

METHOD AND DEVICE FOR DETECTING EDGE DEFECT OF SILICON WAFER, PROCESSING METHOD, AND PRODUCT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims a priority to the Chinese patent application No. 202410862272.6 filed on June 28, 2024, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of semiconductor manufacturing technology, in particular to a method and a device for detecting an edge defect of a silicon wafer, a processing method, and a product.

BACKGROUND

[0003] In the field of semiconductor silicon wafer manufacturing, a defect in an edge region of a silicon wafer is detected by using an automated optical detection device. With an increase in the precision of integrated circuits, the requirements on the silicon substrate, especially the edge region of the silicon wafer, become stricter, so the edge region of the silicon wafer need to undergo more meticulous detection and classification.

[0004] Usually, the defects in the edge region of the silicon wafer include chips, cracks and edge-scratches. Through the detection and classification of the defects, it is able to prevent the silicon wafer from being broken in a subsequent process, and prevent the silicon wafer which has no risk of being broken from being abandoned, thereby reducing the manufacture cost.

SUMMARY

[0005] In order to solve the above-mentioned technical problem, an object of the present disclosure is to provide a method and a device for detecting an edge defect of a

silicon wafer, a processing method, and a product, so as to prevent the waste and loss of the product.

[0006] In order to achieve the above-mentioned object, the present disclosure provides the following technical solutions.

[0007] The present disclosure provides a method for detecting an edge defect of a silicon wafer, including: after a polishing process, detecting an edge of the silicon wafer by using a laser beam generated by an optical detection device to determine at least one target region, the target region being identified as an abnormality defect; determining at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region, each delocalization value being a difference between the feedback signal strength at an arbitrarily selected position and the feedback signal strength at an adjacent position of the arbitrarily selected position, and an angle of circumference of the silicon wafer corresponding to the arbitrarily selected position being different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle; and in a case that the delocalization value of the target region meets a predetermined condition, determining that the target region is an edge haze defect.

[0008] In some embodiments of the present disclosure, the predetermined condition includes: M delocalization values in N delocalization values of the target region are greater than a predetermined threshold, and M/N is greater than a predetermined ratio, where M is an integer greater than or equal to 0, and N is an integer greater than 0.

[0009] In some embodiments of the present disclosure, the predetermined threshold is 800 mW to 1500 mW, and the predetermined ratio is 2/7 to 2/5.

[0010] In some embodiments of the present disclosure, the determining at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region includes: dividing the target region into a plurality of positions based on the predetermined angle, an angle of circumference corresponding to each position and its adjacent position differs by the predetermined angle; and in a

clockwise direction or a counterclockwise direction, calculating a difference value between the feedback signal strength from each position and the feedback signal strength from a next adjacent position, and taking the difference value as the delocalization value.

[0011] In some embodiments of the present disclosure, the predetermined angle is 0.1° to 0.3° .

[0012] The present disclosure further provides in some embodiments a device for detecting an edge defect of a silicon wafer. The device is used for implementing the foregoing method and includes: an detection module configured to, after a polishing process, detect an edge of the silicon wafer by using a laser beam generated by an optical detection device to determine at least one target region, the target region being identified as an abnormality defect; a calculation module configured to determine at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region, each delocalization value being a difference between the feedback signal strength at an arbitrarily selected position and the feedback signal strength at an adjacent position of the arbitrarily selected position, and an angle of circumference of the silicon wafer corresponding to the arbitrarily selected position being different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle; and a determination module configured to, in a case that the delocalization value of the target region meets a predetermined condition, determine that the target region is an edge haze defect.

[0013] The present disclosure further provides in some embodiments a method for processing a silicon wafer, where the silicon wafer has an edge haze defect detected through the above-mentioned method, and the method includes: polishing an edge of the silicon wafer having the edge haze defect, wherein parameters of the polishing are: a polishing pressure of 20 N to 80 N, a high-speed polishing time of 30 s to 80 s, a high-speed polishing rotational speed of 300 rpm to 700 rpm, a low-speed polishing time of 10 s to 30 s, and a low-speed polishing rotational speed of 100 rpm to 300 rpm.

[0014] In some embodiments of the present disclosure, the edge of the silicon wafer is polished so that all delocalization values of an edge region of a polished silicon wafer product are smaller than a predetermined threshold, the delocalization value is a difference between a feedback signal strength at each position and a feedback signal strength at an adjacent position when the edge region of the silicon wafer is scanned by a laser beam, an angle of circumference of the silicon wafer corresponding to the position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle, the predetermined threshold is 800 mW to 1500 mW, and the predetermined angle is 0.1° to 0.3°.

[0015] The present disclosure further provides in some embodiments a silicon wafer product obtained through the above-mentioned processing method. The silicon wafer product does not include an edge haze defect detected through the above-mentioned detection method.

[0016] The present disclosure has the following beneficial effects.

[0017] The defect at the edge of the silicon wafer is identified using the laser beam generated by the optical detection device, to determine the at least one target region, the delocalization value of the target region is determined based on the feedback signal strength of the laser beam at the target region, and the target region is identified as the edge haze defect based on the plurality of delocalization values of the target region. In the embodiments of the present disclosure, the edge haze defect is identified based on the delocalization value of the target region, and after it is determined that the silicon wafer has the edge haze defect, the edge polishing is performed on the silicon wafer to remove the edge haze defect, so as to improve the quality and yield of the product.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Fig. 1 is a schematic view showing an edge defect of a silicon wafer;

[0019] Figs. 2a to 2d are schematic views showing various defects at an edge region of the silicon wafer;

- [0020] Fig. 3 is a schematic view showing parameters of a defect;
- [0021] Fig. 4 is a schematic view showing the defects, e.g., Chip, in an actual production procedure;
- [0022] Fig. 5 is a schematic view showing the edge haze defect of the silicon wafer;
- [0023] Fig. 6 is a flow chart of a method for detecting an edge defect of a silicon wafer according to an embodiment of the present disclosure;
- [0024] Fig. 7 is a schematic view showing an edge haze defect;
- [0025] Fig. 8 is a schematic view showing an AC signal value of the edge haze defect in Fig. 7;
- [0026] Fig. 9 is a schematic view showing a chip;
- [0027] Fig. 10 is a schematic view showing an AC signal value of the chip in Fig. 9;
- [0028] Fig. 11 is a schematic view showing a device for detecting an edge defect of a silicon wafer according to an embodiment of the present disclosure; and
- [0029] Figs. 12 and 13 are schematic views showing a silicon wafer having an edge haze defect.

DETAILED DESCRIPTION

[0030] In order to make the objects, the technical solutions and the advantages of the present disclosure more apparent, the present disclosure will be described hereinafter in a clear and complete manner in conjunction with the drawings and embodiments. Obviously, the following embodiments merely relate to a part of, rather than all of, the embodiments of the present disclosure, and based on these embodiments, a person skilled in the art may, without any creative effort, obtain the other embodiments, which also fall within the scope of the present disclosure.

[0031] In the field of semiconductor silicon wafer manufacturing, edge defects of a silicon wafer are identified using an automated optical detection device, such as Edge Back Front Inspection System (EBFIS), as shown in Fig. 1. Usually, the edge

defects of the silicon wafer include three types, i.e., chip as shown in Fig. 2a, crack as shown in Fig. 2b, and edge-scratch as shown in Fig. 2c. Due to these defects, the silicon wafer has a risk of being broken in a subsequent process. For example, fragments, notches or cracks may easily occur at a back-end due to the chip. Hence, the silicon wafers with the three types of defects are abandoned in a fabrication plant. However, during the production, there is such a type of edge haze defect as shown in Fig. 2d, and this type of defect does not lead to a damage risk. It is impossible to detect and determine this type of defect using a conventional detection method, so this type of defect is merely determined based on a parameter similar to that for determining such defect as chip, and thereby waste and loss of the product occur.

[0032] To be specific, in the conventional automated optical detection, the defects are identified and classified based on defect parameters in Fig. 3 and Table 1.

[0033] Hence, based on the classification of the defect parameters in the related art, it is impossible to differentiate defect such as chip from the edge haze defect. Fig. 4 is a schematic view showing the chip in an actual production procedure, and Fig. 5 is a schematic view showing the edge haze defect of the silicon wafer. Through comparing Fig. 4 with Fig. 5, the chip is usually presented as a whole piece, while the edge haze defect is presented in a scattered manner. In other words, as can be seen from the images, the chip is different from the edge haze defect in terms of delocalization degree. For example, a horizontal delocalization value of the chip in Fig. 4 is small, and a horizontal delocalization value of the edge haze defect in Fig. 5 is large. Hence, the delocalization value is added into the parameters for detecting the defects, so as to differentiate the chip from the edge haze defect based on the horizontal delocalization value. The delocalization value is a difference in horizontal AC (laser signal strength) of the defect in the images.

Table 1

Parameter	Name in Chinese	Notes
Box Width	bian kuang kuan du	
Box Height	bian kuang gao du	
Box Area	bian kuang mian ji	Box width*Box height
Fill Ratio	tian chong bi	Defect area/Box area
Major Axis	zhu zhou	
Minor Axis	duan zhou	
Aspect Ratio	zong heng bi	Major axis/Minor axis
PV	hui jie zhi	
DE (Delocalization)	li yu zhi	

[0034] An object of the present disclosure is to provide a method and a device for detecting an edge defect of a silicon wafer, a processing method, and a product, so as to detect an edge haze defect accurately, thereby preventing the waste and loss of the product.

[0035] The present disclosure provides in some embodiments a silicon wafer detection method which, as shown in Fig. 6, includes the following steps 101, 102 and 103.

[0036] Step 101: after a polishing process, detecting an edge of the silicon wafer by using a laser beam generated by an optical detection device to determine at least one target region. The target region is identified as an abnormality defect.

[0037] In the embodiments of the present disclosure, after polishing and cleaning the silicon wafer, a defect at the edge of the silicon wafer is identified using the laser beam generated by the optical detection device. After the defect has been

detected by the optical detection device, a type of the defect is determined based on such parameters as a box width, a box length, a box area, a ratio of a defect area to the box area (i.e., fill ratio), and a length of a major axis and a length of a minor axis (for determining an aspect ratio), so as to identify such defects as chip, crack and edge-scratch. In the embodiments of the present disclosure, a region which is identified by the optical detection device as the chip is determined as the target region, and subsequently whether the target region is the edge haze defect or the chip needs to be further determined.

[0038] Step 102: determining at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region. Each delocalization value is a difference between the feedback signal strength at an arbitrarily selected position and the feedback signal strength at an adjacent position of the arbitrarily selected position, and an angle of circumference of the silicon wafer corresponding to the arbitrarily selected is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle.

[0039] The edge of the silicon wafer is scanned using the laser beam to obtain a feedback signal of the laser beam at each position, and then the delocalization value of the target region is determined based on the feedback signal strength at each position. The feedback signal strength is an energy strength of a reflected laser signal, in unit of mW. To be specific, the target region is divided into a plurality of positions based on the predetermined angle, an angle of circumference corresponding to each position and its adjacent position differs by the predetermined angle; and in a clockwise direction or a counterclockwise direction, a difference value between the feedback signal strength from the position and the feedback signal strength from a next adjacent position is calculated, and taken as the delocalization value.

[0040] In some embodiments of the present disclosure, the predetermined angle is 0.1° to 0.3° , e.g., 0.1° , 0.2° or 0.3° .

[0041] Fig. 8 is a schematic view showing AC signal values of the edge haze defect in Fig. 7, where the abscissa represents the angle of circumference of the silicon

wafer, and the ordinate represents the AC signal value. Fig. 10 is a schematic view showing AC signal values of the chip in Fig. 9, where the abscissa represents the angle of circumference of the silicon wafer (in unit of 0.1°), and the ordinate represents the AC signal value. The delocalization value is denoted as DE, and it is calculated every 0.1° (i.e., the predetermined angle is 0.1°), $DE1=AC2-AC1$, and $DE2=AC3-AC2$, as shown in Fig. 10.

[0042] It can be seen that, in Fig. 8, in a case that the predetermined angle is 0.1° , a difference between the AC signal values at two adjacent positions is up to 3900 mW (milliwatt), i.e., the delocalization value is up to 3900 mW. In Fig. 10, a difference between the AC signal values at two adjacent positions is not greater than 500 mW, i.e., the delocalization value is not greater than 500 mW. Hence, it is able to differentiate the chip from the edge haze defect based on the delocalization value.

[0043] In a specific embodiment of the present disclosure, in a case that the predetermined angle is 0.1° , an edge region of the silicon wafer is divided into 3600 positions based on the angle of circumference of the silicon wafer, and in the clockwise direction, the 3600 positions include a first position, a second position, a third position, ..., a 3600th position sequentially. Presumed that the target region includes K positions, where K is an integer greater than 1, for the k^{th} position in the K positions, a difference between an AC signal value at the k^{th} position and an AC signal value at the $(k+1)^{\text{th}}$ position is taken as one delocalization value of the target region, and so on, so as to obtain all the delocalization values of the target region. Alternatively, in the counterclockwise direction, the 3600 positions include a first position, a second position, a third position, ..., a 3600th position sequentially. Presumed that the target region includes K positions, where K is an integer greater than 1, for the k^{th} position in the K positions, a difference between an AC signal value at the k^{th} position and an AC signal value at the $(k+1)^{\text{th}}$ position is taken as one delocalization value of the target region, and so on, so as to obtain all the delocalization values of the target region.

[0044] Step 103: in a case that the delocalization value of the target region meets a predetermined condition, determining that the target region is an edge haze defect.

[0045] In the embodiments of the present disclosure, a predetermined threshold is provided, and in a case that one or more of the delocalization values of the target region are greater than the predetermined threshold, the target region is identified as the edge haze defect. Otherwise, the target region is determined as the chip. The predetermined threshold may be set according to practical need.

[0046] In a case of scanning the edge of the silicon wafer by using the laser beam, the larger the AC signal value, the larger the probability of the defect; and the larger the duration of an AC peak value, the larger the defect. Usually, in a case that the AC signal value is greater than 1500 mW, it may be considered that there is the edge haze defect. Fig. 8 is a schematic view showing the AC signal values of the edge haze defect in Fig. 7, where the abscissa represents the angle of circumference of the silicon wafer, and the ordinate represents the AC signal value. Fig. 10 is a schematic view showing the AC signal values of the chip in Fig. 9, where the abscissa represents the angle of circumference of the silicon wafer, and the ordinate represents the AC signal value. In a case that the predetermined angle is 0.1° , the delocalization value of the edge haze defect is up to 3900 mW, while the delocalization value of the chip is smaller than 500 mW. Hence, the predetermined threshold may be 800 mW to 1500 mW, e.g., 800 mW, 900 mW, 1000 mW, 1100 mW, 1200 mW, 1300 mW, 1400 mW or 1500 mW.

[0047] In a specific embodiment of the present disclosure, in a case that the predetermined angle is 0.1° , the predetermined threshold is 1000 mW. In a case that one or more delocalization values of the target region are greater than 1000 mW, it may be considered that the target region is the edge haze defect or discontinuous contamination. In a case that the delocalization values of the target region are not greater than 1000 mW, it may be considered that the target region is a continuous defect, i.e., chip.

[0048] Further, in order to improve the determination accuracy, in a case that a plurality of delocalization values of the target region is greater than the predetermined threshold, it may be considered that the target region is the edge haze defect or discontinuous contamination; otherwise, the target region is a continuous defect, i.e., chip.

[0049] In some embodiments of the present disclosure, in a case that the target region includes N delocalization values, M delocalization values are larger than the predetermined threshold and M/N is greater than a predetermined ratio, it may be determined that the target region is the edge haze defect; otherwise, the target region is the chip, where M is an integer greater than or equal to 0, and N is an integer greater than 0. To be specific, the predetermined ratio is 2/7 to 2/5. In a specific embodiment of the present disclosure, in a case that the target region has a range of 1° and the predetermined angle is 0.1° , the target region includes 10 positions corresponding to 10 AC signal values, and 9 delocalization values are obtained. In a case that more than 1/3 of the delocalization values are greater than the predetermined threshold, the target region may be determined as the edge haze defect, otherwise the target region may be determined as the chip. This is because, in a case that merely one delocalization value of the target region is greater than the predetermined threshold, the delocalization value may correspond to a position at an edge of the defect, and there may exist misdetection. In a case that more than 1/3 of the delocalization values are greater than the predetermined threshold, it means that the defect is discontinuous, i.e., it is the edge haze defect.

[0050] In the embodiments of the present disclosure, the defect at the edge of the silicon wafer is identified using the laser beam generated by the optical detection device, the at least one target region is determined, the delocalization value of the target region is determined based on the feedback signal strength of the laser beam at the target region, and the target region is identified as the edge haze defect based on the plurality of delocalization values of the target region. In the embodiments of the present disclosure, the edge haze defect is identified based on the delocalization value of the target region, and after it is determined that the silicon wafer has the edge haze defect, the edge polishing is performed on the silicon wafer to remove the edge haze defect, so as to improve the quality and yield of the product.

[0051] The present disclosure further provides in some embodiments a device for processing a silicon wafer. The device, as shown in Fig. 11, includes an detection module 21, a calculation module 22 and a processing module 23.

[0052] The detection module 21 is configured to, after a polishing process, detect an edge of the silicon wafer by using a laser beam generated by an optical detection device to determine at least one target region. The target region is identified as an abnormality defect.

[0053] In the embodiments of the present disclosure, after polishing and cleaning the silicon wafer, a defect at the edge of the silicon wafer is identified using the laser beam generated by the optical detection device. After the defect has been detected by the optical detection device, a type of the defect is determined based on such parameters as a box width, a box length, a box area, a ratio of a defect area to the box area (i.e., fill ratio), and a length of a major axis and a length of a minor axis (for determining an aspect ratio), so as to identify such defects as chip, crack and edge-scratch. However, it is impossible to differentiate the chip from the edge haze defect based on these parameters, and the edge haze defect may also be determined as the chip. In the embodiments of the present disclosure, a region which is identified by the optical detection device as the chip is determined as the target region, and subsequently whether the target region is the edge haze defect or the chip needs to be further determined.

[0054] The calculation module 22 is configured to determine at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region. Each delocalization value is a difference between the feedback signal strength at an arbitrarily selected position and the feedback signal strength at an adjacent position of the arbitrarily selected position, and an angle of circumference of the silicon wafer corresponding to the arbitrarily selected position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle.

[0055] The edge of the silicon wafer is scanned using the laser beam to obtain a feedback signal of the laser beam at each position, and then the delocalization value of the target region is determined based on the feedback signal strength at each position. In some embodiments of the present disclosure, the calculation module 22 is specifically configured to: divide the target region into a plurality of positions based on the predetermined angle, the angles of circumference of the silicon wafer corresponding to adjacent positions being different from each other by the predetermined angle; and in a clockwise direction or a counterclockwise direction, calculate a difference value between the feedback signal strength from each position and the feedback signal strength from a next adjacent position, and take the difference value as the delocalization value.

[0056] In some embodiments of the present disclosure, the predetermined angle is 0.1° to 0.3° , e.g., 0.1° , 0.2° or 0.3° .

[0057] Fig. 8 is a schematic view showing AC signal values of the edge haze defect in Fig. 7, where the abscissa represents the angle of circumference of the silicon wafer, and the ordinate represents the AC signal value. Fig. 10 is a schematic view showing AC signal values of the chip in Fig. 9, where the abscissa represents the angle of circumference of the silicon wafer (in unit of 0.1°), and the ordinate represents the AC signal value. The delocalization value is denoted as DE, and it is calculated every 0.1° (i.e., the predetermined angle is 0.1°), $DE1=AC2-AC1$, and $DE2=AC3-AC2$, as shown in Fig. 10.

[0058] It can be seen that, in Fig. 8, in a case that the predetermined angle is 0.1° , a difference between the AC signal values at two adjacent positions is up to 3900 mW, i.e., the delocalization value is up to 3900 mW. In Fig. 10, a difference between the AC signal values at two adjacent positions is not greater than 500 mW, i.e., the delocalization value is not greater than 500 mW. Hence, it is able to differentiate the chip from the edge haze defect based on the delocalization value.

[0059] The processing module 23 is configured to, in a case that the delocalization value of the target region meets a predetermined condition, determine that the target region is an edge haze defect.

[0060] In the embodiments of the present disclosure, a predetermined threshold is provided, and in a case that one or more of the delocalization values of the target region are greater than the predetermined threshold, the target region is identified as the edge haze defect. Otherwise, the target region is determined as the chip. The predetermined threshold may be set according to practical need.

[0061] In a case of scanning the edge of the silicon wafer by using the laser beam, the larger the AC signal value, the larger the probability of the defect; and the larger the duration of an AC peak value, the larger the defect. Usually, in a case that the AC signal value is greater than 1500 mW, it may be considered that there is the edge haze defect. Fig. 8 is a schematic view showing the AC signal values of the edge haze defect in Fig. 7, where the abscissa represents the angle of circumference of the silicon wafer, and the ordinate represents the AC signal value. Fig. 10 is a schematic view showing the AC signal values of the chip in Fig. 9, where the abscissa represents the angle of circumference of the silicon wafer, and the ordinate represents the AC signal value. In a case that the predetermined angle is 0.1° , the delocalization value of the edge haze defect is up to 3900 mW, while the delocalization value of the chip is smaller than 500 mW. Hence, the predetermined threshold may be 800 mW to 1500 mW, e.g., 800 mW, 900 mW, 1000 mW, 1100 mW, 1200 mW, 1300 mW, 1400 mW or 1500 mW.

[0062] Further, in order to improve the determination accuracy, in a case that a plurality of delocalization values of the target region is greater than the predetermined threshold, it may be considered that the target region is the edge haze defect or discontinuous contamination; otherwise, the target region is a continuous defect, i.e., chip.

[0063] In some embodiments of the present disclosure, the processing module 23 is specifically configured to, in a case that the target region includes N delocalization values, M delocalization values are larger than the predetermined threshold and M/N is

greater than a predetermined ratio, determine that the target region is the edge haze defect; otherwise, determine that the target region is the chip, where M is an integer greater than or equal to 0, and N is an integer greater than 0. To be specific, the predetermined ratio is 2/7 to 2/5. In a specific embodiment of the present disclosure, in a case that the target region has a range of 1° and the predetermined angle is 0.1°, the target region includes 10 positions corresponding to 10 AC signal values, and 9 delocalization values are obtained. In a case that more than 1/3 of the delocalization values are greater than the predetermined threshold, the target region may be determined as the edge haze defect, otherwise the target region may be determined as the chip. This is because, in a case that merely one delocalization value of the target region is greater than the predetermined threshold, the delocalization value may correspond to a position at an edge of the defect, and there may exist misdetection. In a case that more than 1/3 of the delocalization values are greater than the predetermined threshold, it means that the defect is discontinuous, i.e., it is the edge haze defect.

[0064] In the embodiments of the present disclosure, the defect at the edge of the silicon wafer is identified using the laser beam generated by the optical detection device, the at least one target region is determined, the delocalization value of the target region is determined based on the feedback signal strength of the laser beam at the target region, and the target region is identified as the edge haze defect based on the plurality of delocalization values of the target region. In the embodiments of the present disclosure, the edge haze defect is identified based on the delocalization value of the target region, and after the silicon wafer is determined to have the edge haze defect, the edge polishing is performed on the silicon wafer to remove the edge haze defect, so as to improve the quality and yield of the product.

[0065] The present disclosure further provides in some embodiments a method for processing a silicon wafer. The silicon wafer has an edge haze defect detected through the above-mentioned method. The method includes subjecting the silicon wafer having the edge haze defect to edge polishing with a polishing pressure of 20 N to 80 N, a high-speed polishing time of 30 s to 80 s, a high-speed polishing rotational speed

of 300 rpm to 700 rpm, a low-speed polishing time of 10 s to 30 s, and a low-speed polishing rotational speed of 100 rpm to 300 rpm.

[0066] In a case of subjecting the silicon wafer to the edge polishing using the above-mentioned parameters, it is able to effectively remove the edge haze defect of the silicon wafer. The polishing pressure is 20 N, 30 N, 40 N, 50 N, 60 N, 70 N or 80 N, the high-speed polishing time is 30 s, 40 s, 50 s, 60 s, 70 s or 80 s, the high-speed polishing rotational speed is 300 rpm, 400 rpm, 500 rpm, 600 rpm or 700 rpm, the low-speed polishing time is 10 s, 20 s or 30 s, and the low-speed polishing rotational speed is 100 rpm, 200 rpm or 300 rpm.

[0067] In the embodiments of the present disclosure, the parameters for the edge polishing are adjusted based on hardness of the silicon wafer. The harder the silicon wafer is, the larger the polishing pressure and the longer the polishing time. In addition, the polishing pressure in the edge polishing of the silicon wafer should be smaller than a polishing pressure in a polishing process, so as to prevent the formation of new edge haze defects.

[0068] In the embodiments of the present disclosure, the silicon wafer is subjected to the edge polishing so that all delocalization values of an edge region of a polished silicon wafer product are smaller than a predetermined threshold, the delocalization value is a difference between a feedback signal strength at each position and a feedback signal strength at an adjacent position when the edge region of the silicon wafer is scanned by a laser beam, an angle of circumference of the silicon wafer corresponding to the position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle, the predetermined threshold is 800 mW to 1500 mW, and the predetermined angle is 0.1° to 0.3°. In this way, the edge haze defect of the silicon wafer is removed through edge polishing, so as to prevent the waste and loss of the product.

[0069] The present disclosure further provides in some embodiments a silicon wafer product obtained through the above-mentioned processing method. The silicon

wafer product does not include an edge haze defect detected through the above-mentioned detection method.

[0070] In a case that the silicon wafer does not include the edge haze defect detected through the above-mentioned detection method, it means that the silicon wafer with the edge haze defect does not have the edge haze defect any more after it is processed through the above-mentioned processing method.

[0071] In a case that the silicon wafer does not include the edge haze defect detected through the above-mentioned detection method, it means that the silicon wafer meets the following conditions: a delocalization value of an edge region of the polished silicon wafer product is smaller than a predetermined threshold, the delocalization value is a difference between a feedback signal strength at each position and a feedback signal strength at an adjacent position when the edge region of the silicon wafer is scanned by a laser beam, and an angle of circumference of the silicon wafer corresponding to the position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle.

[0072] In the embodiments of the present disclosure, after the chip is identified by the optical detection device, the region including the chip is determined as a target region, and then whether the target region is the edge haze defect or the chip is determined. After the target region is identified as the edge haze defect, the silicon wafer is subjected to edge polishing, so that the delocalization value of the edge region of the silicon wafer is smaller than the predetermined threshold and the silicon wafer does not have the edge haze defect any more. At this time, the silicon wafer may be used for the subsequent process as a normal product.

[0073] In some embodiments of the present disclosure, the predetermined threshold is 800 mW to 1500 mW. In a case that the delocalization value of the edge region of the silicon wafer is smaller than the predetermined threshold, it is able to prevent the occurrence of the edge haze defect of the silicon wafer.

[0074] In some embodiments of the present disclosure, the predetermined angle is 0.1° to 0.3° , e.g., 0.1° , 0.2° or 0.3° . In a specific embodiment of the present disclosure,

in a case that the predetermined angle is 0.1° , an edge region of the silicon wafer is divided into 3600 positions based on the angle of circumference of the silicon wafer, and in the clockwise direction, the 3600 positions include a first position, a second position, a third position, ..., a 3600th position sequentially. Presumed that the target region includes K positions, where K is an integer greater than 1, for the kth position in the K positions, a difference between an AC signal value at the kth position and an AC signal value at the (k+1)th position is taken as one delocalization value of the target region, and so on, so as to obtain all the delocalization values of the target region. Alternatively, in the counterclockwise direction, the 3600 positions include a first position, a second position, a third position, ..., a 3600th position sequentially. Presumed that the target region includes K positions, where K is an integer greater than 1, for the kth position in the K positions, a difference between an AC signal value at the kth position and an AC signal value at the (k+1)th position is taken as one delocalization value of the target region, and so on, so as to obtain all the delocalization values of the target region.

[0075] In a specific embodiment of the present disclosure, before determining the defect type of the silicon wafer by using the delocalization value, a defect of the silicon wafer in Figs. 12 and 13 is determined as the chip, and the silicon wafer is directly abandoned. After the defect type of the silicon wafer is determined based on the delocalization value using the technical solution in the embodiments of the present disclosure, the target region of the silicon wafer in Fig. 12 totally includes 8 delocalization values, and 6 of them are greater than 1000 mW, so the silicon wafer is determined to have the edge haze defect. After edge polishing, the silicon wafer is determined not to have the chip, so it is determined as OK. In this way, it is able to improve the yield of the silicon wafer, and prevent the product from being broken in the subsequent process.

[0076] It should be appreciated that, the above embodiments have been described in a progressive manner, and the same or similar contents in the embodiments have not been repeated, i.e., each embodiment merely focuses on the difference from

the others. Especially, the method embodiments are substantially similar to the product embodiments, and thus have been described in a simple manner.

[0077] Unless otherwise defined, any technical or scientific term used herein shall have the common meaning understood by a person of ordinary skills. Such words as “first” and “second” used in the specification and claims are merely used to differentiate different components rather than to represent any order, number or importance. Similarly, such words as “one” or “one of” are merely used to represent the existence of at least one member, rather than to limit the number thereof. Such words as “include” or “including” intends to indicate that an element or object before the word contains an element or object or equivalents thereof listed after the word, without excluding any other element or object. Such words as “connect/connected to” or “couple/coupled to” may include electrical connection, direct or indirect, rather than to be limited to physical or mechanical connection. Such words as “on”, “under”, “left” and “right” are merely used to represent relative position relationship, and when an absolute position of the object is changed, the relative position relationship will be changed too.

[0078] It should be appreciated that, in the case that such an element as layer, film, region or substrate is arranged “on” or “under” another element, it may be directly arranged “on” or “under” the other element, or an intermediate element may be arranged therebetween.

[0079] In the above description, the features, structures, materials or characteristics may be combined in any embodiment or embodiments in an appropriate manner.

[0080] The above embodiments are merely specific implementations of the present disclosure, and shall not be construed as limiting the scope of the present disclosure. Any person skilled in the art may make modifications and substitutions without departing from the spirit of the present disclosure, and these modifications and substitutions shall also fall within the scope of the present disclosure. Hence, the scope of the present disclosure shall be subject to the scope defined by the appended claims.

What is claimed is:

1. A method for detecting an edge defect of a silicon wafer, comprising:

after a polishing process, detecting an edge of the silicon wafer by using a laser beam generated by an optical detection device to determine at least one target region, wherein the target region is identified as an abnormality defect;

determining at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region, wherein each delocalization value is a difference between the feedback signal strength at an arbitrarily selected position and the feedback signal strength at an adjacent position of the arbitrarily selected position, and an angle of circumference of the silicon wafer corresponding to the arbitrarily selected position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle; and

in a case that the delocalization value of the target region meets a predetermined condition, determining that the target region is an edge haze defect.

2. The method according to claim 1, wherein the predetermined condition comprises:

M delocalization values in N delocalization values of the target region are greater than a predetermined threshold, and M/N is greater than a predetermined ratio, where M is an integer greater than or equal to 0, and N is an integer greater than 0.

3. The method according to claim 2, wherein the predetermined threshold is 800 mW to 1500 mW, and the predetermined ratio is $2/7$ to $2/5$.

4. The method according to claim 1, wherein the determining at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region comprises:

dividing the target region into a plurality of positions based on the predetermined angle, wherein an angle of circumference corresponding to each position and its adjacent position on the silicon wafer differs by the predetermined angle; and

in a clockwise direction or a counterclockwise direction, calculating a difference value between the feedback signal strength from each position and the feedback signal strength from a next adjacent position, and taking the difference value as the delocalization value.

5. The method according to claim 4, wherein the predetermined angle is 0.1° to 0.3° .

6. A device for detecting an edge defect of a silicon wafer, wherein the device is used for implementing the method according to any one of claims 1 to 5, and comprises:

an detection module, configured to, after a polishing process, detect an edge of the silicon wafer by using a laser beam generated by an optical detection device to determine at least one target region, wherein the target region is identified as an abnormality defect;

a calculation module, configured to determine at least one delocalization value of the target region based on a feedback signal strength of the laser beam at the target region, wherein each delocalization value is a difference between the feedback signal strength at an arbitrarily selected position and the feedback signal strength at an adjacent position of the arbitrarily selected position, and an angle of circumference of the silicon wafer corresponding to the arbitrarily selected position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle; and

a determination module, configured to, in a case that the delocalization value of the target region meets a predetermined condition, determine that the target region is an edge haze defect.

7. A method for processing a silicon wafer, wherein the silicon wafer has an edge haze defect detected through the method according to any one of claims 1 to 5, and the method comprises:

polishing an edge of the silicon wafer having the edge haze defect, wherein parameters of the polishing are: a polishing pressure of 20 N to 80 N, a high-speed polishing time of 30 s to 80 s, a high-speed polishing rotational speed of 300 rpm to 700 rpm, a low-speed polishing time of 10 s to 30 s, and a low-speed polishing rotational speed of 100 rpm to 300 rpm.

8. The method according to claim 7, wherein the edge of the silicon wafer is polished so that all delocalization values of an edge region of a polished silicon wafer product are smaller than a predetermined threshold, the delocalization value is a difference between a feedback signal strength at each position and a feedback signal strength at an adjacent position when the edge region of the silicon wafer is scanned by a laser beam, an angle of circumference of the silicon wafer corresponding to the position is different from an angle of circumference of the silicon wafer corresponding to the adjacent position by a predetermined angle, the predetermined threshold is 800 mW to 1500 mW, and the predetermined angle is 0.1° to 0.3°.

9. A silicon wafer product obtained through the method according to claim 7 or 8, wherein the silicon wafer product does not comprise an edge haze defect detected through the method according to any one of claims 1 to 5.