Early detection of abnormal film thickness distribution by CNN Takumi Katoh

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Introduction

In recent years, NAND Flash memory has been required to achieve higher density and larger capacity, and the device structure requires more difficult technology, which tends to result in longer cycle times. Accordingly, timely anormal detection in the In-Line is very important. In addition, due to the complexity of the process and device structures, it is difficult to detect abnormalities using conventional detection methods such as average and Std dev. of film thickness. In this paper, we have developed a new detection system using Kriging and convolutional neural network (CNN) to improve an anomalous trend of film thickness within wafer.

Experiments

In this report, Kriging is adopted to create images from film thickness data. This method can be used to predict the overall picture by calculating the thickness at other locations based on the thickness measured at several locations. To classify the predicted whole image, we adopted CNNs, which are generally good at image recognition. Figure 1 shows the network structure of three layers used in this study.

We used a wafer with an anomaly trend in which the film thickness is fan-shaped in the direction of 12 o'clock and processed the multipoint measurement data with Kriging. (Fig.2). Since we had only one anomaly wafer data, we artificially increased the reference data by changing the angle and contrast. Then, we created a discriminator by CNN process which was using the data of anomalous wafer and normal wafer as the teacher data. In addition, to verify the accuracy of the discriminator, we created 52 of abnormal data by randomly adding or subtracting values and verified the accuracy of the discriminator together with 1294 of normal wafer data.

Results & Discussion

Confusion matrix was shown in Tab.1. This table shows the actual number of normal / anormal wafers, and the expected number of normal / anormal wafers identified through the CNN respectively. As can be seen from Tab. 1, the network has succeeded in classifying the artificially created anormal wafer without overlooking. This result suggest it can be possible to detect anormal wafers which indicate small enough fluctuations in statistical like a in wafer mean or sigma. However, 8.8% (= 5 / (5 + 52)) of the wafers detected from CNN are false positives, which is a future task.

We built a system to issue an alert that equipped with the algorithm to detect the anormal wafer. The outline of the system is shown in Fig. 3. This system automatically creates an image from the point data and identifies normal / anormal wafers through the network, engineers can get information in a timely manner. This is expected to be effective in early detection of anomalies.

Conclusion

To early detect for anomalous trend of film thickness within wafer, we developed new method applying Kriging and CNN. It is possible to prevent quality incident even if average and Std dev. of film thickness are within specifications by using this method. In addition, we've built a system that will trigger an alert using the algorithm.

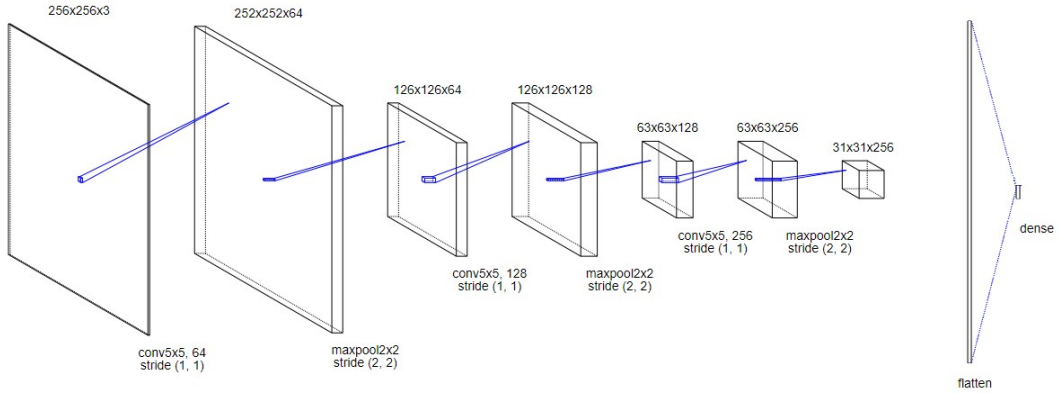

Fig.1 CNN structure (Some layers like a drop out are omitted)

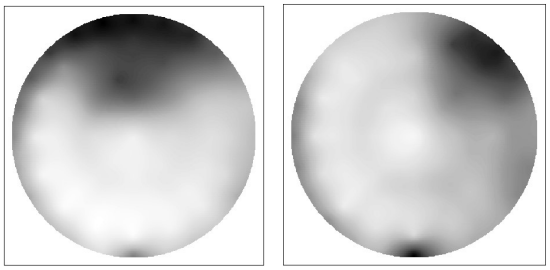

Fig.2 Example of anormal within wafer trend (left) and normal one (right)

Tab. 1 Confusion matrix [counts]

confusion matrix		Prediction Class	
		Positive	Negative
Actual Class	Positive	52	0
	Negative	5	1289

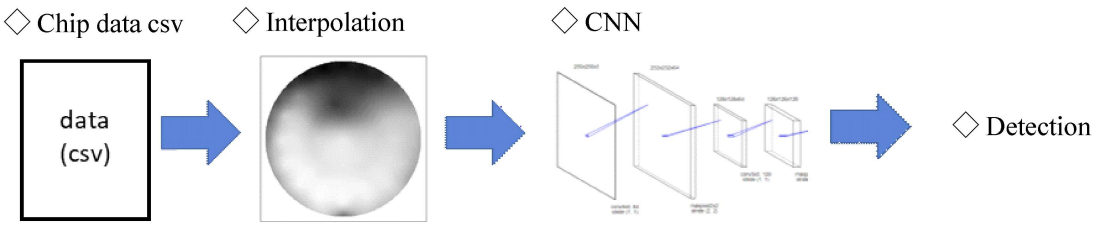

Fig. 3 concept of this system