A SYSTEM AND METHOD FOR INSPECTION

Field of the Invention

The invention relates to the inspection of articles, particularly such articles that require very high definition for the detection of defects. The invention may be applicable to many industries, including for instance, the semi-conductor industry where the article may be a semiconductor wafer, or the electronics industry whereby the article may be a small scale electronic device.

Background:

Inspection systems in order to detect defects within an article are generally required to be both fast as well as accurate. In the textiles industry, much of this inspection can be human based, however for much smaller article, particularly those related to electronics and semi-conductors. It isn't practical to have a human inspection, both in terms of scale as well as the rate of manufacture of said articles.

Automatic imaging systems are limited by the field of view (FOV) which is defined by the optical resolution and camera resolution technology. As the object size gets bigger and resolution required get higher, it required taking multiple images of the object.

When imaging a moving object/article at high resolution, smearing is naturally inherited into the resulted image. It gets worst at higher resolution and higher speed. Hence, on-the-fly imaging is limited by the speed and resolution.

Different types of defects require different lighting designs, where design is defined as lighting techniques e.g. coaxial design, low angle design, etc) and/or different light wavelength e.g. red, blue, Infra, etc.

Hence, imaging an object of a size much bigger than the fixed FOV, at high resolution and at high on-the-fly speed, is a major challenge in imaging world. This is further compounded while trying to detect the different form of defects of an object.

Summary of the present invention:

In a first aspect, the invention provides an inspection system for inspecting an article on-the-fly, the system comprising: an image capture device arranged to capture a plurality of images of the article, each image corresponding to a portion of said article within a field of view projected upon said article; a table arranged to receive and move said article relative to the image capture device; a freeze unit intermediate the image capture device and the table; wherein said freeze unit is arranged to selectively shift the field of view at a speed corresponding to the movement of the table so as to maintain a fixed relative position of the field of view and the article during an image capture event.

In a second aspect, the invention provides a method for inspecting an article by capturing a plurality of images on-the-fly, the method comprising the steps of: capturing at least one images of the article, the image corresponding to a portion of said article

within a field of view projected upon said article; moving said article relative to the image capture device; shifting the field of view at a speed corresponding to the movement of the table, and so; maintaining a fixed relative position of the field of view and the article during the capturing step.

Accordingly, the invention provides a system and method whereby an entire article, such as a semiconductor wafer or electronic device, can be inspected to a very high tolerance. By restricting the field of view to a relatively small portion of the article,, then by moving the field of view so as to be fixed relative to the moving article, during the image capturing event, the problems of the prior art may be avoided.

In one embodiment, the invention may provide a system to acquire and present an article larger than the FOV design.

In various embodiments of the present invention, an inspection system may include:

0) An image acquisition unit or better known as camera unit

1) A freeze unit system directed to still image acquisition while the article is in motion: The unit comprises an image data system and mirror activating system;

2) A multi-lighting system that highlight features/defects on the article with different wavelengths and/or lighting techniques;

3) An X-Y stage that enables the motion as well as positional references to stitch smaller images to produce a single image of the article in full size.

The present invention may provide several important technical advantages. One

important technical advantage of the present invention may include a system and method for inspecting large articles in motion that utilizes a fixed FOV system, a freeze unit, multi-illuminations and an X-Y stage to reproduce different contrast images of the large object at very high speed with still image quality.

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Brief Description of Drawings

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other
10 arrangements of the invention are possible and consequently, the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figure 1 is a schematic view of an inspection system according to one embodiment of
15 the present invention;

Figure 2 is a plan view of an arrangement of an object/article and multiple field-of-view;

20 Figure 3 is an elevation view of a mirror activating system according to a further embodiment of the present invention;

Figure 4 is a timing diagram for an inspection system according to a further embodiment of the present invention;

Figure 5 is a cross-sectional view of an inspection system according to a further embodiment of the present invention;

Figure 6 is a block diagram of an inspection system according to a further embodiment of the present invention;

Figure 7 is a stitch data analysis system according to a further embodiment of the present invention;

Detailed Description

Figure 1 is a diagram of an inspection system 100 for performing an inspection according to one embodiment of the present invention.

The system 100 uses an X-Y stage 113 to facilitate the generation image data, through the image data system 110, by stepping through an object that is larger than the field of view 104 of a camera so as the complete component can be inspected without moving the camera.

The image data system 110 would comprise a camera (not shown) in communication with a control system and data transfer system. The image data system 110 is arranged to capture an image of an article which then subsequently communicate the image to the

control system to determine whether a defect exists. In this sense the camera plus communication network is effectively the same as a prior art inspection system.

The image data system 110 can be used to directly generate image data for component inspection or for other suitable purposes. In this embodiment, the component inspection can be performed by determining the pixel density required to inspect features of the component, such as by determining the area that must be covered by each pixel in order to provide the required level of detail for recognition of damage or other conditions.

The system 100 includes a light system 109 that can be used to generate different lighting techniques at different wavelengths to allow different set of image data to be generated during the scan to provide for the required contrast in the recognition of defective conditions of the component. If the number of pixels required to inspect an entire component is greater than the number of pixels generated by image data system 110 at the desired level of detail, it would be necessary to move the component in order to generate image data of the entire component. X-Y stage can be used to provide the image data of the entire component to image data system 110 by moving the object. In this manner, component is moved in X-Y direction such that the viewing area 106 covers the entire field of view of the component.

The X-Y stage 113 may include linear X-Y encoders to readout accurate current position of the stage and to provide more accurate movement of needed.

The system 100 may include Z-stage for accurate focusing of the camera of the image data system 110. Z-stage may be manually controlled or it may be connected with a control system for auto-focusing.

The image data system 110 would comprise at least one light sensitivity camera to capture an image(s) (CCD or CMOS camera for example). The image data system 110 may include also a few optical and mechanical parts, for example: imaging lens(s), mirror(s), beam splitters, prisms, filters etc.

The mirror actuating system 108 includes a moving mirror 102. The mirror 102 is controlled by a piezo actuator or other motive device. The mirror actuating system 108 may be coupled to the stitch inspection system 112, which may be coupled to image data system 110. Stitch inspection 112 and image data system 110 can be implemented in hardware, software, or a suitable combination of hardware and software, and can be one or more software systems operating on a general purpose processing platform. As used herein, the term "couple" and its cognate terms, such as "couples" and "coupled," can include a physical connection (such as a copper conductor), a virtual connection (such as through randomly assigned memory locations of a data memory device), a logical connection (such as through logical gates of a semiconducting device), other suitable connection, or a suitable combination of such connections. In one embodiment, systems and components are coupled to other systems and components through intervening systems and components, such as through an operating system.

Figure 2 is a diagram of a component/object/article 120, such as a wafer, glass, LCD, substrate, leadframe or any object, partially within in a field of view 122. Component 120 is not fully encompassed by a field of view 122, by moving the component 120 through an X-Y stage. This allows an array of detailed, smaller FOV's 104. Each image data generated while under the field of view 104 will have adjacent overlapping regions 105, thus allowing system 112 to stitch the images back to form the complete object image by using positional reference data and/or image processing algorithms, both of which are readily available, as will be clear to the skilled person.

Figure 3 shows one embodiment of the mirror actuating system 108, comprising a fixed mirror 107 and a second mirror 114 coupled to an actuator 102. The mirror 107 may be semi-transparent.

When the camera 115 exposure is triggered, the article 116 has move from field of view 402 to 403 and the mirror 114 moves in sync to ensure that 402 is the view that is presented to the camera during the full exposure period even though the object is in motion to 403. Effectively, the actuator 102 correspondingly moves the second mirror 114 so as to coincide the movement of the FOV 402, 403 with the movement of the article 116.

Figure 4 is a potential timing diagram for the freeze unit. Signal 501 is the signal to initiate the grab sequence of the camera, which comprises an exposure action 506 and an image transfer action 508. The exposure action is where the system starts to accumulate pixel intensity of the article. During this period, the actuator 102 will be

activated (signal 504) and move in sync with the speed of the article in order to ensure the field of view stay consistent during period 506 from the start of exposure till the end of exposure.

Figure 5 is a diagram of a light array 117 disposed about a freeze unit 108 for moving mirror 114. As shown, the light array 117 may include a partial array of LED lights or other suitable lights that are used to maintain a constant/strobe lighting pattern regardless of the angle of orientation for the freeze unit system 108 or moving mirror 114. The inspection system may include also a coaxial lighting that is placed above the semi-transparent mirror 107 on Figure 5.

In operation, inspection system 100 is used to perform inspection of one or more components. XY stage system 113 will move the component in motion in a manner that it will cover the full field of view of the component given that field of view 104 is much smaller than the component. During the motion of the component, 113 will generate signals to initiate the gathering of pixel density with an FOV 104 into the image data system. Preceding and proceeding image data will contain some level of image overlap, to allow for the stitch inspection system 112 to stitch all image data generated to form a complete image data of the component. The image data is being stitch using the position references generated by XY stage system 113. Inspection system 100 allows still image quality of a component in motion to be obtained by using a moving mirror in a manner that allows the instant of the image area to be same throughout the exposure period of the data gathering. Inspection system 100 is also programmed to image the component in the same field of view 104 with different lighting techniques such as coaxial and/or low angle lightings and/or at different wavelengths thus providing an image data system

generating more than one imaging technique image in a single pass of the full component.

Figure 6 is a diagram of an inspection system 200 for inspecting components. The system 200 includes image data system 110, freeze unit system 108, X-Y stage controller 113, freeze unit controller 202, image data acquisition control 204, X-Y stage controller 206, and stitch data analysis system 208, each of which may be implemented in hardware, software, or a suitable combination of hardware and software.

Freeze unit controller 202 controls the angular position and speed of the mirror in conjunction with the freeze unit system. In one embodiment, the freeze unit system 108 includes a support and associated piezo or other motive devices that are used to control the angle and the speed of the mirror so as to correspond to an image data system 110 exposure time as well as speed and direction of the component in motion.

Image data acquisition control 204 controls image data system 110 to generate data at a rate that correspond to the rate of movement of the XY stage controller 106 and field of view 104. In one exemplary embodiment, image data can be generated for trigger or for other suitable areas, such that image data acquisition control 204 causes an image data system 110 to capture data presently in an area encompassed by the viewing area 104. Image data acquisition control 204 receives X-Y stage position rate data from X-Y stage controller 206, so as to ensure that the image data is generated in synchronization with the movement of the mirror 102.

In operation, the inspection system 200 allows a component such as a semiconductor wafer to be inspected where the level of detail and the speed of gathering data that are required would otherwise require the wafer to be in stationary before system 110 can gather the data. The inspection system 200 controls a mirror such that when the component is still in motion, a still image quality can be achieved without stopping at each field of view of the full wafer in motion.

Figure 7 is a diagram of system 300 for stitch data analysis in accordance with an exemplary embodiment of the present invention. System 300 includes read position reference system 302, image stitch system 304, and component inspection system 306, each of which can be implemented in hardware, software, or suitable combination of hardware and software.

Component inspection system 302 identifies the position to start the data gathering of system 110 through software, hardware or suitable combination of hardware and software.

Image Stitch system 304 identifies the stitch point within image data sets. In one embodiment, the stitch system 304 can be used in conjunction with read position reference 302, such as where stitch locations can be determined. Stitch system 304 locate the stitch position without regard to the angular orientation of the image data. In this exemplary embodiment, stitch can be located using data from read position references or through using suitable image analysis processes or through both position

references and image analysis processes. The component system 306 can receive position data from 302 and image data from 304 or other suitable systems, and can perform inspection based on previously located wafer perimeters, components, or other suitable data

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In operation, system 300 performs analysis and inspection of component and features using image data generated in conjunction with moving mirror. System 300 allows suitable sections of the components such as dies, to be inspected, such as by identifying damaged areas.

Claims:

1. An inspection system for inspecting an article on-the-fly, the system comprising

an image capture device arranged to capture a plurality of images of the article, each image corresponding to a portion of said article within a field of view projected upon said article;

a table arranged to receive and move said article along X and Y axes relative to the image capture device;

a freeze unit intermediate the image capture device and the table;

wherein said freeze unit is arranged to selectively shift the field of view at a speed corresponding to the movement of the table so as to maintain a fixed relative position of the field of view and the article during an image capture event.

2. The inspection system according to claim 1, wherein the field of view of each image having adjacent overlapping regions.

3. The inspection system according to claim 1 or 2, wherein the inspection system is arranged to store the plurality of images and relative positions of said images.

4. The inspection system according to any one of claims 1 to 3, further including a stitching system for combining said plurality of images as a single image of the article.

5. The inspection system according to any one of claims 1 to 4, further including a lighting system for projecting light of different conditions on said article, said plurality of images including images under different lighting conditions.

6. The inspection system according to claim 5, wherein said lighting conditions include any one or a combination of: visible light, infrared, ultraviolet, coaxial light, low angle light.

7. The inspection system according to any one of claims 1 to 6, wherein said freeze unit includes at least one mirror coupled to an actuator, said actuator arranged to shift the field of view by moving said coupled mirror.

8. The inspection system according to claim 7, wherein said actuator rotates said mirror.

9. The inspection system according to claim 7 or 8, wherein said actuator translates said mirror.

10. The inspection system according to any one of claims 7 to 9, wherein said freeze unit includes at least one fixed mirror intermediate the table and the at least one actuated mirror.

11. A method for inspecting an article by capturing a plurality of images on-the-fly, the method comprising the steps of:

capturing at least one images of the article, the image corresponding to a portion of said article within a field of view projected upon said article;

moving said article relative to the image capture device along X and Y axes;

shifting the field of view at a speed corresponding to the movement of the table, and so;

maintaining a fixed relative position of the field of view and the article during the capturing step.

12. The method according to claim 11, wherein the field of view of each image having adjacent overlapping regions.

13. The method according to claim 10, further including the step of storing the plurality of images and relative positions of said images.

14. The method according to claim 10 or 11, further including the step of stitching said plurality of images and so creating a single image of the article.

15. The method according to claim 12, further including the step of inspecting the stitched and/or unstitched image of the article for defects.

16. The method according to any one of claims 10 to 13, further including the step of projecting light of different conditions on said article, said plurality of images including images under different lighting conditions.

17. The method according to any one of claims 10 to 14, wherein the shifting step includes rotating a mirror directing the field of view to an image capture device.

18. The method according to any one of claims 10 to 13, wherein the maintaining step includes capturing each image multiple times, each under different lighting conditions.

19. The method system according to claim 17, further including the step of fixing a second mirror intermediate the table and the rotated mirror.