Development of Versatile Fault Detection Using Image Sensors - Takuya Sugiura

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Abstract

We have been developing various fault detection method using image sensors. In this paper, we report on applying the image sensor to two cases, wafer transfer misalignment and cracked wafer detection in the transfer systems.

1. Introduction

We have been developing various fault detection methods to realize high productivity aiming at smart factory. However, in transfer systems, it is difficult to detect its fault by using widely used sensors because its configurations are too versatile to install sensors in the proper locations. Therefore, we focused on image sensors which can detect various faults by color, shape, position, and so on. In this paper, we developed fault detection method using image sensors and applied it to two types of equipment, ion implanter and vertical furnace.

2. Examples

2-1. Detection of wafer transfer misalignment

The first case is the detection of wafer transfer misalignment in ion implanter. Fig.1 shows a schematic diagram of the equipment. In this equipment, the transfer arm that grasps the wafer moves from horizontal to vertical position. At this timing, wafer drop occurs due to the wafer transfer misalignment. Therefore, we considered detecting wafer misalignment by image sensors. We placed a camera and a lighting at view-port to capture the wafer position. In order to detect wafer misalignment, we decided to measure the gap area value between wafer and transfer arm. Fig.2 shows the process to measure the gap area. First, the camera captured the wafer and transfer arm. At this timing, we highlighted the edges of them by lighting and recognized the gap area by using the edges in the red square. Next, we changed the color of the gap area to white and of the rest area to black by image processing. Fig.3(a) shows a comparison of the normal and fault gap area. In these cases, the fault gap area was smaller than normal. Fig.3(b) shows the transition of the gap area values including these cases. The values of normal were within the limits, but the one of fault was below the lower limit. Hence, we can detect the fault. Furthermore, Fig.4 shows the long-term transition. The gap area values tend to spread gradually. This trend indicates that transfer precision is getting worse and can be utilized for predictive maintenance. Thus, we confirmed that the image sensor is effective to detect the wafer transfer misalignment.

2-2. Detection of cracked wafer

The second case is the detection of cracked wafers in vertical furnace. Fig.5 shows a schematic diagram of the equipment. In this equipment, wafer crack occurs due to heating and cooling processes, and more wafers are broken by the transfer arm attacking the cracked wafer. Therefore, we considered detecting cracked wafers by image sensors. We placed a camera at view-port to capture the wafers during wafer descent sequence. In order to detect cracked wafers, we decided to measure the wafer spacing. Fig.6 shows the process to detect cracked wafers. First, the camera captured the wafer images. Next, by the image processing, the wafer edges were detected as straight lines in the area enclosed by the red square with no disturbances in the background and the spacing between the lines were measured. Fig.7 shows examples of judging whether cracked wafers are present or not. Fig.7(a) is the image without cracked wafers. The measured spacing was suitable and judged to be normal. On the other hands, Fig.7(b) is the artificial image with a cracked wafer. The measured spacing was judged to be fault as too wide because the cracked wafer was not straight line and not detected. Hence, we can detect cracked wafers. Thus, we confirmed that the image sensor is effective to detect cracked wafers.

Conclusion

We have been developing various fault detection method using image sensors for high productivity. In this paper, we reported on applying the image sensor to two types of equipment, ion implanter and vertical furnace. In both cases, we were able to detect the faults by using different algorithms. Thus, we confirmed that the image sensor is effective for fault detection. In the future, we will contribute to high productivity through the more various fault detections using image sensors.

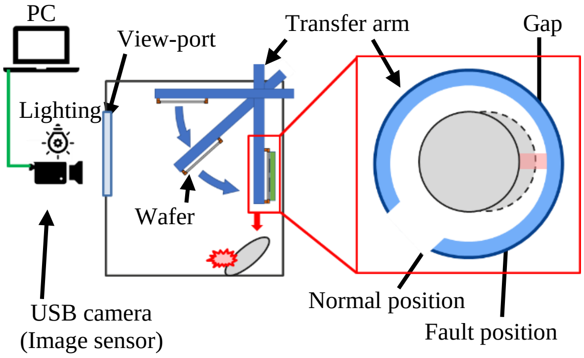


Fig.1 Schematic diagram of ion implanter transfer system and enlarged image of transfer arm.

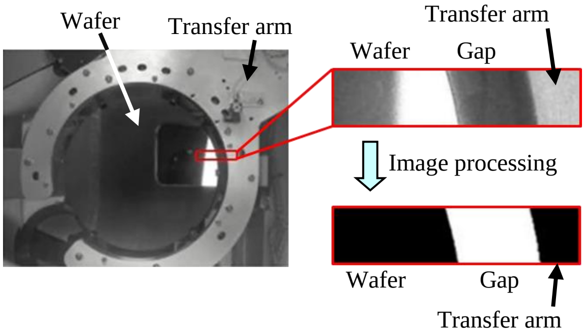
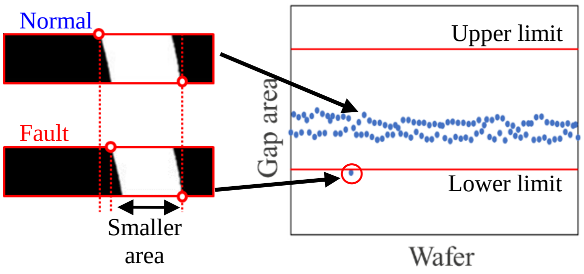


Fig.2 Photograph of wafer and transfer arm from the view-port and the image processing to measure the gap area.



(a) Comparative image of normal and fault.

(b) The transition of the gap area values.

Fig.3 The result of gap area measurement.

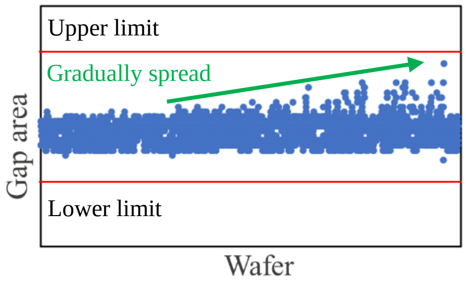


Fig.4 The long-term transition of gap area values.

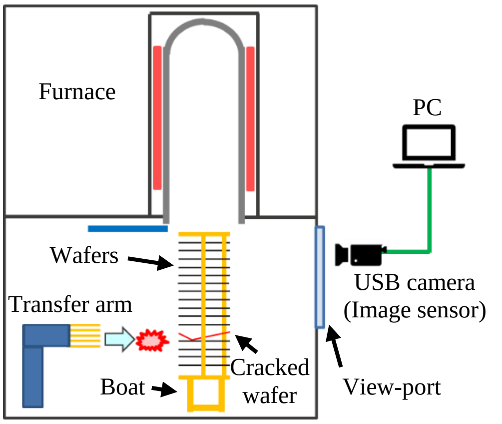


Fig.5 Schematic diagram of vertical furnace.

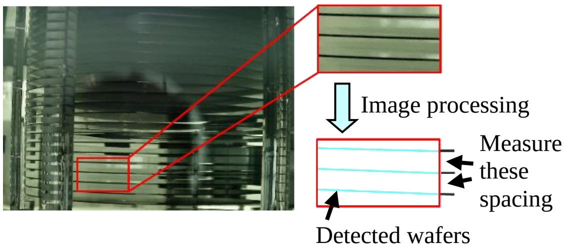
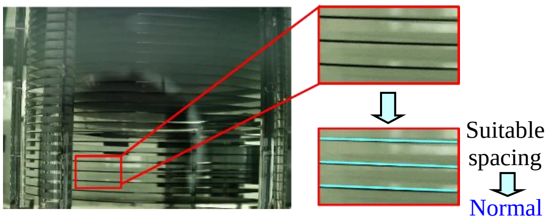
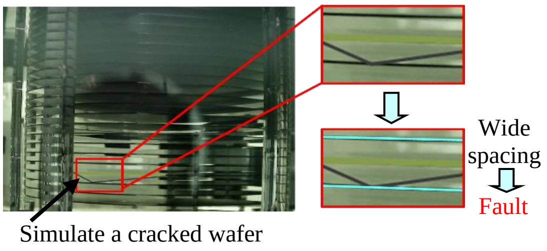


Fig.6 Photograph of wafers from the view-port and the image processing to measure the wafer spacing.



(a) The image without cracked wafers.



(b) The image with a cracked wafer. (Artificial)

Fig.7 Examples of judging whether cracked wafers are present or not.