7 shows schematically an image recording that consists of

image regions of previous image recordings;

5 Figs. 8 to 10 show schematic lateral plan views of a focal plane of the component to be imaged in relation to a surface of an image sensor of the optical component measurement system;

10 Fig. 11 shows a time-velocity diagram by means of which a relative distance between an optically active element and the image sensor of the optical component measurement system is varied;

15 Fig. 12 shows a time-focus path diagram by means of which an exemplary embodiment for recording images of the component is to be explained;

20 Fig. 13 shows another time-focus path diagram by means of which another exemplary embodiment for recording images of the component is to be explained.

25 The device variants described here and their functional and operating aspects serve purely for a better understanding of their structure, mode of operation and properties; they do not restrict the disclosure to the exemplary embodiments, for instance. The figures are partly schematic, wherein substantial properties and effects are depicted in some cases significantly enlarged, in order to clarify the functions, active principles, technical configurations and features. Here each mode of operation, each principle, each technical configuration and each feature which is/are disclosed in the figures or in the text can be combined freely and in any way with all claims, 30 any feature in the text and in the other figures, other modes of operation,

principles, technical configurations and features that are contained in this disclosure or result from it, so that all conceivable combinations of the devices described are to be associated. Here even combinations between all individual statements in the text, meaning in each section of the description, in the claims and even combinations between various variants in the text, in the claims and in the figures are comprised and can be made the subject of further claims. Nor do the claims limit the disclosure and thus the options of combining all features displayed with one another. All disclosed features are explicitly disclosed here also individually and in combination with all other features.

Detailed description

Components corresponding to one another or similar in function are provided with corresponding reference signs in the figures. The devices and methods are now described with reference to exemplary embodiments.

In Figure 1 an adjusting device 100 for an achromat 130 as the first optically active element is illustrated. The achromat 130 consists of a flint glass lens 130B and a crown glass lens 130A. The adjusting device 100 comprises a mount 140 for the achromat 130. The mount 140 is attached to an inner side of a hollow cylindrical tube 110 and a longitudinal centre line of the tube 110 is oriented coaxially with an optical axis OA of the achromat 130. The mount 140 is formed to be annular in the present implementation. The mount 140 receives the achromat 130 through an opening in the mount 140 in such a way that the optical axis OA of the achromat 130 is coaxial with the longitudinal centre line of the tube 110. The tube 110 has a low permeability (relative permeability $\mu > 1$) and a paramagnetic material. The paramagnetic material is aluminium. In another variant the tube 110 has plastic as a material.

The mount 140 is elastically flexible at least in a longitudinal direction of the

tube. To this end the mount 140 has a material containing rubber that is elastically deformable. In another variant the mount 140 is formed as a bellows or a helical spring. In another variant the mount 140 is formed as a cup spring, which holds the achromat 130 in such a way that its optical axis OA is coaxial with the longitudinal centre line of the tube 110.

As illustrated in Fig. 1, the mount 140 is attached at a first end region to the tube 110. A wall thickness of the mount 140 reduces along the optical axis OA towards a second end region of the mount 140, at which the achromat 130 is held. Here the second end region of the mount 140 is not attached to the tube 110 and is spaced from the tube 110 in a direction orthogonal to the optical axis OA. The mount 140 has at least one recess for this, which acts as a holder for the achromat 130. The achromat 130 is received and held in the recess.

The adjusting device 100 further comprises a first actuator 120 for adjusting the mount 140 in order to move the achromat 130 along the optical axis OA relative to the tube 110. In Fig. 1 the first actuator 120 has a coil 121 for this, which surrounds the mount 140 at least in sections.

The coil 121 is in contact with the tube 110 in Fig. 1. In another variant the coil 121 is arranged spaced at a distance from the tube 110.

In Fig. 1 the first end region of the mount 140 is arranged outside the coil 121 with reference to the optical axis OA. The second end region of the mount 140, on the other hand, is located inside the coil 121 with reference to the optical axis OA.

In another variant the position of the first end region of the mount 140 coincides with an end of the coil 121 with reference to the optical axis OA. In

another variant the position of the first end region of the mount 140 lies inside or outside the coil 121 with reference to the optical axis. In another variant the second end region of the mount 140 lies inside or outside the coil 121 with reference to the optical axis OA.

5

The mount 140 has a yoke 141, 142 containing soft iron in the second end region of the mount 140. In another variant the mount 140 has a permanently magnetic yoke 141, 142. In Fig. 1 the mount 140 has the yoke 141, 142 in the second end region of the mount 140. The yoke 141, 142 is arranged opposite the holder of the mount 140. In another variant the yoke 141, 142 is located between the achromat 130 and the mount 140.

10

If an electric current is conducted through the coil 121, a magnetic field is formed inside this. When the coil 121 is energised, a force acts due to the magnetic field on the yoke 141, 142 containing soft iron, which force pulls the yoke 141, 142 containing soft iron into the centre of the coil 121. The yoke 141, 142 containing soft iron is an unalloyed iron with a high purity value. The mount 140 is stretched or compressed by this (depending on where the coil 120 is arranged with reference to the yoke 141, 142 containing soft iron along the optical axis OA), as the mount 140 is firstly attached fixedly to the inner side of the tube 110. Secondly, the yoke 141, 142 containing soft iron of the mount 140 is pulled into the centre of the coil 121 by the magnetic field. Due to the magnetic field applied, the mount 140 is stretched or compressed such that a position of the achromat 130 with the mount 140 is moved along the optical axis OA. An orientation of the achromat 130 is not changed in this case, so that by moving the position of the achromat 130 only the focus of the achromat 130 is moved along the optical axis OA.

15

20

25

30

In another variant the mount 140 has the permanently magnetic yoke 141, 142. The permanently magnetic yoke 141, 142 extends in a longitudinal di-

rection parallel to the optical axis OA. The north and south pole of the permanently magnetic yoke 141, 142 are oriented so that the north and south pole are each oriented in opposite directions along the optical axis OA. In this case the mount 140 is deformed as a function of a current direction of the electric current in the coil 121. The mount 140 is thus deformed in the first direction and in a second direction, wherein the second direction is opposite to the first direction.

Since the mount 140 is elastically flexible, it has a deformation resistance that counteracts deformation. On deformation of the mount 140, a force generated by the deformation resistance increases or decreases depending on the degree of deformation of the mount 140. If a magnetic field is generated, therefore, and the mount 140 is deformed by the force generated by the magnetic field, the force generated by the deformation resistance and the force generated by the magnetic field form a force equilibrium. If the magnetic field is reduced and finally turned off, the mount 140 assumes an initial position once more due to its elastically flexible properties. By targeted control of the current strength of the electric current the position of the mount 140 is accordingly adjusted along the optical axis OA.

A lightweight construction for an optically active element is thus realised by the construction illustrated in Fig. 1. Furthermore, the achromat 130 is substantially less susceptible to oscillations due to the mount 140, as oscillations of external sources are damped by the mount 140. If a focus of the achromat 130 has to be adjusted, the mount 140 is deformed by a corresponding magnetic field. Only small masses are moved in this case, so that oscillations of the actuator 120 are minimised.

In another exemplary embodiment the adjusting device 100 comprises a linear guide (not shown) instead of the coil 121. The linear guide is designed to guide the mount 140 parallel to the optical axis OA. The position of the

mount 140 and thus also of the achromat 130 along the optical axis OA is adjustable accordingly. The adjusting device 100 comprises a drive device (not shown), which is designed to move the mount 140 along the linear guide.

5

Possible exemplary embodiments of the mount 140 are depicted in Figs. 2 and 3. Figs. 2 and 3 show a plan view of the mount 140, the yoke 141, 142 and the achromat 130.

10

The mount 140 in Fig. 2 consists of at least two mount pieces 143, 144, which together hold the achromat 130. In one variant the achromat 130 is arranged between the two mount pieces 143, 144, so that the two mount pieces 143, 144 lie opposite one another. In another variant the mount has at least four mount pieces (not shown), which are each arranged offset by

15

90° around the optical axis OA and hold the achromat 130.

According to the variant of the mount 140 shown in Fig. 3, the mount 140 has a yoke 141, 142 at each of the two mount pieces 143, 144. In the variant with four mount pieces the mount 140 has a yoke at each of at least two

20

Fig. 3 illustrates another variant of the mount 140 in which the mount 140 is formed as a ring mount 145 to hold the achromat 130.

25

According to the variant shown in Fig. 4, the yoke 146 is formed to be annular. An induction current generated by the magnetic field in the annularly formed yoke 146 is suppressed by a number of slots in the annularly formed yoke 146. Due to the annularly formed yoke 146 the force generated by the magnetic field acts uniformly on the mount 140 and this is deformed uniformly. Alternatively, the yoke can be formed as described for Fig. 3.

30

Fig. 4 shows an optical component measurement system 200 for measuring at least one surface O of a semiconductor chip B as a component. The optical component measurement system 200 comprises a seat 150. The seat 150 is designed to position the semiconductor chip B in front of a camera device 220 in order to measure the first surface O of the semiconductor chip B with the camera device 220. The first surface is a lateral surface of the semiconductor chip B in Fig. 4. However, the seat 150 is not limited to orienting the semiconductor chip B only with this surface O to the camera device 220. The seat 150 is designed to direct the semiconductor chip B with another surface of the semiconductor chip B at the camera device 220 in order to inspect other surfaces of the semiconductor chip B also. The optical component measurement system 200 further comprises a light source (not shown), which is designed to transmit light to the first surface O of the semiconductor chip B and to illuminate the semiconductor chip B. The light source is designed to illuminate the semiconductor chip B with light of a certain wavelength or a certain wavelength range. The light emitted by the light source in one variant is visible light with a wavelength in the range from approx. 380 to 790 nm. In other variants infrared light or polarised light is used.

The camera device 220 comprises a CCD chip 230 as an image sensor, which is designed to receive light reflected at the first surface O of the semiconductor chip B. In other variants the image sensor can be a CMOS chip or an image sensor sensitive to certain wavelengths, such as a microbolometer array or a pyroelectric array. Depending on the light wavelength range used, the CCD chip has a sensitivity adjusted thereto for the respective light range or also for polarised light. Furthermore, an adjusting device 100 as shown in Fig. 1 is arranged together with an achromat 130 as a first optically active element in the beam path of the reflected light L. In addition, a converging lens 160 is located as a second optically active element in the beam path be-

tween the achromat 130 and the CCD chip 230. An optical axis of the converging lens 160 is oriented coaxially to the optical axis OA of the achromat 130.

5 In the optical component measurement system 200 shown in Fig. 4, the adjusting device 100 comprises the coil 121 as the first actuator 120. The mount 140 in this exemplary embodiment is elastically flexible in a longitudinal tube direction of the tube 110.

10 Alternatively, the optical component measurement system 200 comprises a linear guide instead of the coil 121. The mount 140 is attached via the linear guide to the inner side of the tube 110. The linear guide is further designed to guide the mount 140 parallel to the optical axis OA. The linear guide is formed as a rail, which extends parallel to the optical axis OA. In another
15 variant the linear guide is formed as two rails. The two rails lie symmetrically opposite one another relative to the axis OA.

The first surface O of the semiconductor chip B is arranged in Fig. 4 not parallel to an image sensor surface 231 of the CCD chip 230 but tilted by an angle alpha to the optical axis OA. The angle alpha in Fig. 4 is greater or
20 smaller than 90° .

The optical component measurement system 200 in Fig. 4 further comprises a control device ECU, which is designed to control the first actuator 120. The control device ECU is accordingly designed to control the electric current
25 supplied to the coil 121 and thus to adjust a relative distance between the achromat 130 and the CCD chip 230 (or the image sensor surface 231 of the CCD chip 230). If the optical component measurement system 200 comprises the linear drive instead of the coil 121, the control device ECU is designed
30 to control a motor that moves the mount 140 along the linear guide.

In Fig. 4 the control device ECU comprises an image processing function BV. In another variant the control device ECU and the image processing function BV can be two separate units that are designed to communicate with one another.

5

In addition, the optical image measurement system 200 in Fig. 4 has a second actuator 240 controlled by the control device ECU. The second actuator 240 is designed to adjust the CCD chip 230 in order to move the CCD chip 230 along the optical axis OA relative to the achromat 130.

10

The optical component measurement system 200 further comprises a position detection sensor 250, which is designed to determine a position and/or location of the achromat 130 and/or of the image sensor surface 231 of the CCD chip 230. The position detection sensor 250 is arranged and attached in Fig. 1 on the inner side of the tube 110 and opposite the yoke 142. In another variant the position detection sensor 250 can be arranged and attached on the inner side of the tube 110 and opposite the yoke 141.

15

In another variant the position detection sensor 250 can be integrated into the CCD chip 230. Here the mount 140 has a marking on at least one surface region facing the CCD chip 230. The CCD chip 230 is designed to detect this marking and to determine a position and/or location of the achromat 130 based on the marking detected.

20

The position detection sensor 250 supplies information about the position and/or location of the achromat 130 and/or of the image sensor surface 231 of the CCD chip 230 to the control device ECU, which controls the first and/or second actuator 120, 240 on the basis of the information supplied. The position detection sensor 250 is an optical position detection sensor, but in another variant can be an (electro-) mechanical position detection sensor.

25

30

In Fig. 4 the control device ECU is designed to adjust the relative distance between the achromat 130 and the CCD chip 230 by controlling the first and/or the second actuator 120, 240 in order to project a focal plane SE of the reflected light L onto the image sensor surface 231 of the CCD chip 230 that faces the reflected light L.

In one possible case the surface O of the semiconductor chip B is substantially parallel to the image sensor surface 231 of the CCD chip 230. The control device ECU controls the first and/or the second actuator 120, 240 in such a way that the focal plane SE is projected onto the image sensor surface 231 of the CCD chip 230.

If the CCD chip 230 then records an image of the semiconductor chip B, the semiconductor chip B is imaged sharply in the image and the semiconductor chip B is inspected for possible defects or imperfections. If a defect or an imperfection is ascertained by the image processing function BV, the image processing function BV supplies imperfection information about the semiconductor chip B.

The first and/or the second actuator 120, 240 are designed to increase or reduce a relative distance between the achromat 130 and the CCD chip 230 by 100 μm in a few milliseconds. Put more precisely, the first and/or the second actuator 120, 240 are designed to vary the relative distance by 100 μm within 2 to 10 ms, preferably within roughly 5 ms. The relative distance between the achromat 130 and the CCD chip 230 is increased or reduced in such a way that no overshoot of the achromat 130 and/or of the CCD chip 230 occurs or is produced in particular along the movement direction.

Since the semiconductor chip B in Fig. 4 is tilted towards the image sensor surface 231 of the CCD chip 230, it is not possible for the control device ECU to project the focal plane SE of the reflected light L substantially completely

onto the image sensor surface 231 of the CCD chip 230 by adjusting the relative distance between the achromat 130 and the image sensor surface 231 of the CCD chip 230.

5 The image processing function BV is designed to record a first image BA by means of the CCD chip 230. Based on the first image BA recorded by the CCD chip 230, the image processing function BV determines whether the focal plane SE of the reflected light L is projected substantially completely onto the image sensor surface 231 of the CCD chip 230. If the image processing
10 function BV determines that the focal plane SE is not projected substantially completely onto the image sensor surface 231 of the CCD chip 230, the image processing function BV determines a first image region B1 of a first plurality of image regions B1, B2 of the first image BA. In the first image region B1 a first sub-region of the focal plane SE of the reflected light L is projected
15 onto the image sensor surface 231 of the CCD chip 230.

The first recorded image BA is illustrated schematically in Fig. 5, wherein image regions with a continuous black line are sharply imaged image regions. Expressed another way, the image regions with black continuous lines are
20 image regions in which a sub-region of the focal plane SE of the reflected light L is projected onto the image sensor surface 231 of the CCD chip 230. Image regions with a dashed black line are image regions that are blurred or in which a sub-region of the focal plane SE is not projected onto the image sensor surface 231 of the CCD chip 230.

25 Based on the first image BA the image processing function BV determines a second image region B2 of the first plurality of image regions B1, B2 in which a second sub-region of the focal plane SE of the reflected light L is not projected onto the image sensor surface 231 of the CCD chip 230.

30 The image processing function BV then supplies a control signal to the con-

trol device ECU. Based on the control signal, the control device ECU controls the first and/or the second actuator 120, 240 to adjust the relative distance between the achromat 130 and the CCD chip 230. In this case the second portion of the focal plane SE of the reflected light L is projected onto the image sensor surface 231 of the CCD chip 230. The second sub-region of the focal plane SE of the reflected light L is then projected onto the image sensor surface 231 of the CCD chip 230. The first sub-region of the focal plane SE of the reflected light L, on the other hand, is no longer projected onto the image sensor surface 231 of the CCD chip 230. The image processing function BV then transmits a signal to the CCD chip 230 to record a second image BB.

As shown schematically in Fig. 6, the image processing function BV determines, based on the second image BB, a third image region B3 of a second plurality of image regions B3, B4 of the second image BB. In the third image region B3 the first sub-region of the focal plane SE of the reflected light L is not projected onto the image sensor surface 231 of the CCD chip 230. The image processing function BV then determines a fourth image region B4 of the second plurality of image regions B3, B4 of the second image BB. In the fourth image region B4 the second sub-region of the focal plane SE of the reflected light L is projected onto the image sensor surface 231 of the CCD chip 230. In the second image BB the fourth image region B4 consequently images an extract of the semiconductor chip B sharply. The first and second plurality of image regions are not limited to the number two.

In a preferred implementation, the first and the second image region B1, B2 of the first image BA each image a portion of the semiconductor chip B that substantially corresponds to the portion of the semiconductor chip B in the third and fourth image regions B3, B4 of the second image BB. It is thus guaranteed that in the image regions B1, B2, B3, B4 of the first and second image BA, BB, identical portions of the semiconductor chip B are imaged.

The first and second image region B1, B2 of the first image BA and the third and fourth image region B3, B4 of the second image BB are depicted in Fig. 5 to 7 as image regions connecting to one another. Alternatively, the first and the second image region B1, B2 of the first image BA and the third and the fourth image region B3, B4 of the second image BB can overlap at least partially.

The image processing function BV is designed to cut the first image region B1 out of the first image BA and the fourth image region B4 out of the second image BB. On the basis of the cut-out image regions B1, B4 the image processing function BV produces a third image BC. The third image BC is a completely sharp imaging of the semiconductor chip B, as in the first image region B1 of the first image BA and in the fourth image region B4 of the second image BB the semiconductor chip B is sharply imaged.

The image processing function BV is further designed to determine on the basis of the first image region B1 of the first image BA and/or the fourth image region B4 of the second image BB and/or the third image BC whether the semiconductor chip B has at least one defect or imperfection. If the semiconductor chip B has a defect or an imperfection, the image processing function BV supplies imperfection information.

The focal plane SE with an associated depth of field ST is now to be illustrated in Figs. 8 to 10. To record the semiconductor chip B sharply, the focal plane SE must be projected substantially onto the image sensor surface 231 of the CCD chip 230. Since the focal plane SE has a certain depth of field ST, the semiconductor chip B is imaged sharply even if the focal plane SE is not entirely parallel to the image sensor surface 231 of the CCD chip 230. The semiconductor chip B is likewise imaged sharply if the focal plane SE is projected at a certain distance in front of or behind the image sensor surface

231 of the CCD chip 230. The depth of field ST here describes the distance within which an object, here the semiconductor chip B, is imaged sufficiently sharply.

5 As shown schematically in Fig. 8, the focal plane SE is projected parallel to the image sensor surface 231 of the CCD chip 230 and along the optical axis OA at a distance from the image sensor surface 231. The depth of field ST of the focal plane SE is sufficiently great in Fig. 8, so that a recorded image of a focal plane SE of the reflected light L projected in such a way is sharp.

10 The case of the tilted semiconductor chip B is depicted schematically in Figs. 9 and 10. Since the surface O of the semiconductor chip B is tilted towards the image sensor surface 231 of the CCD chip 230, the focal plane SE of the reflected light L is also tilted towards the image sensor surface 231 of the
15 CCD chip 230.

In Fig. 9 the first sub-region of the focal plane SE is projected onto the image sensor surface 231 of the CCD chip 230, so that in the first recorded image BA the first image region B1 reproduces a sharp imaging of the
20 semiconductor chip B. Although the focal plane SE only partially intersects the image sensor surface 231 of the CCD chip 230, the first image region B1 of the first image BA is imaged sharply thanks to the depth of field ST. In the second image region B2, the second sub-region of the focal plane SE with the depth of field ST is no longer projected onto the image sensor surface 231 of the CCD chip 230, so that the second image region B2 of the first
25 image BA reproduces a blurred imaging of the semiconductor chip B.

At the control command of the image processing function BV, the control device ECU controls the first and/or the second actuator 120, 240 in order to
30 adjust the relative distance between the achromat 130 and the CCD chip 230. The focal plane SE is adjusted here relative to the image sensor surface

231 of the CCD chip 230, so that the second sub-region of the focal plane SE is projected onto the image sensor surface 231 of the CCD chip 230.

As illustrated schematically in Fig. 10, in the second recorded image BB in the fourth image region B4, the second sub-region of the focal plane SE with the depth of field ST of the reflected light L is now projected onto the image sensor surface 231 of the CCD chip 230. Since even in the second image BB the focal plane SE only partially intersects the image sensor surface 231 of the CCD chip 230, thanks to the depth of field ST the fourth image region B4 of the second image BB reproduces a portion of the semiconductor chip B sharply. On the other hand, in the third image region B3 of the second image BB the first sub-region of the focal plane SE with the depth of field ST is no longer projected onto the image sensor surface 231 of the CCD chip 230. The third image region B3 of the second image BB accordingly reproduces a portion of the semiconductor chip B in a blurred manner.

Corresponding to the previous description of the optical component measurement system 200 a method is now described for measuring a surface of at least one semiconductor chip B.

In one step the semiconductor chip B is oriented towards the camera device 220. In a next step the first surface O of the semiconductor chip B is measured by means of the camera device 220.

In a next step, light L reflected at the surface O of the semiconductor chip B is received by the CCD chip 230. In a further step, the achromat 130 is held in the beam path of the reflected light L by means of the mount 140, which is elastically flexible in a longitudinal direction. The longitudinal direction is oriented parallel to the optical axis OA of the achromat 130. In a next step, the relative distance between the CCD chip 230 and the achromat 130 is adjusted in order to move the achromat 130 relative to the CCD chip 230 along

the optical axis OA.

In Fig. 11 a time-velocity (t, v) diagram is illustrated. The control device ECU is designed to adjust the relative distance between the achromat 130 and the CCD chip 230 by means of such a diagram.

At time t_0 the relative distance between the achromat 130 and the CCD chip 230 is adjusted by the first and/or second actuator 120, 240. The achromat 130 and/or the CCD chip 230 are accelerated to a predetermined velocity v_1 within half a first time period (t_0-t_1) by the first and/or second actuator 120, 240. After the half time period (t_0-t_1) the achromat 130 and/or the CCD chip 230 is decelerated by the first and/or second actuator 120, 240.

Following adjustment of the achromat 130 and/or of the image sensor 230, the focal plane SE is projected as in Fig. 9 onto the image sensor surface 231 of the CCD chip 230. After the achromat 130 and/or the CCD chip 230 have come to a stop, the first image BA is recorded within a second time period (t_1-t_2).

The first and the second image region B1, B2 are then determined by the image processing function BV on the basis of the first image BA. In the first image BA in the first image region B1 the first sub-region of the focal plane SE is projected onto the image sensor surface 231 of the CCD chip 230. On the other hand, in the second image region B2 the second portion of the focal plane SE is not projected onto the image sensor surface 231 of the CCD chip 230. For recording and reading out an image the CCD chip 230 requires a time of 6 to 12 ms, (for example roughly 8 to 10 ms), depending on the light conditions during recording and on the chip size and read-out speed (pixels / s), which influences the read-out duration.

At the control command of the image processing function BV, the control device ECU then controls the first and/or second actuator 120, 240 at the beginning of a third time period (t_2 - t_3) in order to adjust the relative distance between the achromat 130 and the CCD chip 230. Here the relative distance is adjusted to that the second sub-region of the focal plane SE is projected onto the image sensor surface 231 of the image sensor 230.

Accordingly, up to half of the third time period (t_2 - t_3) the achromat 130 and/or the CCD chip 230 are accelerated up to the predetermined velocity. After half of the third time period (t_2 - t_3) the achromat 130 and/or the CCD chip 230 are decelerated. As soon as the achromat 130 and/or the CCD chip 230 have come to a stop, the second image BB is recorded by the CCD chip 230. The distance by which the relative distance between the achromat 130 and the CCD chip 230 is reduced or increased lies in the range between 70 and 150 μm , preferably at 100 μm . This distance is travelled in a time period of 2 to 10 ms, preferably within 10 ms. The distance by which the relative distance between the achromat 130 and the CCD chip 230 is moved is dependent on the first and/or second optically active element 130, 160 used and its optical properties.

The image processing function BV is further designed to supply another control command to the first and/or second actuator 120, 240 in order to adjust the relative distance between the image sensor 230 and the achromat 130 to an initial length following the recording of the second image BB.

In another variant three images each with three image regions are recorded by the CCD chip 230. In one of the three image regions a sub-region of the focal plane SE is projected onto the image sensor surface 231 of the CCD chip 230, while in the other two image regions the focal plane SE is not projected onto the image sensor surface 231 of the CCD chip 230. The process of the three image recordings functions like the process of the two image re-

cordings, only with three images with three image regions each. To record the three images and adjust the relative distance between the achromat 130 and the CCD chip 230 accordingly, the optical component measurement system requires a time of 80 to 120 ms, preferably 100 ms.

5

In a first variant the seat 150 is designed to position the semiconductor chip B in front of the camera device 220 such that the focal plane SE is at least partially projected onto the image sensor surface 231 of the CCD chip 230. The image processing function BV accordingly first records the first image BA by the CCD chip 230. The image processing function BV then determines the first and second image regions B1, B2 and before or at time t_0 transmits the control command to the control device ECU. The control device ECU controls the first and/or second actuator 120, 240 based on the control command in order to accelerate the achromat 130 and/or the CCD chip 230 to the velocity v_1 within half of the first period (t_0-t_1). After half of the first period (t_0-t_1) the achromat 130 and/or the CCD chip 230 are decelerated. Once the achromat 130 and/or the CCD chip 230 have come to a stop, the second image BB is recorded by the CCD chip 230.

10

15

20

25

Figs. 12 and 13 each depict a time-focus path diagram, in which different steps 310 to 360 and 410 to 460 are executed at different times, wherein steps corresponding to one another are provided with the same reference signs. Three images of the semiconductor chip B are recorded in Figs. 12 and 13. An image is divided respectively into three image regions, wherein only one image region in each case has a sharp image of a sub-region of the semiconductor chip B. Thus only one image region in each case is in the range of the depth of field. However, the number of images recorded is not limited to this number. In another variant several image regions can be located completely or at least partially within the depth of field and/or overlap.

30

In Fig. 12 the semiconductor chip B is positioned in front of the camera de-

vice 220 by the seat 150 before the time t_0 . After the time t_0 the CCD chip 230 records a first image of the semiconductor component B in step 310. In a step 311 following step 310, the image processing function BV determines in the first image a first image region of a first plurality of image regions in which a first sub-region of the focal plane SE of the reflected light L is projected onto the image sensor surface 231 of the CCD chip 230. The image processing function BV further determines in step 311 a second and third image region of the first image in which a second and a third sub-region of the focal plane SE of the reflected light L is not projected onto the image sensor surface 231 of the CCD chip 230.

After a predetermined time period following the recording of the first image in step 310, the image processing function BV supplies a control command to the first and/or the second actuator 120, 240. In step 320 the first and/or the second actuator 120, 240 adjust the relative distance between the CCD chip 230 and the achromat 130 by a predetermined path length. During the determination of the first, second and third image regions by the image processing function BV the relative distance is adjusted accordingly between the CCD chip 230 and the achromat 130.

The predetermined path length is dependent on optical properties of the achromat 130, the lens 160 and/or dimensions of the surface O of the component B. The predetermined path length is preferably predetermined as a function of the depth of field ST, so that the predetermined path length is smaller than, equal to or greater than the depth of field ST. As depicted in Fig. 12, a velocity to cover the predetermined path length is increased first slowly and then more strongly. After a certain partial path length has been covered, the velocity is reduced initially sharply and then more slightly. An abrupt movement and stopping of the achromat 130 and/or the CCD chip 230 by the first and/or second actuator 120, 240 and thus an overshoot along the movement direction are thus avoided.

After ending of the adjustment of the relative distance in the step 320, a second image is recorded by means of the CCD chip 230 in step 330. In a step 331 following step 330, the image processing function BV determines in the second image a fourth and sixth image region of a second plurality of image regions, in which the first and third sub-region of the focal plane SE of the reflected light L is not projected onto the image sensor surface 231 of the CCD chip 230. The image processing function BV further determines in step 331 a fifth image region of the second image in which the second sub-region of the focal plane SE of the reflected light L is projected onto the image sensor surface 231 of the CCD chip.

Following successful recording of the second image in step 330, the image processing function again supplies a control command to the first and/or second actuator 120, 240. In step 340 the first and/or the second actuator 120, 240 adjust the relative distance between the CCD chip 230 and the achromat 130 by the predetermined path length. In another variant the relative distance between the CCD chip 230 and the achromat 130 can be adjusted in step 340 by a second predetermined path length that is greater or smaller than the predetermined path length in step 320. The relative distance between the CCD chip 230 and the achromat 130 is adjusted accordingly during the determination of the fourth, fifth and sixth image regions by the image processing function BV.

On ending of the adjustment of the relative distance in step 340, a third image is recorded by means of the CCD chip 230 in step 350. Following the successful recording of the third image, the image processing function BV determines in step 351 a seventh and eighth image region of the third image in which the first and second sub-region of the focal plane SE of the reflected light L is not projected onto the image sensor surface 231 of the CCD chip 230. The image processing function BV further determines in step 351 a

ninth image region of the third image in which the third sub-region of the focal plane SE of the reflected light L is projected onto the image sensor surface 231 of the CCD chip 230.

5 After the third image was recorded in step 350, the image processing function BV supplies another control command to the first and/or second actuator 120, 240. The first and/or second actuator 120, 240 adjust the relative distance between the CCD chip 230 and the achromat 130 to its initial length in step 360. The relative distance between the CCD chip 230 and the achromat 130 is adjusted accordingly during the determination of the seventh, eighth and ninth image regions by the image processing function BV. The adjustment of the relative distance between the CCD chip 230 and the achromat 130 to its initial length is carried out like the adjustment of the relative distance in steps 320 and 340, but in the opposite direction.

15 After step 360 the image processing function BV examines in consecutive steps 312, 332, 352 based on the respective image regions determined of the first, second and third image whether the semiconductor chip B has defects.

20 In another variant, following one of steps 360, 312, 332, 352 the image processing function BV can produce a fourth image in step 353, in which it cuts out the first, fifth and ninth image region of the first, second and third image and joins them together.

25 In another variant the image processing function BV carries out step 311 after one of steps 330, 331, 340, 350, 351, 360. The image processing function BV can also carry out step 331 after one of the steps 340, 350, 351, 360 and/or step 351 after one of steps 312, 332.

It is thus possible to decouple image processing and inspection of the images of the semiconductor chip B from the process of image recording. Due to the independence of recording of images of the semiconductor chip B from the image processing and inspection of the images, the process of image recording can be reduced to fewer steps. A period for the image recordings per component is accordingly reduced and a larger number of components and corresponding image recordings can be achieved within the same time.

In Fig. 13 the semiconductor chip B is positioned in front of the camera device 220 before time t_0 . After time t_0 a first image is recorded by means of the CCD chip in step 410 and is supplied to the image processing function BV. During step 410 the image processing function BV supplies a control command to the first and/or second actuator 120, 240 to adjust the relative distance between the CCD chip 230 and the achromat 130 at a predetermined velocity. The first and/or second actuator 120, 240 adjust the relative distance between the CCD chip 230 and the achromat 130 even while the recording of the first image is being carried out.

The time at which the relative distance between the CCD chip 230 and the achromat 130 is adjusted at the predetermined velocity, and the predetermined velocities, are based on the optical properties of the achromat 130, the lens 160, the depth of field ST , the dimensions of the surface O of the component B, masses of the achromat 130 and/or the lens 160 and/or the image sensor 230 as well as the response behaviour of these due to the first and/or second actuator 120, 240. If the depth of field is $70\text{ }\mu\text{m}$ great, for example, the focal plane SE may be displaced during recording of the first image by a maximum of $70\text{ }\mu\text{m}$. Sharp imaging of a sub-region of the semiconductor chip B on an image region of the image recorded is thus guaranteed.

In Fig. 13 the predetermined velocity along the travel path on which the im-

ages are produced is kept constant. In another variant the velocity for adjusting the relative distance between the CCD chip 230 and the achromat can be within a predetermined velocity range or can change between at least two different velocities.

5

After the focal plane SE was adjusted by a predetermined path length and/or for a predetermined time, a second image is recorded by means of the CCD chip 230 in step 430. Independently of the recording of the second image, the relative distance between the CCD chip 230 and the achromat 130 is further adjusted at the predetermined velocity. In another variant the second image is recorded when a predetermined focal plane position is reached.

10

After the focal plane SE was further adjusted by a predetermined path length and/or for a predetermined time, a third image is recorded by means of the CCD chip 230 in step 450. As in the recording of the second image, the relative distance between the CCD chip 230 and the achromat 130 is adjusted at the predetermined velocity also during the recording of the third image. In another variant the predetermined velocity is reduced during the recording of the third image until finally the relative distance between the CCD chip 230 and the achromat 130 is adjusted no more.

15

20

Steps 311, 312, 331, 332, 351, 352, 353, 360 can be carried out as already described for Fig. 12.

25

30

According to Fig. 13 the achromat 130 and/or the image sensor 230 are only accelerated and stopped once while the first, second and third image are recorded. A respective stopping and renewed acceleration are avoided, so that the duration for the image recordings per component is reduced further. Likewise, oscillations of the optical component measurement system 200 due to renewed acceleration and stopping are avoided.

CLAIMS

1. Optical component measurement system (200) for measuring at least one surface of at least one component (B), having a seat (150), which is designed to position the component (B) in front of a camera device (220) in order to measure a first surface (O) of the component (B) with the camera device (220), wherein the camera device (220) comprises an image sensor (230), which is designed to receive light (L) reflected at the first surface (O) of the component (B); wherein the optical component measurement system (200) comprises a first optically active element (130), which is arranged in a beam path of the reflected light (L) to the image sensor (230), a control device (ECU), an image processing function (BV), and an adjusting device (100) for the first optically active element (130), the adjusting device (100) comprising:
- a mount (140) for the first optically active element (130), wherein the mount (140) is attached to an inner side of a hollow cylindrical tube (110) and a longitudinal centre line of the tube (110) is oriented coaxially to an optical axis (OA) of the first optically active element (130), and wherein the mount (140) is elastically flexible at least in a longitudinal direction of the tube; and
- a first actuator (120) for adjusting a relative distance between the optically active element (130) and the image sensor (230) in order to move the optically active element (130) relative to the image sensor (230) along the optical axis (OA), wherein the control device (ECU) is designed to control the first actuator (120), wherein the image processing function (BV) is designed to:
- record a first image (BA) by means of the image sensor (230), which image is supplied to the image processing function (BV);
 - supply a control command to the control device (ECU) to control the first actuator (120) in order to adjust the relative distance between the first optically active element (130) and the image sensor (230) by a predetermined path length;
 - record a second image (BB) by means of the image sensor (230), which image is supplied to the image processing function (BV),

wherein the image processing function (BV), following the recording of the first image (BA) or following the recording of the second image (BB), is designed to:

- determine a first image region (B1) of a first plurality of image regions (B1, B2) of the first image (BA) in which a first sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230); and
- determine a second image region (B2) of the first plurality of image regions (B1, B2) of the first image (BA) in which a second sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and
- determine a third image region (B3) of a second plurality of image regions (B3, B4) of the second image (BB) in which the first sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and
- determine a fourth image region (B4) of the second plurality of image regions (B3, B4) of the second image (BB) in which the second sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230).

2. Optical component measurement system (200) according to claim 1,

wherein the first actuator (120) comprises a coil (121) surrounding the mount (140) at least in sections;

wherein the control device (ECU) is designed to control an electric current supplied to the coil (121) to generate a magnetic field;

wherein the mount (140) has a component (141, 142) that contains soft iron or is permanently magnetic and which is designed to move the mount (140) along the

longitudinal centre line of the tube (110) as a function of the electric current supplied to the coil (121).

3. Optical component measurement system (200) according to one of the preceding claims, further comprising:

a second actuator (240) controlled by the control device (ECU) for adjusting the image sensor (230) in order to move the image sensor (230) relative to the first optically active element (130) along the optical axis (OA); and/or

at least one light source, which is designed to transmit light to the first surface (O) of the component (B);

wherein, as an option, the control device (ECU) is designed to adjust the relative distance between the first optically active element (130) and the image sensor (230) by controlling the first and/or the second actuator (120, 240) in order to project a focal plane (SE) of the reflected light (L) onto an image sensor surface (231) of the image sensor (230) facing the reflected light (L).

4. Optical component measurement system (200) according to any one of the preceding claims, wherein the image processing function (BV) is designed to:

- record a first image (BA) by means of the image sensor (230), which image is supplied to the image processing function (BV);
- determine on the basis of the first image (BA) produced whether the focal plane (SE) of the reflected light (L) is projected substantially completely onto the image sensor surface (231) of the image sensor (230); and

if the focal plane (SE) of the reflected light (L) is not projected substantially completely onto the image sensor surface (231) of the image sensor (230), then

- to determine a first image region (B1) of a first plurality of image regions (B1, B2) of the first image (BA) in which a first sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230);
- determine a second image region (B2) of the first plurality of image regions (B1, B2) of the first image (BA) in which a second sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230);

- supply a control command to the control device (ECU) to control the first and/or the second actuator (120, 240) in order to adjust the relative distance between the first optically active element (130) and the image sensor (230) and to project the second sub-region of the focal plane (SE) of the reflected light (L) onto the image sensor surface (231) of the image sensor (230);
- record a second image (BB) by means of the image sensor (230), which image is supplied to the image processing function (BV);
- determine a third image region (B3) of a second plurality of image regions (B3, B4) of the second image (BB) in which the first sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and
- determine a fourth image region (B4) of the second plurality of image regions (B3, B4) of the second image (BB) in which the second sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230).

5. Optical component measurement system (200) according to any one of claims 1 to 3, with the second actuator (240) indicated in claim 3, wherein the image processing function (BV) is designed to:

- supply a control command to the control device (ECU) to control the first and/or the second actuator (120, 240) in order to adjust the relative distance between the first optically active element (130) and the image sensor (230) by a predetermined path length.

6. Optical component measurement system (200) according to any one of claims 1 to 3, with the second actuator (240) indicated in claim 3, wherein the image processing function (BV) is designed to:

- record a first image (BA) by means of the image sensor (230), which image is supplied to the image processing function (BV);
- supply a control command to the control device (ECU) to control the first and/or the second actuator (120, 240) in order to adjust the relative distance

between the first optically active element (130) and the image sensor (230) during the recording of the first image (BA) at a predetermined velocity;

- record a second image (BB) by means of the image sensor (230), which image is supplied to the image processing function (BV), after the first image (BA) was recorded or after a predetermined time period after the first image (BA) was recorded and while the relative distance between the first optically active element (130) and the image sensor (230) is adjusted.

7. Optical component measurement system (200) according to claim 1 or 4,

wherein the first and second image region (B1, B2) of the first image (BA) each image a portion of the component (B) that substantially corresponds to the portion of the component (B) in the third and fourth image region (B3, B4) of the second image (BB); and/or

wherein in the first image (BA) the first sub-region of the focal plane (SE) and in the second image (BB) the second sub-region of the focal plane (SE) are projected within a predetermined depth of field (ST) onto the image sensor surface (231) of the image sensor (230); and

wherein in the first image (BA) the second sub-region of the focal plane (SE) and in the second image (BB) the first sub-region of the focal plane (SE) are projected outside the predetermined depth of field (ST) onto the image sensor surface (231) of the image sensor (230).

8. Optical component measurement system (200) according to one of claims 1 or 4 and/or 7, wherein the image processing function (BV) is further designed to:

- cut the first image region (B1) out of the first image (BA) and the fourth image region (B4) out of the second image (BB); and
- join the cut-out first and fourth image regions (B1, B4) together to produce a third image (BC); and/or
- determine on the basis of the first image region (B1) of the first image (BA) and/or the fourth image region (B4) of the second image (BB) and/or the third image (BC) whether the component (B) has at least one imperfection; and

if the image processing function (BV) determines at least one imperfection, then
- to supply imperfection information about the component (B).

9. Optical component measurement system (200) according to any one of the
preceding claims, with the second actuator (240) indicated in claim 3, further com-
prising:

a position detection sensor (250), which is designed to determine a position and/or
location of the first optically active element (130) and/or of the image sensor surface
(231) of the image sensor (230) and to supply information about the position and/or
location of the optically active element (130) and/or of the image sensor surface
(231) of the image sensor (230) to the control device (ECU), which controls the first
and/or the second actuator (120, 240) on the basis of the information supplied,
wherein the position detection sensor, as an option, is an optical or (electro-) me-
chanical position detection sensor.

10. Optical measurement system (200) according to any one of the preceding
claims,
wherein the camera device (220) comprises a second optically active element (160)
between the first optically active element (130) and the image sensor (230) in the
beam path, wherein an optical axis of the second optically active element (160) is
oriented coaxially to the optical axis of the first optically active element (130); and/or
wherein the first optically active element (130) is an achromat; and/or
wherein the second optically active element (160) is a converging lens.

11. Optical component measurement system (200) for measuring at least one
surface of at least one component (B), having a seat (150), which is designed to
position the component (B) in front of a camera device (220) in order to measure a
first surface (O) of the component (B) with the camera device (220),
wherein the camera device (220) comprises an image sensor (230), which is de-
signed to receive light (L) reflected at the first surface (O) of the component (B);

wherein the optical component measurement system (200) comprises a first optically active element (130), which is arranged in the beam path of the reflected light (L) to the image sensor (230), a control unit (ECU), an image processing function (BV), and an adjusting device (100) for the first optically active element (130), the adjusting
5 device (100) comprising:

a mount (140) for the first optically active element (130), wherein the mount (140) is attached to an inner side of a hollow cylindrical tube (110) by means of a linear guide and a longitudinal centre line of the tube (110) is oriented coaxially to an optical axis (OA) of the first optically active element (130), and wherein the linear guide
10 is designed to guide the mount (140) parallel to the optical axis (OA);

a first actuator (120) for adjusting a relative distance between the image sensor (230) and the first optically active element (130) in order to move the first optically active element (130) relative to the image sensor (230), wherein the control device (ECU) is designed to control the first actuator (120),

15 wherein the image processing function (BV) is designed to:

- record a first image (BA) by means of the image sensor (230), which image is supplied to the image processing function (BV);
- supply a control command to the control device (ECU) to control the first actuator (120) in order to adjust the relative distance between
20 the first optically active element (130) and the image sensor (230) by a predetermined path length;
- record a second image (BB) by means of the image sensor (230), which image is supplied to the image processing function (BV),

wherein the image processing function (BV), following the recording of the first image (BA) or following the recording of the second image (BB), is designed to:

- determine a first image region (B1) of a first plurality of image regions (B1, B2) of the first image (BA) in which a first sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230); and
25
- determine a second image region (B2) of the first plurality of image regions (B1, B2) of the first image (BA) in which a second sub-region of the focal
30

plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and

- determine a third image region (B3) of a second plurality of image regions (B3, B4) of the second image (BB) in which the first sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and
- determine a fourth image region (B4) of the second plurality of image regions (B3, B4) of the second image (BB) in which the second sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230).

12. Method for measuring at least one surface of at least one component (B), with the following steps:

- orientation of the component (B) to a camera device (220);
- measurement by means of the camera device (220) of the first surface (O) of the component (B);
- receiving, by means of an image sensor (230) of the camera device (220), of light (L) which was reflected at the first surface (O) of the component (B);
- holding of a first optically active element (130) in the beam path of the reflected light (L) by means of a mount (140) that is elastically flexible in a longitudinal direction, wherein the longitudinal direction is oriented parallel to an optical axis (OA) of the optically active element (130);
- recording of a first image (BA);
- adjustment of a relative distance between the image sensor (230) and the first optically active element (130), wherein the first optically active element (130) is moved relative to the image sensor (230) along the optical axis,
- recording of a second image (BB),
- determination of a first image region (B1) of a first plurality of image regions (B1, B2) of the first image (BA) in which a first sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230); and

- determination of a second image region (B2) of the first plurality of image regions (B1, B2) of the first image (BA) in which a second sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and
 - 5 - determination of a third image region (B3) of a second plurality of image regions (B3, B4) of the second image (BB) in which the first sub-region of the focal plane (SE) of the reflected light (L) is not projected onto the image sensor surface (231) of the image sensor (230); and
 - determination of a fourth image region (B4) of the second plurality of image regions (B3, B4) of the second image (BB) in which the second sub-region of the focal plane (SE) of the reflected light (L) is projected onto the image sensor surface (231) of the image sensor (230).
- 10
13. Method according to claim 12, with the following step:
- 15 - adjustment of the relative distance between the image sensor (230) and the first optically active element (130) in order to project a focal plane (SE) of the reflected light (L) onto an image sensor surface (231) of the image sensor (230) facing the reflected light (L).
- 20
14. Method according to one of claims 12 or 13, with the following step:
- determination on the basis of the first image (BA) whether the focal plane (SE) of the reflected light (L) is projected substantially completely onto the image sensor surface (231) of the image sensor (230).
- 25
15. Method according to one of claims 12 or 13, with the following steps:
- adjustment of the relative distance between the image sensor (230) and the first optically active element (130) during the recording of the first image (BA) at a predetermined velocity;
 - recording of the second image (BB) after the first image (BA) was recorded or
 - 30 after a predetermined time period after the first image (BA) was recorded and

during the adjustment of the relative distance between the image sensor (230) and the first optically active element (130).

16. Method according to one of claims 12 or 14,

5 wherein the first and second image region (B1, B2) of the first image (BA) each image a portion of the component (B) that substantially corresponds to the portion of the component (B) in the third and fourth image region (B3, B4) of the second image (BB); and/or

10 wherein in the first image (BA) the first sub-region of the focal plane (SE) and in the second image (BB) the second sub-region of the focal plane (SE) are projected within a predetermined depth of field (ST) onto the image sensor surface (231) of the image sensor (230);

15 wherein in the first image (BA) the second sub-region of the focal plane (SE) and in the second image (BB) the first sub-region of the focal plane (SE) are projected outside the predetermined depth of field (ST) onto the image sensor surface (231) of the image sensor (230).

17. Method according to one of claims 12 or 14 and/or 16, with the following steps:

- 20 - cutting of the first image region (B1) out of the first image (BA) and the fourth image region (B4) out of the second image (BB); and
- joining together of the cut-out first and fourth image regions (B1, B4) to produce a third image (BC); and/or
- 25 - determination on the basis of the first image region (B1) of the first image (BA) and/or the fourth image region (B4) of the second image (BB) and/or the third image (BC) whether the component (B) has at least one imperfection; and

if the component (B) has at least one imperfection, then

- supplying of imperfection information about the component (B).

18. Method according to any one of claims 12 to 17,
wherein the mount (140) has a component containing soft iron and the mount (140)
is deformed by the generated magnetic field in a first direction relative to the image
sensor (230) along the optical axis (OA).

5

19. Method according to any one of claims 12 to 17,
wherein the mount (140) has a permanently magnetic component and the mount
(140) is deformed by the generated magnetic field in the first or a second direction
relative to the image sensor (230) depending on a flow direction of the electric cur-
rent in the coil (121), wherein the second direction is opposite to the first direction.

10