SYSTEM AND METHOD FOR INSPECTION OF SEMICONDUCTOR PACKAGES

Field of Invention

The present invention relates generally to a system and method for optically inspecting the surfaces of articles for defects. More specifically, the present invention relates to a system and method for inspection of semiconductor packages. The system and method of the present invention enables simultaneous inspection of multiple surfaces of the semiconductor packages.

Background

Quality control of manufactured semiconductor packages or devices is an increasingly important and costly aspect of the manufacturing process of the semiconductor packages. Semiconductor packages such as Quad Flat No Leads (QFN), Ball Grid Arrays (BGA) and Wafer Level Chip Scale Packaging (WLCSP) packages generally require stringent quality controls and analyses before their distribution and export. Defect detection (hereinafter referred to as quality inspection) of surfaces of semiconductor packages enables a manufacturer to eliminate or correct such defects before the distribution and export of the semiconductor packages. With the increasing emphasis on and requirement for greater precision and quality of semiconductor packages, quality inspection of surfaces of semiconductor packages is becoming an increasingly important step in the overall manufacturing process of semiconductor packages.

Semiconductor packages are typically inspected for presence of surface defects such as internal cavities and inaccurate pattern formation. In addition, semiconductor packages are generally inspected for detecting defects to location, pitch, co-planarity and tip alignment of terminals. Furthermore, semiconductor packages can be inspected for missing or mis-located characters in marks or manufacturers' details that are printed on the semiconductor packages' surface. Typically, each of a bottom or top surface, and side surfaces of semiconductor packages needs to be inspected prior to distribution and export.

There are several known systems and methods for the inspection of semiconductor packages. Photographic devices such as charge-coupled device (CCD) cameras are

predominantly used for image capture during the inspection of semiconductor packages. A typical system and method for the inspection of semiconductor packages utilizes a single camera arrangement to inspect the bottom or top surface and the side surfaces simultaneously. However, the use of the single camera arrangement typically results in a reduced inspection resolution or reduced defect detection due to a large combined inspection area of the bottom or top surface, together with the side surfaces. In addition, lens and mirrors that are used together with the single camera arrangement typically need to be displaced or positioned during inspection. The displacement of the lens and mirrors during inspection generally results in calibration and adjustment feedback losses.

An alternative system for inspection of semiconductor packages is described in US patent application publication US 2003/0086083 A1 of Ebert et al. Ebert et al.'s system comprises multiple individual mirrors and lens. A beam splitter of Ebert et al.'s system divides reflected light from the semiconductor package along separate high and low magnification paths for capturing of high and low magnification images of the semiconductor package by a high and low magnification camera respectively. The low magnification image is used for identifying an area of interest, which is then further magnified by the high magnification camera for finer inspection. However, the system of Ebert et al. typically occupies a significant amount of space. In addition, Ebert et al.'s system involves individual placement of the multiple mirrors and lens which can be both resource consuming and accuracy compromising. Furthermore, both the high and low magnification images captured by the system of Ebert et al. are of an identical image (albeit of differing resolutions) of the same area of interest.

US patent US 6,952, 491 B2 and US patent application publication US 2004/0263834 A1, both of Alumot et al., describe a method and apparatus for inspecting surfaces of semiconductor devices. The method and apparatus of Alumot et al. effects the inspection of the surfaces of semiconductor devices in two phases. In a first phase, a surface of the semiconductor device is inspected at a relatively high speed and a relatively low spatial resolution. In a second phase, selected locations of the surface of the semiconductor device are then inspected at a relatively high spatial resolution. Information gathered during the first phase and the second phase is analysed by an external processor or controller. Comparisons are made between images obtained by

the first and second phase and reference images for enabling detection of surface defects on the semiconductor device.

However, the two-phase method of inspection disclosed by Alumot et al. is considerably time and resource consuming. In addition, the detection of surface defects by Alumot et al.'s method and apparatus requires the comparison between the image obtained and the reference image, a process that may be significantly inaccurate and time-consuming. Furthermore, the apparatus and method of Alumot et al. only allows for inspection of one surface of the semiconductor device. The apparatus of Alumot et al. also comprises multiple components and is substantially bulky. Increased space needed for installation of the apparatus of Alumot et al. typically results in increased required manufacturing area and ultimately increased manufacturing costs.

Therefore, it will be appreciated by a person skilled in the art that improvements to systems and methods for inspection of semiconductor packages will be required. An improved system and method for inspection of semiconductor packages should allow for higher and multiple resolutions of image capture for defect detection or quality inspection. In addition, the improved system should preferably be space-efficient.

Summary

In accordance with a first aspect of the present invention, there is disclosed a semiconductor device inspection system comprising a reflector assembly configured for receiving light reflected from a first surface of a semiconductor device and light reflected from at least one second surface of the semiconductor device. The first surface extends substantially along a first plane and the at least one second surface extends substantially along at least one second plane. The at least one second plane is angled away from the first plane, the reflector assembly further configured for directing the received light from the first surface and the at least one second surface substantially along a first direction. The semiconductor device inspection system further comprises a beam splitter for splitting light directed along the first direction into a first light beam for travelling along a first path and a second light beam for travelling along a second path. The first path substantially intersects a first image capture plane and the second path substantially intersects a second image capture

plane, image of at least one of the first surface and the at least one second surface being acquirable from each of the first image capture plane and the second image capture plane for subsequent inspection thereof.

In accordance with a second aspect of the present invention, there is disclosed a method for inspecting a semiconductor device, the method comprising capturing a first image, the first image having a first view. The method further comprises capturing a second image, the second image having a second view. The first view comprises one of and the second view comprising the other of an image of a first surface of the semiconductor device and an image of the first surface with at least one second surface of the semiconductor device. The first surface extends substantially along a first plane and the at least one second surface extends substantially along at least one second plane. The at least one second plane is angled away from the first plane. The method further comprises processing at least one of the first image and the second image for inspecting at least one of the first surface and the at least one second surface of the semiconductor device. The capturing of the first image and the capturing of the second image is performed one of simultaneously and sequentially to thereby enable one of simultaneously and sequential inspection of the at least one of the first surface and the at least one second surface of the semiconductor device.

In accordance with a third aspect of the present invention, there is disclosed a method for inspecting a semiconductor device, the method comprising capturing a first image, the first image characterized by at least one of a first view and a first set of properties and capturing a second image, the second image characterized by at least one of a second view and a second set of properties. The first view comprises one of and the second view comprising the other of an image of a first surface of the semiconductor device and an image of the first surface with at least one second surface of the semiconductor device. The first surface extends substantially along a first plane and the at least one second surface extends substantially along at least one second plane, the at least one second plane being angled away from the first plane. Each of the first set of properties and the second set of properties comprises at least one of at least one illumination colors, at least one illumination brightness and at least and at least one angles of illumination. The method further comprises processing at least one of the

first image and the second image for inspecting at least one of the first surface and the at least one second surface of the semiconductor device. The capturing of the first image and the capturing of the second image is performed one of simultaneously and sequentially to thereby enable one of simultaneous and sequential inspection of the at least one of the first surface and the at least one second surface of the semiconductor device.

Brief Description of the Drawings

FIG. 1 shows a partial system configuration of a system for inspection of semiconductor packages according to a first exemplary embodiment of the present invention;

FIG. 2 shows a partial cross-sectional front view of an angular illumination assembly and side prism structure of the system of FIG. 1;

FIG. 3 shows a partial enlarged cross-sectional front view of the side prism structure of FIG. 2 and light redirection thereby;

FIG. 4 shows a flowchart of light travel along an exemplary first optical path between the semiconductor package and a first camera of the system of FIG. 1;

FIG. 5 shows the travel of light along the exemplary first optical path of FIG. 4;

FIG. 6 shows a flowchart of light travel along an exemplary second optical path between the semiconductor package and a second camera of the system of FIG. 1;

FIG. 7 shows the travel of light along the exemplary second optical path of FIG. 6;

FIG. 8 shows a combination of the travel of light along the exemplary first optical path of FIG. 4 and the exemplary first optical path of FIG. 6;

FIG. 9 shows an image captured by the first camera and an image captured by the second camera of the system of FIG. 1;

FIG. 10 shows the travel of light through a prism assembly of the system for inspection of semiconductor packages of FIG. 1; and

FIG. 11 shows a flowchart of a method for inspection of semiconductor packages according to a second exemplary embodiment of the present invention.

Detailed Description

Quality control of manufactured semiconductor packages or devices is an increasingly important and costly aspect of the manufacturing process of semiconductor packages. There are several systems and methods for quality inspection or defect detection of semiconductor packages' surfaces. Existing systems and methods have several disadvantages or problems as previously described. One disadvantage is a limited resolution of images captured with systems comprising a single camera. Movement of components of the existing systems, for example lens and mirrors, typically result in calibration losses and adjustment feedback losses. In addition, existing systems for quality inspection of semiconductor packages that comprise multiple cameras typically occupy significant space, and therefore increase manufacturing costs. Therefore, it will be appreciated by a person skilled in the art that improvements to systems and methods for quality inspection of semiconductor packages are required.

For purposes of brevity and clarity, the description of the present invention is limited hereinafter to a system and method for inspection of semiconductor packages that enable multiple magnification and multiple surface inspection. This however does not preclude various embodiments of the invention from other applications where fundamental principles prevalent among the various embodiments of the invention such as operational, functional or performance characteristics are required.

Exemplary embodiments of a system and method for inspection of semiconductor packages are described hereinafter with reference to FIG. 1 to FIG. 10, in which like elements have like reference numerals.

A system 10 for inspection of semiconductor packages (also known as semiconductor substrates) 12 is provided according to a first exemplary embodiment of the present

invention. The semiconductor packages 12 includes, but is not limited to, Quad Flat No Leads (QFN), Ball Grid Arrays (BGA) and Wafer Level Chip Scale Packaging (WLCSP) packages. Preferably, the system 10 comprises a lighting assembly 14 or lighting arrangement, a prism assembly 16 and a number of cameras.

Each semiconductor package 12 preferably comprises a top surface, a bottom surface and four side surfaces. The top surface and the bottom surface of the semiconductor package 12 can also be referred to a top side and a bottom side respectively of the semiconductor package 12. Preferably, each of the four side surfaces of the semiconductor package 12 is angled with respect to the top surface and the bottom surface of the semiconductor package 12. It should be appreciated by a person skilled in the art that the semiconductor package 12 can have more than four side surfaces. For example, the semiconductor package 12 can be of an octagonal or decagonal shape with corresponding eight or ten side surfaces.

Preferably, the inspection of the semiconductor package 12 involves image capture of the top surface, the bottom surface and each of the four side surfaces of the semiconductor package 12. Alternatively, the inspection of the semiconductor package 12 involves image capture of any number of the surfaces of the semiconductor package 12.

The system 10 for inspection of semiconductor packages 12 preferably enables image capture of the bottom surface as well as each of the four side surfaces of the semiconductor packages 12. The image capture of the bottom surface as well as each of the four side surfaces of the semiconductor package 12 facilitates detection of defects located at any of the surfaces.

Surface defects of semiconductor packages 12 includes, but are not limited to, voids, cracks, stains, contamination, wrong pattern and inaccurate interconnect positioning. The detection of surface defects enables correction of detected surface defects. Alternatively, the detection of surface defects of semiconductor packages 12 facilitates disposal of flawed semiconductor packages 12. Therefore, inspection of semiconductor packages 12 preferably results in an enhanced overall quality of the semiconductor packages 12 manufactured.

The semiconductor package 12 is preferably positioned at a ready position 18 during inspection or image capture. The lighting assembly 14 is operable for supplying or directing light to the semiconductor package 12 positioned at the ready position 18. Preferably, the lighting assembly 14 comprises an angular illumination assembly 20 and an on-axis illumination assembly 22. The angular illumination assembly 20 and the on-axis illumination assembly 22 preferably comprise multiple layer light-emitting diode (LED) devices. Alternatively, the angular illumination assembly 20 and the on-axis illumination assembly 22 comprise xenon flash illuminators. Further alternatively, the angular illumination assembly 20 and the on-axis illumination assembly 22 comprise different types of lighting devices or apparatuses known to a person skilled in the art. Alternatively, the angular illumination assembly 20 and the on-axis illumination assembly 22 each comprise different lighting or illumination devices.

Preferably, the angular illumination assembly 20 and the on-axis illumination assembly 22 are both spatially arranged in a predetermined configuration. Further preferably, the spatial arrangement or configuration of the angular illumination assembly 20 and the on-axis illumination assembly 22 is substantially fixed. As will be appreciated by a person skilled in the art, the fixed spatial arrangement of the lighting assembly 14 enhances ease and operational efficiency of lighting the semiconductor packages 12 during inspection.

The angular illumination assembly 20 supplies or directs light to the bottom surface and each of the four side surfaces of the semiconductor package 12 positioned at the ready position 18. Preferably, the multiple layer LED devices of the angular illumination assembly 20 are each arranged at predetermined angles to the bottom surface of the semiconductor package 12 positioned at the ready position 18. Further preferably, the predetermined angles can be adjusted or varied accordingly to allow light to be directed at the semiconductor package at required or desired angles. In addition, the multiple layer LED devices are preferably spatially arranged to substantially avoid interference with light reflected off the bottom surface and each of the four side surfaces of the semiconductor package 12 positioned at the ready position 18.

Preferably the on-axis illumination assembly 22 supplies or directs light primarily to the bottom surface of the semiconductor package 12 positioned at the ready position 18.

The system 10 for inspection of semiconductor packages 12 further comprises the prism assembly 16, also known as a reflector assembly. The prism assembly 16 comprises a number of surfaces or reflective surfaces. Preferably, the number of surfaces are specifically arranged or inter-configured in relation to each other. Further preferably, the number of surfaces is interpositioned for defining a passageway therebetween. Each of the number of surfaces has carefully predetermined properties or characteristics. For example, at least one of the number of surfaces comprises a coating having a carefully predetermined reflection, transmission and absorption ratio. In addition, at least one of the number of surfaces is preferably constructed by an Optical Cementing process.

Preferably, at least a portion of light supplied or directed to the surfaces of the semiconductor package 12 positioned at the ready position 18 is reflected by the surfaces of the semiconductor package 12. At least a portion of the reflected light from the semiconductor package 12 preferably enters the prism assembly 16 before exiting therefrom and entering at least one of the number of cameras. The number of cameras is preferably two, namely a first camera 24 and a second camera 26 (also referred to as a first image capture device and a second image capture device). Preferably, both the first camera 24 and the second camera 26 are high-resolution cameras. Each of the first camera 24 and the second camera 26 can be of an equally high resolution. Alternatively, each of the first camera 24 and the second camera 26 are of different resolutions.

Preferably, light entering the first camera 24 and the second camera 26 enables image capture by the first camera 24 and the second camera 26 respectively. The high-resolution of the first camera 24 and the second camera 26 enables high-resolution images to be captured. Therefore, the high-resolution of the first camera 24 and the second camera 26 preferably enhances accuracy and ease of surface defect detection by the system 10.

Preferably, the operation of the first camera 24, the second camera 26 and the lighting assembly 14 are controlled by one or a combination of a computer-based system and a programmable controller (not shown). The programmable controller is preferably connected or in signal communication to at least one of the angular illumination assembly 20 and the on-axis illumination assembly 22. The programmable controller preferably controls or determines properties or characteristics of light supplied by at least one of the angular illumination assembly 20 and the on-axis illumination assembly 22 to the semiconductor package 12 positioned at the ready position 18. The properties of light controlled by the programmable controller include, but are not limited to, brightness or intensity, color and illumination angle. For example, the programmable controller is able to control the angle of each of the multiple layer LED devices with respect to a reference plane defined at or along the bottom surface of the semiconductor device 12 positioned at the ready position 18, hence the angle of light directed by each of the multiple layer LED devices to the semiconductor package 12 positioned at the ready position 18.

Preferably, light reflected off the bottom surface of the semiconductor device 12 is substantially perpendicular the reference plane. Further preferably, each of the four side surfaces of the semiconductor device 12 is perpendicular the reference plane. Light reflected off each of the four side surfaces of the semiconductor device is preferably substantially parallel the reference plane.

The angular illumination assembly 20 and the on-axis illumination assembly 22 can be controlled for simultaneously illuminating the semiconductor package 12 with both angular and on-axis light. Alternatively, the angular illumination assembly 20 and the on-axis illumination assembly 22 can be controlled for effecting alternating time-interval based angular illumination and on-axis illumination of the semiconductor package 12. The programmable controller is able to individually control each of the different properties of light supplied by the lighting assembly 14. In addition, the controller is preferably capable of controlling or determining a set of properties of light supplied by the lighting assembly 14.

Light is composed of elementary particles known as photons. Light exhibits properties of both waves and particles, a phenomenon commonly referred to as wave-particle duality. Generally, light is also known as a bundle of light beams or light waves. Each light beam or light wave has a wavelength. The wavelength of the light beam determines frequency of the light beam. The frequency of the light beam is a factor in determining transmissibility, absorption and reflectivity of the light beam when the light beam strikes or hits a surface.

As previously mentioned, the inspection or image capture of the surfaces of the semiconductor package 12 occurs when the semiconductor package 12 is positioned at the ready position 18. Images are captured when light (interchangeably referred to as light beams) reflected off the surfaces of the semiconductor package 12 enters either the first camera 24 or the second camera 26.

Preferably, light reflected off the surfaces of the semiconductor packages 12 travels first through the prism assembly 16 before entering either the first camera 24 or the second camera 26. Preferably, light that eventually enters the first camera 24 follows a first optical path through the prism assembly 16. Further preferably, light that eventually enters the second camera 26 follows a second optical path through the prism assembly 16.

An exemplary process flow of a first optical path 100 is shown as in FIG. 5 and FIG. 6. In a step 110 of the first optical path 100, reflected light from the bottom surface and each of the four side surfaces of the semiconductor package 12 positioned at the ready position 18 enters the prism assembly 16 through a first entry surface 50. The first entry surface 50 is preferably coated with an anti-reflection coating for preventing or substantially reducing reflection of light striking the first entry surface 50.

In a step 120, light entering the prism assembly 16 is reflected off a second reflective surface 52. The second reflective surface 52 is preferably coated with a special coating. Preferably, the special coating has a reflectivity, transmissibility and absorption ratio of 50%, 50% and 0% respectively. Further preferably the reflection, transmission and absorption ratio is variable with a tolerance of up to +/- 5%.

Alternatively, the reflection, transmission and absorption ratio is adjustable or variable as required.

The law of reflection states that an incident light beam striking an interface at an angle (i.e. angle of incidence), *i*, measured between a line perpendicular the interface (i.e. normal) and the incident light beam, will be reflected off the interface at a same angle, *i*. In other words, angle of reflection of light beams or light is equal to the angle of incidence.

Quantity of light beams being reflected off the second reflective surface 52 depends on the reflectivity, transmissibility and absorption ratio of the special coating. Preferably, light is reflected off the second reflective surface 52 at an angle of reflection equal that of the angle of incidence.

In a step 130, the reflected light from the second reflective surface is directed through a third reflective surface 54 within the prism assembly 16. Preferably, light hits or strikes the third reflective surface 54 perpendicularly to impede reflection off the third reflective surface 54. The third reflective surface 54 is preferably made by the Optical Cementing process. Preferably, surfaces made by the Optical Cementing process have equal or substantially equivalent refractive indexes on both sides.

Light traveling through the third reflective surface 54 is then reflected off a fourth reflective surface 56 within the prism assembly 16 in a step 140. Preferably, light is directed at the fourth reflective surface 56 at an angle (i.e. angle of incidence) to a normal of the fourth reflective surface 56. The fourth reflective surface 56 is preferably coated with the special coating similar to that of the second reflective surface 52. Further preferably, the reflectivity, transmissibility and absorption ratio of the special coating of the fourth reflective surface 56 is substantially equivalent to that of the second reflective surface 52. Alternatively, the reflection, transmission and absorption ratio of the special coating of the fourth reflective surface 56 is different from that of the second reflective surface 52. Both the second reflective surface 52 and the fourth reflective surface 56 can function as a beam splitter. This means that light directed to either the second reflective surface 52 or the fourth reflective surface

56 can be reflected as a number of light beams, each of the number of light beams directed along a different path or direction.

Preferably, light is reflected off the fourth reflective surface 56 at an angle of reflection equal that of the angle of incidence. Quantity of light beams or light being reflected off the fourth reflective surface 56 depends on the reflectivity, transmissibility and absorption ratio of the special coating.

Preferably, light reflected off the fourth reflective surface 56 is preferably directed to a fifth reflective surface 58. The fifth reflective surface 58 preferably has a mirror finish with a reflectance of greater than 92%. Alternatively, the mirror finish has a reflectance of a different value. Increasing the reflectance of the fifth reflective surface 58 enables a higher percentage of light beams striking therewith to be reflected therefrom.

In a step 150 of the first optical path 100, the light directed to the fifth reflective surface 58 is reflected thereby. Light is preferably reflected off the fifth reflective surface 58 at an angle of reflection equal that of the angle of incidence.

In a step 160, the light reflected off the fifth reflective surface 58 exits the prism assembly 16 through a first exit surface 60. Preferably, the first exit surface 60 shares the same or substantially similar properties as that of the first surface 50. This is to say, the first exit surface 60 preferably comprises the anti-reflection coating to impede or substantially reduce reflection of light. Alternatively, the first exit surface 60 has different properties as compared to the first surface 50.

Light exiting the prism assembly 16 through the first exit surface 60 passes through a first camera lens 62 before entering the first camera 24 in a final step 170. The first camera 24 preferably defines a first image capture plane. Preferably the first camera lens 62 is spatially positioned between the first exit surface 60 and the first camera 24. Further preferably, the spatial positions of the first camera 24 and the first camera lens 62 are substantially fixed. The first camera lens 62 preferably has a long lens to object distance. The first camera lens 62 has a predetermined focal length for achieving a predetermined magnification or magnification factor. Preferably, the focal length, and

hence the magnification, of the first camera lens 62 can be varied as required using techniques well known to a person skilled in the art.

Preferably, the focal length or magnification effected by the first camera lens 62 enables light reflected from the bottom surface as well as light reflected from each of the four side surfaces of the semiconductor package 12 positioned at the ready position 18 to enter the camera. Therefore, the first camera 24 is preferably capable of capturing images of multiple surfaces, namely the bottom surface and each of the four side surfaces, of the semiconductor package 12 positioned at the ready position 18.

An exemplary second optical path 200 is shown in FIG. 7 and FIG. 8. Preferably, step 210, step 220 and step 230 of the second optical path 200 are similar to step 110, step 120 and step 130 respectively of the first optical path 100. Therefore, in the step 210, reflected light from the bottom surface of the semiconductor surface positioned at the ready position 18 enters the prism assembly 16 through the first surface 50. Light is then reflected off the second reflective surface 52 in the step 220 at an angle of reflection equal the angle of incidence. Reflected light off the second reflective surface 52 then travels through the third reflective surface 54 in the step 230.

In a step 240 of the second optical path 200, light traveling through the third reflective surface 54 is transmitted through the fourth reflective surface 56 within the prism assembly 16. The percentage of light transmitted through the fourth reflective surface 56 is preferably dependent on the reflectivity, transmissibility and absorption ratio of the special coating of the fourth reflective surface 56. Preferably, the reflectivity, transmissibility and absorption ratio of the special coating is 50%, 50% and 0% respectively. Therefore, 50% of light beams striking the fourth reflective surface 56 are preferably transmitted through the fourth reflective surface 56.

Light transmitted through the fourth reflective surface 56 exits the prism assembly 16 through a second exit surface 64 in a step 250. Preferably, the second exit surface 64 shares the same or substantially similar properties as that of the first exit surface 60. This is to say, the second exit surface 64 is preferably coated with an anti-reflection coating to impede or substantially reduce the reflection of light thereby. Alternatively,

the second exit surface 64 has different properties as compared to the first exit surface 60.

In a step 260 of the second optical path 200, light exiting the prism assembly 16 passes through a second camera lens 66 before entering the second camera 26. The second camera 26 preferably defines a second image capture plane. Preferably, the second camera lens 66 is spatially positioned between the second exit surface 64 and the second camera 26. Further preferably, the spatial positions of the second camera 26 and the second camera lens 66 are substantially fixed. The second camera lens 66 preferably has a long lens to object distance. In addition, the second camera lens 66 has a predetermined focal length for achieving a predetermined magnification. As with the first camera lens 62, the focal length, and hence the magnification, of the second camera lens 66 can also be varied as required using techniques well known to a person skilled in the art.

Preferably, the magnification of the second camera lens 66 is different from that of the first camera lens 62. Preferably, the focal length and magnification effected by the second camera lens 66 only enables entry of light reflected from the bottom surface of the semiconductor package 12 positioned at the ready position 18 to enter the second camera 26. Therefore, the second camera 26 is preferably capable of capturing images of a single, more specifically bottom, surface of the semiconductor package 12 positioned at the ready position 18. Preferably, the magnification of the second camera lens 66 is higher than that of the first camera lens 62 enabling a higher image magnification of the bottom surface of the semiconductor package 12 with the second camera 26.

The different focal length, and hence magnification, of the first camera lens 62 from the second camera lens 66 thereby enables the system 10 to capture images of multiple magnifications or multiple views. It will be appreciated by a person skilled in the art that increasing the number of camera lens of the system 10, each with a different focal length, together with a corresponding increase in number of surfaces of the prism assembly 16, can enable the system 10 to capture images with an increasing number of magnifications or number of views.

The first camera 24 and the second camera 26 of the system 10 are preferably positioned substantially adjacent each other, in line with the first exit surface 60 and the second exit surface 64 respectively. Physical space required by the positioning or placement of the first camera 24 and the second camera 26 preferably determines distance or space required between the fourth reflective surface 56 and the fifth reflective surface 58 of the prism assembly 16.

Preferably the use of the prism assembly 16 reduces space required for installation of the system 10 as compared with existing systems for inspection of semiconductor packages 12. Further preferably, each of the first surface 50, the second reflective surface 52, the third reflective surface 54, the fourth reflective surface 56 and the fifth reflective surface 58 of the prism assembly 16 are spatially fixed or immobile. The immobility of each of the above-mentioned surfaces of the prism assembly 16 eliminates or substantially reduces calibration or adjustment feedback losses present with existing systems that utilize movable mirrors and lens.

A method for inspection of semiconductor packages 12 as shown in FIG. 10 is provided in a second exemplary embodiment of the present invention. Preferably, the method 300 utilizes the system 10.

In a step 310, the semiconductor package 12 is positioned at the ready position 18. The ready position 18 is preferably located within a side view prism structure 68 of the system 10. Preferably, the side view prism structure comprises a number of surfaces or mirrors, more specifically four surfaces. Preferably, the ready position 18 is located substantially within a space defined by the four surfaces of the side view prism structure 68. Preferably, each of the four surfaces of the side view prism structure 68 is for receiving light reflected by each of the four sides of the semiconductor package 12.

The lighting assembly then supplies a first flash of light or illumination directed at the semiconductor package 12 in a step 320. Preferably, the first flash of light illuminates the bottom surface together as well as each of the four side surfaces of the semiconductor package 12 positioned at the ready position 18.

Preferably, the first flash of light has a predetermined set of properties. The predetermined set of properties is preferably determined or controlled by the controller. As previously described, the set of properties preferably comprises a specific brightness or intensity, color and illumination angle. For example, the set of properties comprises a 50% brightness, red color and 50-degree illumination angle. Preferably, each property within the set of properties can be individually altered as required.

The set of properties is preferably specifically selected for highlighting a specific type of surface defect of semiconductor packages 12. This is because the detection of certain semiconductor packages' 12 surface defects is most accurately or easily done using light having a certain set of properties, as will be appreciated by a person skilled in the art.

The first flash of light directed at the semiconductor package 12 positioned at the ready position 18 is reflectable off the bottom surface and each of the four side surfaces of the semiconductor package 12. Preferably, light reflected off the bottom surface of the semiconductor package 12 is perpendicular to light reflected off each of the four side surfaces of the semiconductor package 12.

In a step 330, a first image of the semiconductor package 12 is captured by the first camera 24. Preferably, the first camera 24 is exposed for a predefined length of time to enable the entry of light. Entry of light into the first camera 24 thereby enables image capture by the first camera 24. Preferably, light entering the first camera 24 follows the first optical path 100.

Preferably, images captured by the first camera 24 are of multiple surfaces of the semiconductor package 12 at the ready position 18. This is to say, images captured by the first camera 24 preferably comprise an image of the bottom surface together with an image of each of the four side surfaces of the semiconductor package 12 positioned at the ready position 18. In addition, the first image captured is preferably characterized by the predetermined set of properties of the first flash of light.

In a step 340, the lighting assembly supplies a second flash of light directed at the semiconductor package 12 positioned at the ready position 18. Preferably, the second flash of light has the same predetermined set of properties as the first flash of light. Alternatively, the second flash of light has a different set of properties as compared to the first flash of light.

A second image is then captured by the second camera 26 in a step 350. Preferably, the second camera 26 is exposed for a predefined length of time to enable the entry of light. Likewise with the first camera 24, the entry of light into the second camera 26 thereby enables image capture by the second camera 26. Preferably, light entering the second camera 26 follows the second optical path 200.

Preferably, images captured by the second camera 26 are of a single surface of the semiconductor package 12 positioned at the ready position 18. This is to say, images captured by the second camera 26 only comprise an image of the bottom surface of the semiconductor package 12 positioned at the ready position 18.

The second image, as with the first image, is preferably characterized by the predetermined set of properties of the second flash of light. Therefore, both the second image and the first image preferably shares a common predetermined set of characteristics, and is hereinafter referred to as a first set of images.

Preferably, images within each set of images are characterized by the same set of properties. For example, each image within each set of images preferably shares a same brightness, color and illumination angle. Alternatively, each image within each of set of images shares a common different set of properties.

As described above, the first set of images is captured or obtained by performing the steps 320 to 350. Preferably, the steps 320 to 350 can be repeated as often as necessary to enable multiple sets of images to be captured. Preferably, the set of properties of light supplied by the lighting assembly is variable or reselectable with each repeat of the steps 320 to 350. As previously described, the varying of the properties of light supplied to the semiconductor package 12 is for enhancing the detection of different surface defects.

Preferably, the first image and the second image, or the first set of images, captured by the first camera 24 and the second camera 26 are downloaded or transmitted to the programmable controller or controller for analysis thereby in a step 360. The programmable controller is preferably in signal communication with the first camera 24 and the second camera 26. Preferably, the images are downloaded to the programmable controller as image signals. The programmable controller is preferably programmed for analyzing the images downloaded thereto. The images downloaded to the programmable controller are preferably processed using method and algorithms known to a person skilled in the art, for example, image differencing, negativing, thresholding or edge detection for identifying or detecting surface defects of the semiconductor package 12. Further preferably, the programmable controller is capable of enabling automated surface defect detection of semiconductor packages 12 being inspection by the system 10.

The method 300 for inspection of semiconductor packages 12 preferably enables a sequential image capture by the first camera 24 and second camera 26. Further preferably, the first camera 24 and the second camera 26 capture the sequential images in an alternating sequence. The programmable controller preferably controls the synchronization of the alternating exposure of the first camera 24 and the second camera 26 for alternating image capture thereby. Image capture by the alternating first camera 24 and second camera 26 helps to reduce impact of delay due to data transfer during the capture of images by the first camera 24 and the second camera 26.

Generally, time is required for data transfer during the capture of images. The duration of data transfer generally increases with increasing resolution of cameras. The duration of data transfer substantially influences speed or efficiency of image capture by the first camera 24 and the second camera 26, and consequently, the overall efficiency of the system 10 and method 300 for inspection of semiconductor packages 12.

Therefore, it will be apparent that the alternating image capture by the first camera 24 and the second camera 26 reduces the impact of delay caused by data transfer. This

helps to increase throughput of inspection of semiconductor packages 12 and thereby manufacturing capacity.

Although the exemplary embodiments of the present invention utilizes time-synchronized alternating image capture, it will be appreciated by a person skilled in the art that simultaneous image capture by both the first camera 24 and the second camera 26 is also possible with the system 10 provided by the present invention.

In the foregoing manner, a system and method for inspection of semiconductor packages are described according to exemplary embodiments of the present invention. Although only exemplary embodiments of the present invention are disclosed, it will be apparent to a person skilled in the art in view of this disclosure that numerous changes and/or modifications can be made without departing from the scope and spirit of the present invention.

Claims

1. A semiconductor device inspection system comprising:

a reflector assembly configured for receiving light reflected from a first surface of a semiconductor device and light reflected from at least one second surface of the semiconductor device, the first surface extending substantially along a first plane and the at least one second surface extending substantially along at least one second plane, the at least one second plane being angled away from the first plane, the reflector assembly further configured for directing the received light from the first surface and the at least one second surface substantially along a first direction; and

a beam splitter for splitting light directed along the first direction into a first light beam for travelling along a first path and a second light beam for travelling along a second path,

wherein the first path substantially intersects a first image capture plane and the second path substantially intersects a second image capture plane, image of at least one of the first surface and the at least one second surface is acquirable from each of the first image capture plane and the second image capture plane for subsequent inspection thereof.

2. The system as in claim 1, further comprising:

a first image capture device defining the first image capture plane; and

a second image capture device defining the second image capture plane, each of the first image capture device and the second image capture device for generating image signals from the acquired image of at least one of the first surface and the at least one second surface.

3. The system as in claim 2, further comprising:

at least one first lens disposed along the first path and being shaped and dimensioned for modifying optical magnification of the image of at least one of the first surface and the at least one second surface acquirable by the first image capture device; and

at least one second lens disposed along the second path and being shaped and dimensioned for modifying optical magnification of the image of

at least one of the first surface and the at least one second surface acquirable by the second image capture device.

4. The system as in claim 2, each of the first image capture device and the second image capture device being in signal communication with one of a computer-based device and a controller for processing the image of at least one of the first surface and the at least one second surface acquired by each of the first image capture device and the second image capture device and communicated to the one of a computer-based device and a controller as the image signals to thereby inspect the semiconductor device.

5. The system as in claim 1, further comprising

a reflective surface disposed for receiving the second light beam directed along the second path by the beam splitter, the second light beam travelling along a second direction from the beam splitter towards the reflective surface and subsequently along a third direction when redirected by the reflective surface towards the second image capture plane, each of the second direction and the third direction being substantially coincident the second path.

6. The system as in claim 5, the first light beam travelling in the first direction when travelling along the first path and the third direction being substantially parallel the first direction.

7. The system as in claim 1, the reflector assembly comprising:

at least one first reflective surface positioned for receiving and directing light reflected from the at least one second surface of the semiconductor device substantially along a first axis,

wherein at least a portion of light reflected from the first surface travels substantially along the first axis.

8. The system as in claim 7, the at least one first reflective surface being defined by one of at least one mirror and at least one prism.

9. The system as in claim 1, the reflector assembly comprising:

a plurality of first reflective surfaces positioned for receiving and directing light reflected from a plurality of side surfaces of the semiconductor device substantially along a first axis, each of the plurality of side surfaces extending along one of a plurality of side planes and constituting the at least one second surface, each of the plurality of side planes constituting the at least one second planes.

10. The system as in claim 9, each of the plurality of first side planes being substantially perpendicular the first plane.

11. The system as in claim 9, the plurality of first reflective surfaces being inter-positioned for defining a passageway therebetween, the first axis intersecting the semiconductor device and being substantially perpendicular the first surface of the semiconductor device, and the semiconductor device being disposed for the passage of light reflected from the first surface thereof through the passageway and substantially along the first axis.

12. The system as in claim 11, further comprising:

a second reflective surface positioned for intersecting the first axis, the second reflective surface for receiving and redirecting light travelling along the first axis towards the beam splitter.

13. The system as in claim 12, further comprising:

an illuminator for generating light, the illuminator being disposed for directing light generated thereby along the first axis and towards the semiconductor device, the second reflective surface substantially interposing the illuminator and the semiconductor device, the second reflective surface being light permeable for enabling passage of a portion of light directed by the illuminator towards the semiconductor device therethrough.

14. The system as in claim 9, further comprising:

a first image capture device defining the first image capture plane for capturing a first image therefrom;

a second image capture device defining the second image capture plane for capturing a second image therefrom,

a first lens disposed along the first path and having an optical magnification factor for enabling capture of image of the plurality of side surfaces and the first surface of the semiconductor device as the first image by the first image capture device; and

a second lens disposed along the second path and having an optical magnification factor for enabling capture of image of the first surface of the semiconductor device as the second image by the second image capture device.

15. The system as in claim 14, the optical magnification factor of the second lens being higher than the optical magnification factor of the first lens, and image portion of the first surface of the semiconductor device in second image being a magnification of the image portion of the first surface of the semiconductor device in the first image.

16. The system as in claim 7, further comprising:

a plurality of illumination devices operable for generating and disposed for directing light towards the semiconductor device.

17. The system as in claim 16, the plurality of illumination device further being disposed and operable for directing light at the semiconductor device at at least one of a plurality of angles.

18. The system as in claim 16, the plurality of illumination device further being disposed and operable for directing light at the semiconductor device at at least one of a plurality of colours, at least one of a plurality of brightness and at least one of a plurality of degree of illumination.

19. A method for inspecting a semiconductor device, the method comprising:

capturing a first image, the first image having a first view;

capturing a second image, the second image having a second view, the first view comprising one of and the second view comprising the other of an

image of a first surface of the semiconductor device and an image of the first surface with at least one second surface of the semiconductor device, the first surface extending substantially along a first plane and the at least one second surface extending substantially along at least one second plane, the at least one second plane being angled away from the first plane; and

processing at least one of the first image and the second image for inspecting at least one of the first surface and the at least one second surface of the semiconductor device,

wherein the capturing of the first image and the capturing of the second image is performed one of simultaneously and sequentially to thereby enable one of simultaneously and sequential inspection of the at least one of the first surface and the at least one second surface of the semiconductor device.

20. The method as in claim 19, wherein the first image is capturable from a first image plane and the second image is capturable from a second image plane, the first image plane and the second image plane being defined by a first image capture device and a second image device respectively.

21. The method as in claim 19, further comprising:

receiving image signals corresponding to at least one of the first image and the second image, the image signals corresponding to the first image and the second image being generated by the first image capture device and the second image capture device respectively; and

processing the received image signals to thereby inspect at least one of the first surface and the at least one second surface of the semiconductor device.

22. The method as in claim 19, further comprising:

modifying at least one of optical magnification of the first image and optical magnification of the second image,

wherein the modification of the optical magnification of the at least one of the first image and the second image is effected by at least one of at least one first lens and at least one second lens respectively.

23. The method as in claim 22, the at least one first lens having a first optical magnification factor for enabling capturing of the first image of the first view and the at least one second lens having a second optical magnification factor for enabling capturing of the second image of the second view, wherein the second optical magnification factor is higher than the first optical magnification factor and the image portion of the first surface of the semiconductor device in the second image being a magnification of image portion of the first surface of the semiconductor device in the first image.

24. The method as in claim 19, further comprising:

directing light to the semiconductor device, the light reflectable off the first surface and the at least one second surface of the semiconductor device for receipt by a reflector assembly, the reflector assembly being configured for directing received light reflected from the first surface and the at least one second surface substantially along a first direction, the light directed along the first direction being subsequently split into a first light beam for traveling along a first path and a second light beam for traveling along a second path,

wherein the first path substantially intersects the first image capture plane and the second path substantially intersects the second image capture plane.

25. The method as in claim 24, wherein the first image capture plane receives the first light beam and the second image capture plane receives the second light beam to thereby facilitate capture of the first image and the second image respectively.

26. The method as in claim 24, wherein the splitting of light directed along the first direction into the first light beam and the second light beam is effected by a beam splitter.

27. The method as in claim 24, the reflector assembly comprising:

at least one reflective surface positioned for receiving and directing light reflected from the at least one second surface of the semiconductor device substantially along a first axis,

wherein at least a portion of light reflected off the first surface travels substantially along the first axis.

28. The method as in claim 27, wherein the at least one reflective surface is defined by one of at least one mirror and at least one prism.

29. The method as in claim 24, the reflector assembly comprising:

a plurality of first reflective surfaces positioned for receiving and directing light reflected from a plurality of side surfaces of the semiconductor device substantially along a first axis, each of the plurality of side surfaces extending along one of a plurality of side planes and constituting the at least one second surface, each of the plurality of side planes constituting the at least one second plane.

30. The method as in claim 29, wherein each of the plurality of first side planes is substantially perpendicular the first plane.

31. The method as in claim 29, the plurality of first reflective surfaces being inter-positioned for defining a passageway therebetween, the first axis intersecting the semiconductor device and being substantially perpendicular the first surface of the semiconductor device, and the semiconductor device being disposed for the passage of light reflected from the first surface thereof through the passageway and substantially along the first axis.

32. The method as in claim 31, wherein the reflector assembly further comprises a second reflective surface positioned for intersecting the first axis, the second reflective surface for receiving and redirecting light traveling along the first axis towards the beam splitter.

33. The method as in claim 32, further comprising:

directing light along a first axis and towards the semiconductor device, the light directed along the first axis being generated by an illuminator, the second reflective surface substantially interposing the illuminator and the semiconductor device, the second reflective surface being light permeable for

enabling passage of a portion of directed along the first axis towards the semiconductor device therethrough.

34. The method as in claim 19, further comprising:

controlling a plurality of illuminators for directing light at the semiconductor device,

wherein the plurality of illuminators is operable for directing light at the semiconductor device at at least one of a plurality of angles.

35. The method as in claim 19, each of the first image and the second image characterizable by one of a first set of properties and a second set of properties, each of the first set of properties and the second set of properties comprising at least one of at least one illumination color, at least one illumination brightness and at least one angle of illumination.

36. A method for inspecting a semiconductor device, the method comprising:

capturing a first image, the first image characterized by at least one of a first view and a first set of properties; and

capturing a second image, the second image characterized by at least one of a second view and a second set of properties, the first view comprising one of and the second view comprising the other of an image of a first surface of the semiconductor device and an image of the first surface with at least one second surface of the semiconductor device, the first surface extending substantially along a first plane and the at least one second surface extending substantially along at least one second plane, the at least one second plane being angled away from the first plane, each of the first set of properties and the second set of properties comprising at least one of at least one illumination colors, at least one illumination brightness and at least and at least one angles of illumination; and

processing at least one of the first image and the second image for inspecting at least one of the first surface and the at least one second surface of the semiconductor device,

wherein the capturing of the first image and the capturing of the second image is performed one of simultaneously and sequentially to thereby enable

one of simultaneously and sequential inspection of the at least one of the first surface and the at least one second surface of the semiconductor device.

37. The method as in claim 36, further comprising:

receiving light reflected from a plurality of side surfaces of the semiconductor device by a plurality of reflective surfaces, each of the plurality of side surfaces extending along one of a plurality of side planes and constituting the at least one second surface, each of the plurality of side planes constituting the at least one second planes, each of the plurality of reflective surfaces being substantially parallel one of the plurality of side planes.

38. The method as in claim 37, wherein the plurality of reflective surfaces is defined by one of a plurality of mirrors and at least one prism.