False Alarm Reduction in AutoEncoder System by Using Our Original Waveform Extraction Method - Yuki Ishizeki

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Abstract

We have developed the waveform extraction algorithm to reduce the false alarm rate in fault detection using AutoEncoder. In this paper, we report the results of applying our original algorithm to actual equipment data and evaluating the performance of fault detection.

1. Introduction

In recent years, there have been many reports on research aiming at Smart Factory, in which they utilize AI (Artificial Intelligence) and do not require human intervention. To realize Smart Factory, we are also developing a fault detection system using AE (AutoEncoder) which is one of the AI. However, we found out that system using simple AE has a problem of many false alarms, which hinders realization of Smart Factory. To solve this problem, waveform extraction is effective, but it is difficult to extract data from unstable time and shape such as EPD (Endpoint Detection) waveforms by using conventional method. Therefore, we have developed the algorithm that can adapt to changes in shape by extracting waveforms based on their features. In this paper, we report the results of applying the algorithm to actual equipment data and evaluating the performance of fault detection.

2. Experimental

The EPD waveforms of the dry etcher in this case study were difficult to extract by using conventional methods because the shape of the waveform varied depending on the first wafer's effect and layer thickness. First, we evaluated the performance of the extraction algorithm by extracting the monitoring area from the typical and specific waveforms shown in Fig.1 based just on the feature of the typical waveform. Next, we evaluated the fault detection performance of the system combined with AE and extraction algorithm. Fig.2 shows the shapes of the normal and faulty waveforms used in the evaluation. The faulty waveform is longer than normal one and have a broad peak. In this study we made simple AE and AE combined with extraction algorithm learn normal waveforms. Then we inputted 100 normal waveforms and 1 faulty waveform to AEs and evaluated fault detection performance of each AE by using max value of difference (Diff) between input and output of AEs.

3. Results

First, Fig.3 shows the evaluation results of waveform extraction. The extraction algorithm succeeded in extracting the monitoring area from both waveforms despite large difference of shape. Next, Fig.4 shows the evaluation results of the fault detection performance with the simple AE. The blue dots are the results of normal waveforms, and the red dot is the result of faulty waveform. The Diff value of the faulty waveform was 2.37, and the false alarm rate was 4% when the threshold was set to detect this fault. This rate is high in the operation of the system, and if the threshold is set to reduce false alarms, faults will be overlooked. The reason for the false alarm was that the high Diff occurred in the areas of steep changes in the data due to shifts in the time axis of the input and output data as shown in Fig.5. Next, Fig.6 shows the evaluation results of the fault detection performance with the system combining AE and waveform extraction algorithm. The blue dots are the results of normal waveforms, and the red dot is the result of faulty waveform. The Diff value of the faulty waveform was 0.11, and the false alarm rate was 0% when the threshold was set to detect this fault. From these results, we confirmed that the combination of the waveform extraction algorithm and AE can extract the monitoring area even if the shape of the waveform fluctuates widely, and the false alarm rate was considerably reduced.

4. Conclusion

Fault detection of waveform by using simple AE has the problem of many false alarms. This problem can be solved by waveform extraction, but it is difficult to extract it reliably using conventional methods. Therefore, we have developed our original waveform extraction algorithm to solve this problem. By combining this algorithm with AE, we were able to extract the monitoring area accurately even if the shape of the waveform fluctuates, consequently we were able to reduce the false alarm rate from 4% to 0% and improved the fault detection performance. In the future, through utilizing our technology for FDC of various semiconductor equipment, we will realize Smart Factory.

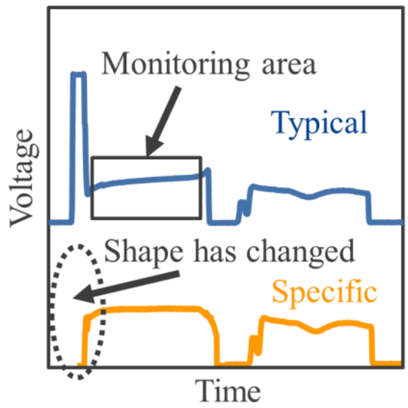

Fig.1 Typical and specific waveform shapes
The area surrounded by square in Typical case is the monitoring area.
The area surrounded by the dotted line in the Specific case is the area where the shape has changed.

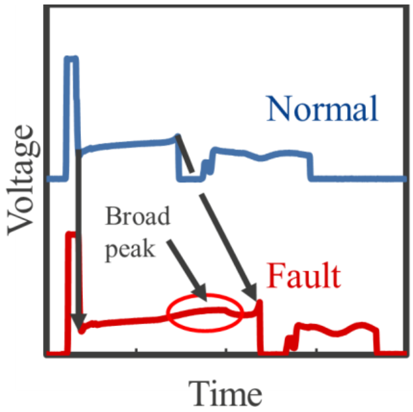

Fig.2 Normal and faulty waveforms used for fault detection evaluation

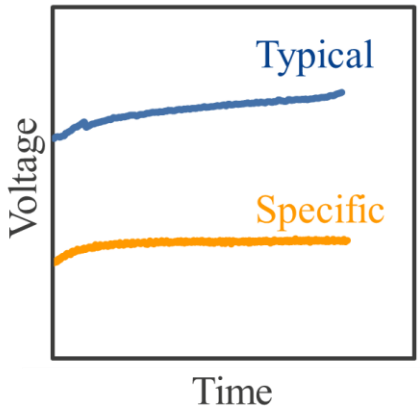

Fig.3 Performance evaluation results of our original waveform extraction algorithm

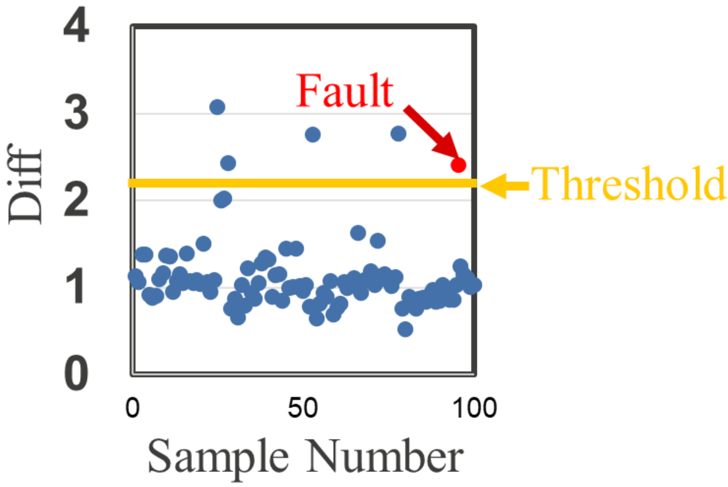

Fig. 4 Determination results by simple AE

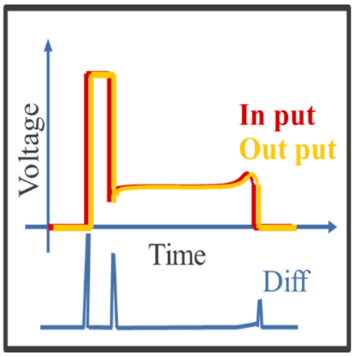

Fig.5 Cause of false alarm in normal waveform

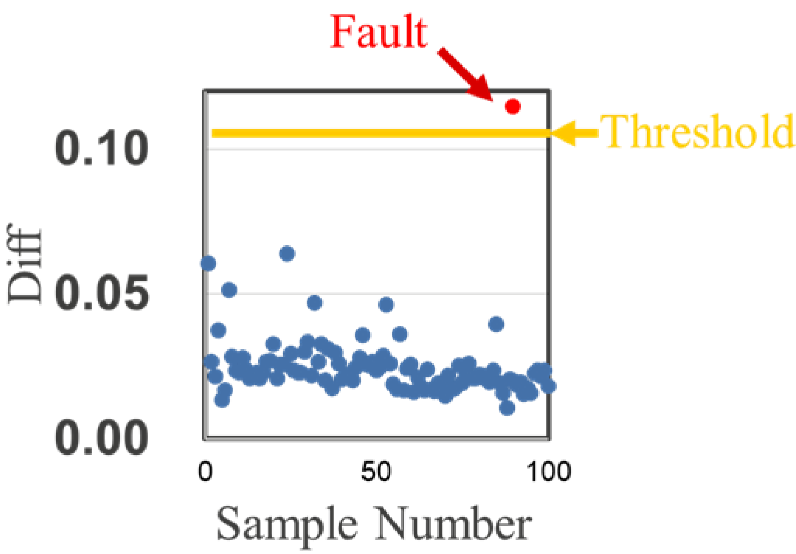

Fig.6 Determination results combined with waveform extraction algorithm and AE