Design and Implementation of an Ellipsometer Inspection System that Conforms to the Wafer's MI Process in the Production Process

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Abstract: Due to the recent semiconductor yield issue, the proportion of the MI (Measurement, Inspection) process in the semiconductor industry is rapidly growing. Mass production of one wafer takes enormous cost and time, and due to the nature of wafers, defective wafers cannot be reused, which causes enormous losses. In this study, we propose an inspection method system using an ellipsometer for the wafer MI process. It is expected that cost reduction in semiconductor production can be achieved by making wafer defect inspection more efficient.

Keywords: Semiconductor Process, MI, Ellipsometer,Wafer Align, CCD Aligner

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1. Introduction

Increasing development and yield and reducing process time due to competition to refine semiconductor processes are factors that maximize productivity and profits of semiconductor companies, and the key solution for this is MI process. Among MI processes, thin-film metrology is a measurement equipment that is used primarily in major semiconductor processes. Thin-Film Metrology in the exposure process is one of the very important element technologies because if the Wafer vision alignment is poor, numerous defective Wafer can be produced due to incorrect measurement.

Semiconductors are currently upgrading their technology through pattern refinement using equipment that can draw circuit widths finely at the nano level through EUV technology, so it is necessary to upgrade their technology to review product production during product production. The Ellipsometer is a measuring device that measures the change in polarization state after light reflection or transmission, and the change in polarization state is corrected according to the characteristics of the measured sample and can have a resolution of up to angstroms. Several companies are identifying fine patterns, recognizing problems during the process, and maximizing productivity through process improvement activities by applying the Ellipsometer production process, and a Wafer inspection system is essential for this.

Thin film thickness measuring equipment is an important measuring instrument that is often used in each process. Therefore, it is possible to expect an increase in semiconductor production efficiency by introducing the Ellipsometer System into the production process to reduce time in the process by identifying defects during the actual factory production process.

In this paper, we propose an inspection system design using Ellipsometer for the MI process during the semiconductor process.

Measure the area where the Wafer is inspected for defects using an Ellipsometer. Existing Ellipsometer equipment is not equipped with equipment to align Wafer, so Wafer cannot be aligned when Wafer is inspected using Ellipsometer. Combining CCD Aligner with Ellipsometer helps Wafer measurements be made more accurately and quickly.

By combining the WTR to transfer Wafer to the CCD Aligner and the Ellipsometer measurement equipment, rapid and accurate input and recovery of the Wafer is possible.

Combining Wafer's auto-alignable CCD Aligner, WTR takes Wafer from the Wafer slot, puts Wafer into CCD Aligner, collects Wafer aligned after Wafer alignment, measures Wafer's thin film thickness using Ellipsometer, and proposes Wafer's Examine system.

2. Related Work

2.1 MI (Measurement, Inspection)

There are several processes in the semiconductor Wafer process, and several studies are underway to manufacture Wafers more efficiently for each process. [1] [2] [3]

To make as many normal chips as possible in one Wafer, each process must be fully controlled, and accurate measurement is essential for complete control. Metrology is the exact measurement of the Wafer process as intended, and Inspection is the inspection of whether the Wafer is defective or the particle is separated, and the combination of these two is called the MI (Measurement, Inspection) process. The semiconductor process consists of a total of eight steps, and as the measurement is carried out at the end of each process, the MI process in the semiconductor process is very important.

2.2 Ellipsometer

Ellipsometry is a technology that uses interference or phase difference between reflected light on a thin film surface and reflected light from an interface under the thin film, and changes due to the influence of the medium as light passes through the medium. The change uses a property in which the degree is proportional to the refractive index and thickness of the thin film. The device for measuring this is referred to as an Ellipsometer, and various methods for measuring thin film thickness using the Ellipsometer are being studied. [4] [5] [6] Ellipsometer measurement law is a non-destructive test, and the advantage of measuring time is relatively short to measure the sample, and it is relatively easy to measure semiconductors. [7] Ellipsometry measures the polarization variation of incident light and reflected light to determine the thickness of the thin film and the complex refractive index, and the thickness of the thin film can be measured from the lowest number of angstroms to hundreds of micrometers. These Ellipsometer technologies are currently being applied in various fields, ranging from basic research such as physics, electronics, and biology to industrial applications, and can be applied to semiconductor measurement processes. Fig. 1 shows a schematic diagram for measuring wafers using Ellipsometer.

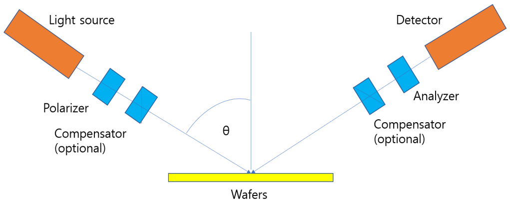

Fig. 1. Schematic of Ellipsometer.

2.3 CCD Aligner

Fig. 2 is an overall configuration diagram of the CCD Aligner. The CCD Aligner is operated using a vision system. The method of measuring [8] using Vision Aligner for Wafer allows the controller to rotate the chuck once when the wafer is placed on the chuck of the aligner, at which point the image profile of the wafer can be obtained from the CCD circuit. After one turn, the chuck motor stops, and in this case, the controller may obtain image data of the wafer from the CCD circuit. Using these values, the eccentric amount of the wafer and the direction of the fret or notch are calculated. Thereafter, after going through an eccentric correction process of matching the center of the chuck and the wafer, the direction of the fret or notch is aligned in a predetermined direction. As a result, the position of the visual marking marked on the wafer is analyzed using a camera to check whether the eccentricity of the wafer and the direction of the flat or notch are accurately aligned. The amount of error is calculated based on the measurement of the initial alignment result. Repeating accuracy may be obtained by repeating such an operation more than 2,000 times.

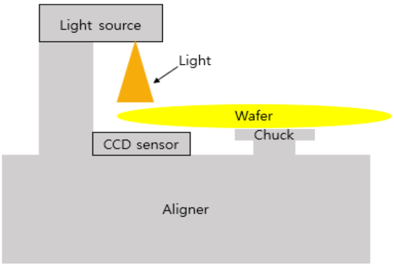

Fig. 2. CCD Aligner.

3. Align Inspection System for Ellipsometer

3.1 System Design

A thin film thickness measuring device using Ellipsometer, which can be used in the MI process of semiconductor Wafer, was designed.

By interlocking the WTR(Wafer Transfer Robot) and CCD Aligner with the existing Ellipsometer equipment, WTR scans the Wafer to be inspected in the Wafer slot and puts it into the CCD Aligner. The injected Wafer is aligned by CCD aligner by Wafer Aligner. The aligned Wafer is recovered by the WTR again and the recovered Wafer is put into the Ellipsometer. The injected Wafer has a structure in which the thickness of a thin film is measured using an Ellipsometer.

Fig. 3 shows the overall structure of the proposed system. The WTR is located between the Wafer case and the Wafer Aligner, and the Ellipsometer System is located in the center, combined with each other, and interlocked.

3.2 Operation Procedures of Ellipsometer Inspection

Fig. 4 shows the overall flow of the Ellipsometer system. Determine whether to place the Wafer on the Wafer Stage

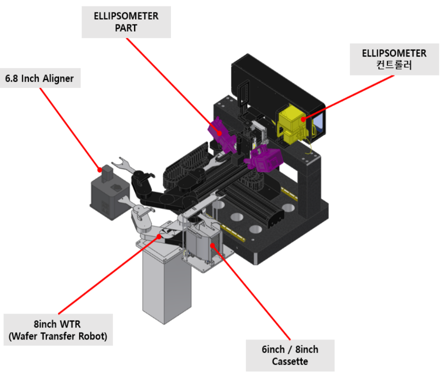

Fig. 3. Proposed System Structure.

after automatic alignment using the WTR or after manual alignment for Ellipsometer measurement. If Wafer measurement is performed manually without using WTR, the user can use the Ellipsometer System after arbitrarily aligning the Wafer position. If Wafer is automatically measured, detect the Wafer cassette of the WTR inspection target, recognize the slot in which Wafer is inserted, wait for the Wafer transfer, and check if the CCD Aligner is empty. If the CCD Aligner is empty, transfer from the Wafer in the slot at the bottom of the Wafer cassette to the CCD Aligner. The transferred Wafer is aligned from the CCD Aligner and is prepared to be transferred to the Stage of the Ellipsometer System. If the stage is found to be empty, the WTR takes the aligned wafer from the CCD Aligner and sends it to the Ellipsometer Stage for Ellipsometer measurement. The transferred Wafer is completed by measuring the Ellipsometer, and the measured Wafer is moved to the completed cassette and received. After that, if Wafer remains in the cassette to be inspected, repeat the process until Wafer does not remain in the cassette to be inspected, and if it does not remain, the measurement system is terminated.

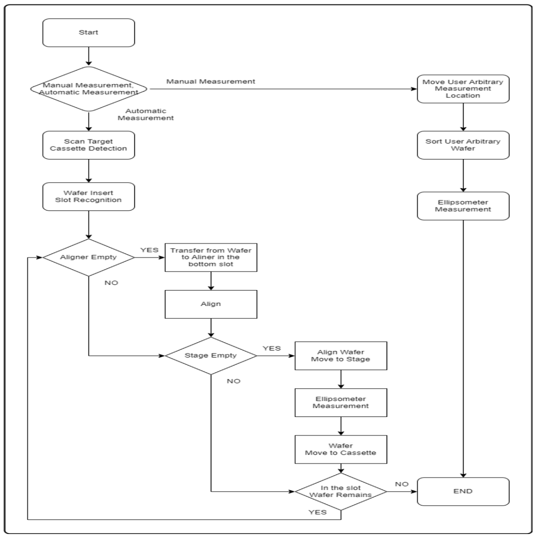

Fig. 4. Whole System Flowchart.

4. Implemenation and Results

4.1 Motor Control and Laser Sensor Linkage

STD-LP2 was used for the Load Port of this study. The WTR robot used STD-WTR128. The CCD Aligner used AL128. The Ellipsometer device used M-2000 [9].

Fig. 5 is a diagram that designs hardware based on the LM Bearing and the precision control motor for the implementation of the precision Wafer Stage. In addition, a sensor network and a data collection analysis system were established to measure this. Thereafter, a computing system for motor control and laser sensor interworking was established. Considering the combination of the Ellipsometer System and WTR, the Wafer holder and Y-axis configuration can be transferred and returned. In the case of the Wafer holder, the Wafer is adsorbed using a vacuum, so that the Wafer movement does not occur when moving to the stage. 6-in, 8-in, and 12-in wafers may be mounted by giving a step to the holder so that wafers having various specifications may be mounted.

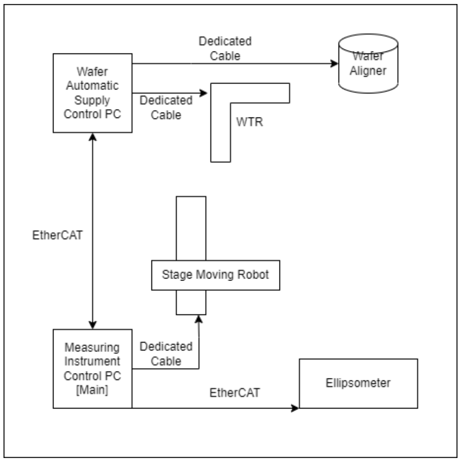

Fig. 5. Combination of Ellipsometer System and WTR.

4.2 Edge Precision Control Module for Data Analysis and Utilization

Fig. 6 shows the entire software for the system. Using motion control and sensor data collection modules, an Edge precision control module that can analyze and utilize data was studied and implemented as software. It was developed to facilitate code exchange between developers and maximize the efficiency of writing by developing an algorithm by API/DLL so that it can be developed as a publicized model rather than applied to a specific type of application. Looking at the S/W configuration, WTR is controlled in the JMT Control area. The Stage sends the Wafer's insertion and injection signals, the number of Wafer slots, and errors in WTR to the Ellipsometer System area, which manages measurement points and results. Based on the signals received earlier in the Ellipsometer System area, Ellipsometer's operating instructions and Ellipsometer's measurement instructions are sent to CompleteEASE, a software dedicated to Ellipsometer that processes measurement and raw data. After measurement, software communication is configured in the form of transmitting the status and measurement results of the Ellipsometer back to the Ellipsometer System, sending Stage's Wafer detection signal, Wafer measurement completed, and JMT Control.

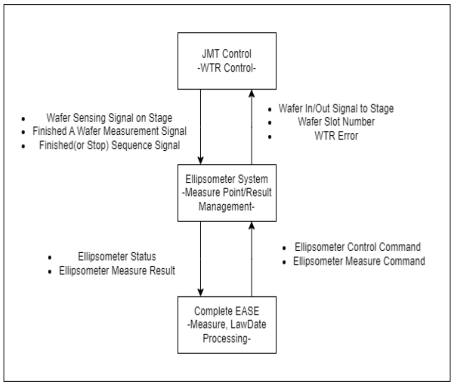

Fig. 6. All Software.

4.3 Result

Fig. 7 is an image of WTR. The WTR performed normal operation according to the order configured in the system flowchart. The WTR recognized the Wafer slot in the Wafer case and extracted the Wafer from the bottom. In the WTR, the extracted Wafer is located in the opposite direction. It was transferred to the CCD Aligner at Fig. 8 and the CCD Aligner recognized and aligned the Wafer transferred to the WTR.

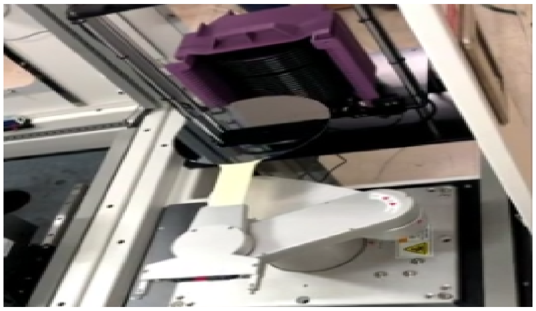

Fig. 7. WTR.

Fig. 8. CCD Aligner.

Wafer, whose alignment was completed in CCD Aligner, was recovered by WTR again and shown in Fig. 9 Transferred to Ellipsometer Stage.

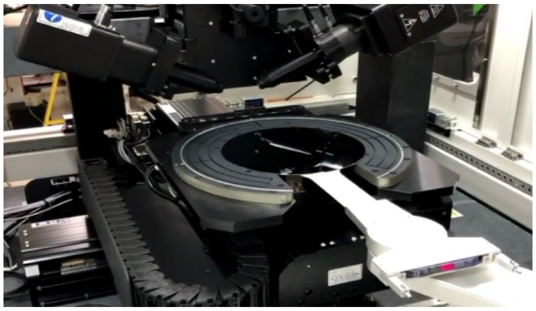

Fig. 9. Ellipsometer Stage.

The transferred Wafer was measured by Ellipsometer, and the measurement was shown in CompleteEAS, the Ellipsometer software. It is displayed in a shape such as Fig. 10 and can be checked. Fig. 10 is a result photo using a wafer position recognition system [10] using a radial calibrator. The black dot in Fig. 10 indicates the radius and angle, and the color indicates Wafer's film thickness. The unit of thickness is nm, red indicates thickness, and blue indicates thinness.

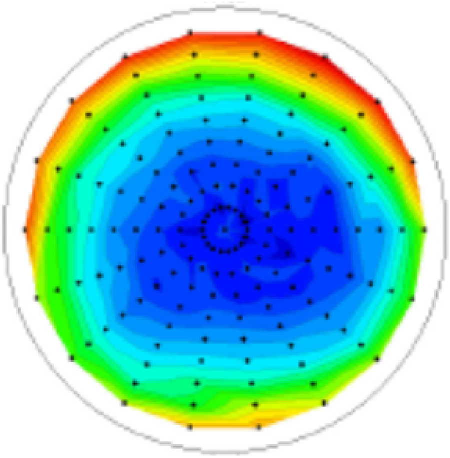

Fig. 10. Measurement Results Displayed on CompleteEASE.

4.4 Conclusion

It was developed to enable the introduction of a system in the production process of the Ellipsometer, which is difficult to link due to its high development difficulty. The actual semiconductor production efficiency was increased by reducing the time by measuring defects in the corresponding process through determination during the semiconductor process. can secure element technology such as Ellipsometer, micro pattern analysis, fine Alignment analysis, and precision Alignal. In future work, we expect to develop a device that enables more reliable alignment by mounting additional Alignment devices on Ellipsometer devices, applying a new algorithm [11] to existing CCD aligners, and mounting Ellipsometer's vision camera to increase the accuracy and speed of Wafer measurement checks with machine vision-based systems [12].

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The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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