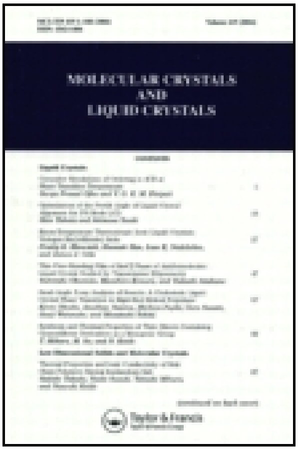

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ITO Wet Etch Properties by Various Moving Modes of Substrate in an In-Line Wet Etch/Cleaning System

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For the cost reduction in the fabrication of display panels, a reverse moving system was equipped to a new compacted in-line wet etch/cleaning system. For the possibility of the alternating movement of glass substrate during wet etch process, indium tin oxide (ITO) patterns were obtained by wet etch process in various moving modes of glass substrates in the new system and the results were compared and analyzed. The results showed that the alternating motion of substrate is superior to the normal motion of substrate in etch rate and is almost equivalent to the normal motion in etch uniformity.

Keywords: alternating motion; etch rate; etch uniformity; in-line wet etch/cleaning system; ITO

INTRODUCTION

The wet etch and cleaning process in manufacturing semiconductor device and display panel are mostly carried out in the in-line wet etch/cleaning system because of the fast operation speed and convenience. For the improvement in productivity and the maximization of profit, silicon wafer substrates for semiconductor and glass substrates for display panel tend to get larger and larger. Accordingly, the in-line wet etch/cleaning system in the production line also gets larger and larger. That requires a larger space occupied by the system [1]. The enlarged wet etch/cleaning system discharges more hume as compared with the process system in the past and requires an additional ventilation system for removing the hume. After all, the overall cost

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of installation will be increased and the increased cost will be reflected on the prices of display panels such as thin film transistor – liquid crystal display (TFT-LCD) and plasma display panel (PDP). In order to improve the cost problems, we have conducted a study to get the same effect of wet etch and cleaning process as the general in-line system while considering the efficiency in space from reducing the system size by installing a compacted wet etch/cleaning system in which a 2nd generation sized ($300 \times 400\,mm^2$) glass substrate can be loaded and used [2–4]. For the efficiency in space, a reverse moving mode function was added to the moving function of glass substrate in the wet etch/cleaning system. Therefore, a substrate can be moved back and forth in the forward/reverse direction within a fixed section of the system. For the comparison the etch properties of the alternating movement of substrate in the system and those of the normal movement of substrate in a single direction in the same system, ITO wet etch test were performed in both moving modes of substrate. The results will be investigated to check the impact made on the wet etch process when the substrate moves back and forth.

EXPERIMENTS

A compacted in-line wet etch/cleaning system was established and was equipped with a reverse moving system. The system is largely divided into the "Reaction Bath" area and "Quick Drain and Rinse (QDR)" area as shown in Figure 1. The reaction bath area, in which actual wet etch process is carried out, consists of the "Load" section for the insertion of substrate, the "Etch 1 and Etch 2" section for

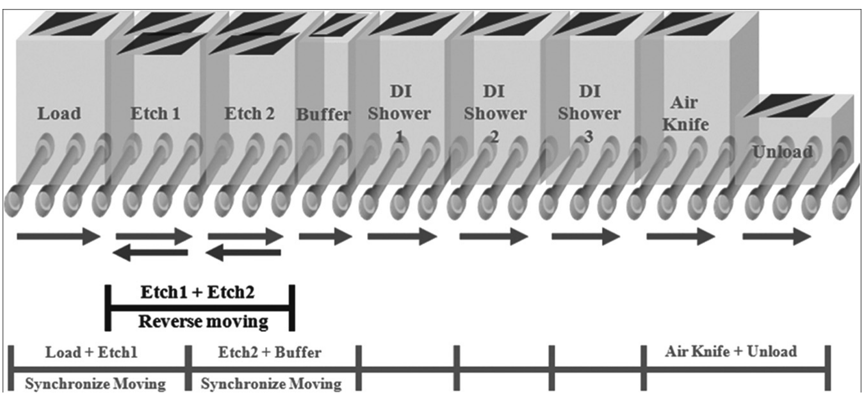

FIGURE 1 Schematic diagram of the established in-line wet etch/cleaning system and the movement of glass substrate during wet etch process.

actual wet etch process by spraying, and the "Buffer" section for the stabilization of the substrate after wet etch process and the prevention of over etch. The QDR bath area is further divided into the "Shower 1, 2 and 3" sections for the cleaning of the substrate after wet etch process and "Air Knife Unload" section for the removal of the remaining de-ionized (D.I) water on the substrate and the unloading.

The system is designed not only to support a reverse moving mode in which the substrate are moved back and forth in the forward/reverse direction in the Etch 1 and Etch 2 sections but also to make the substrate move back and forth repeatedly in one bath of both Etch 1 and Etch 2 sections. It was programmed to set the number of reverse moving times up to 999 times and it is indispensable to obtain an additional delay time of about 2 seconds per a change in the moving direction of substrate. Electronic sensor was attached on both parts that the substrate enters into each section and the substrate exits from the section. Therefore, as the sensor react when the substrate is touched in case of entering into and exiting from the section, it was possible to define the time that the substrate stays within a section.

From the process results when ITO layers were wet etched in three different moving modes, etch rate and etch uniformity were obtained and compared. One of the three moving modes is normal mode (the substrate moves in one direction after entering an etch bath) as shown

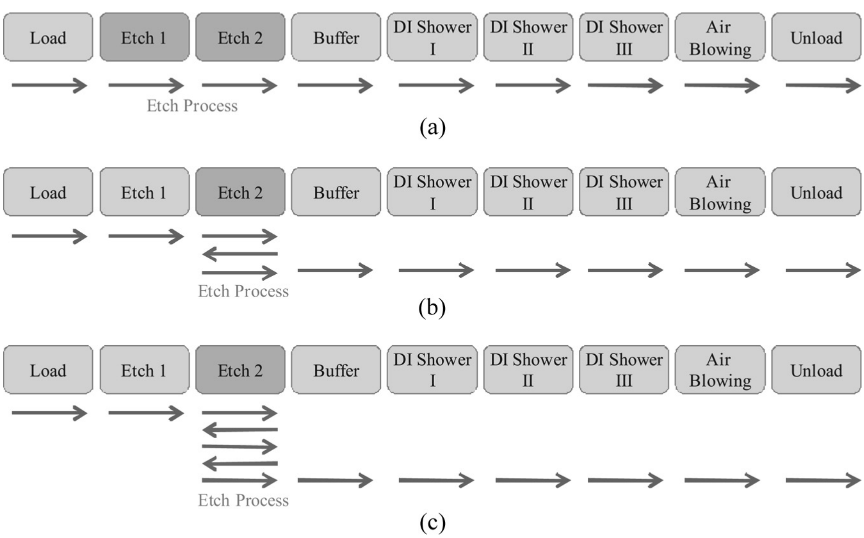

FIGURE 2 Moving modes of glass substrate in the in-line wet etch/cleaning system (a) normal mode (b) 1 reverse moving mode and (c) 2 reverse moving mode.

in Figure 2(a). The others are 1 reverse moving mode (the substrate moves back and forth in the forward/reverse direction in an Etch 2 bath) and 2 reverse moving mode (the substrate moves back and forth twice in an Etch 2 bath) as shown in Figure 2(b) and (c), respectively.

RESULTS AND DISCUSSION

Table 1 shows the time taken as a result of the movement of the substrate in each section of the in-line wet etch/cleaning system in case of three different moving modes. The "the Load–Etch 1" and "Etch 2–Buffer" sections were designed as the same section in the operation and the moving speed of the substrate was maintained as 1 m/min. In case of normal mode, the time taken in wet etch process was defined as the time taken from "the Load–Etch 1" section to "Etch 2–Buffer" except the time taken in the Load section of 25 sec. In case of reverse 1 and 2 mode, the time taken in wet etch process was defined as the time taken in "Etch 2–Buffer" because the wet etch was only carried out in Etch 2 bath. The time taken purely in wet etch process were obtained as shown in Figure 3. For normal mode and 1 reverse moving mode, the overall wet etch times were almost the same as the wet etch process was carried out only in Etch 2 section in case of reverse moving modes.

In the wet etch process, the pressure of spray nozzle was maintained as 0.1 Mpa during wet etch and D.I showering. The ITO etchant was composed of 23.0% hydrochloric acid, 2% nitric acid, and 75% D.I water and was fixed at 40°C. 2.8 mm thick glass substrates on which ITO was sputtered with a thickness of 1300 Å were used in the experiment [5]. After wet etch and D.I. showering, the remained D.I. water was removed on the glass substrate by air blowing at the pressure of 3 kg/cm^2. After all the process in various moving modes, etch thickness were measured by using an α-step at the 16 points

TABLE 1 The Time Required for the Movement of Substrate in Various Moving Modes (sec)

Region / Moving mode	Load + Etch 1	Etch 2 + Buffer	DI shower (1,2,3)	Air Blowing + Unload
Normal	82.3	96.2	53.2	34.5
1 reverse moving	82.0	147.2	51.7	34.0
2 reverse moving	84.3	201.3	53.1	30.4

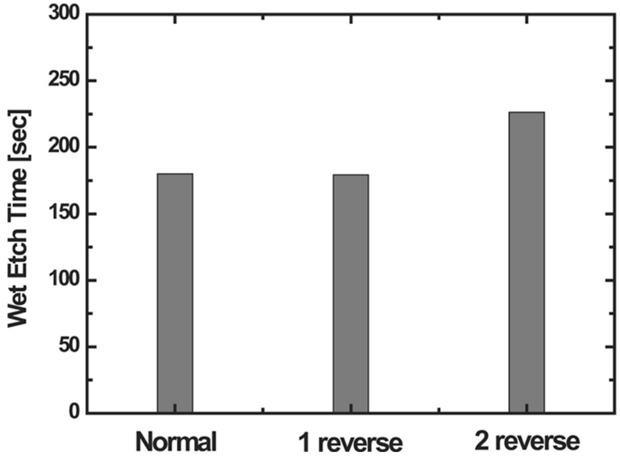

FIGURE 3 The time taken purely in wet etch process in case of Figure 2(a), (b), and (c).

on the $300 \times 400\,mm^2$ sized glass substrate. Then etch rates and uniformities were calculated and compared.

Figure 4 shows the averages and the standard deviations of the etched thickness obtained from the experiment. The average thickness was 811.4 Å in the normal mode, 1102.3 Å in the 1 reverse moving mode, and 1334.9 Å in the 2 reverse moving mode. The standard

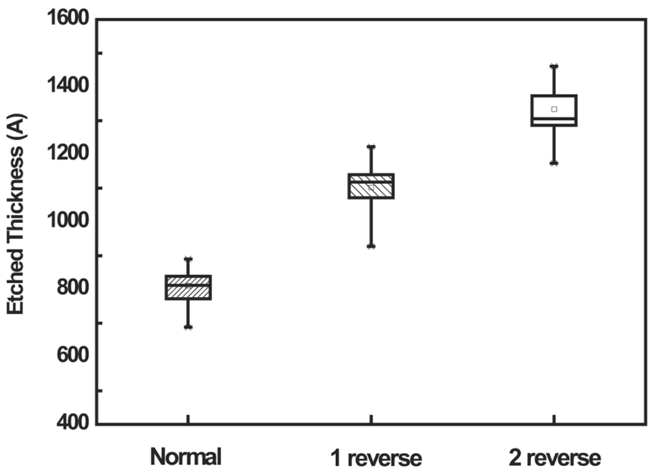

FIGURE 4 The averages and the standard deviations of the etched thickness of ITO.

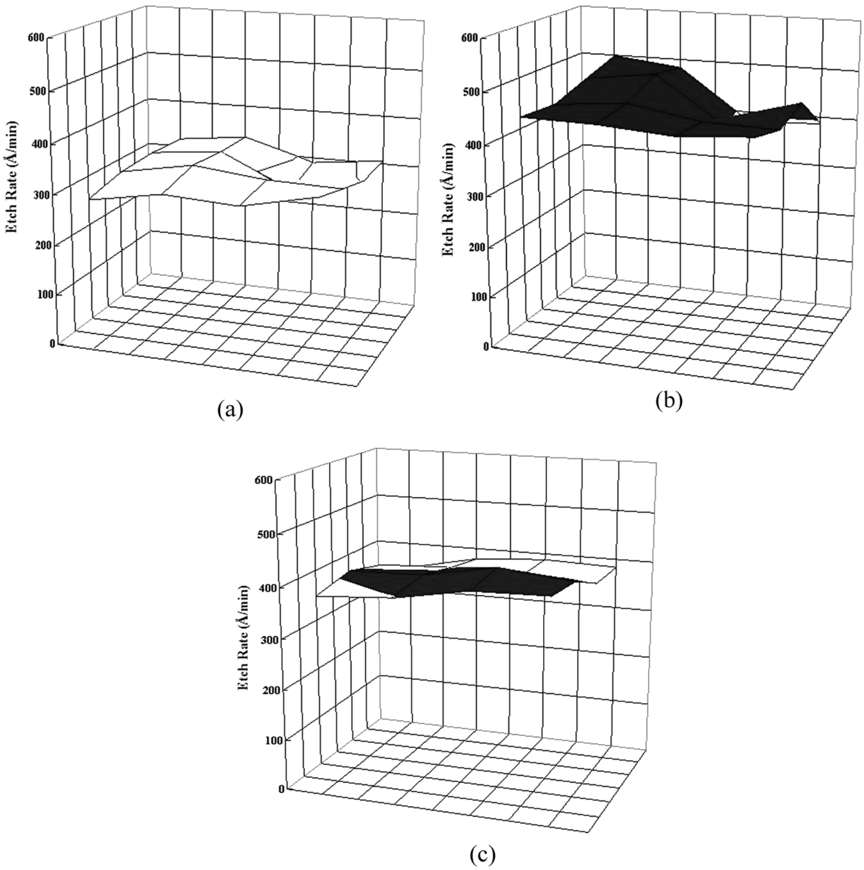

FIGURE 5 The distribution of etched rates of ITO at 16 points of (a) normal mode (b) 1 reverse moving mode and (c) 2 reverse moving mode.

deviation was 51.7 Å in the normal mode, 87.0 Å in the 1 reverse moving mode, and 73.5 Å in the 2 reverse moving mode. From the Figures 5 and 6, the distributions of etch rates on the whole glass substrate were obtained and the averages and the standard deviations were calculated. The average etch rate was 316.9 Å/min in the normal mode, 449.9 Å/min in the 1 reverse moving mode, and 397.3 Å/min in the 2 reverse moving mode. The standard deviation was 19.5 Å/min in the normal mode, 34.8 Å/min in the 1 reverse moving mode, and 21.9 Å/min in the 2 reverse moving mode. The etch rate in the 2 reverse mode was smaller than that in the 1 reverse mode by about 50 Å/min.

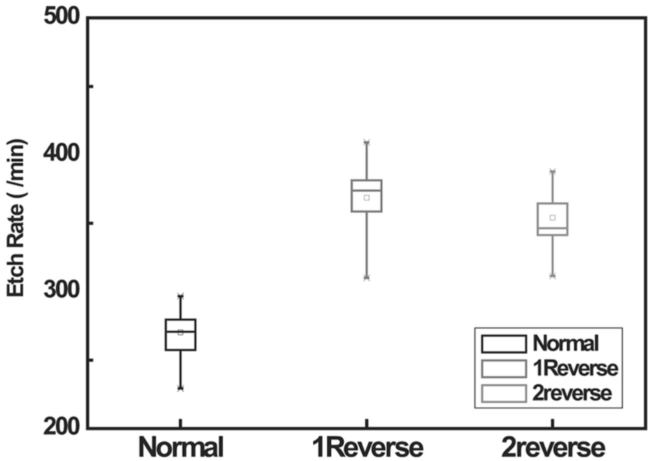

FIGURE 6 The averages and the standard deviations of the etch rates of ITO at 16 points of Figure 5.

Although the time taken in wet etch process in the normal mode is almost the same as that in the 1 reverse moving mode, the etch rate appears to be much larger in the 1 reverse moving mode than normal mode. Moreover, the etch uniformity has appeared a bit larger in 1 reverse moving mode than in normal mode. From the comparison and the analysis, it is possible to apply the reverse moving mode in wet etch process in an in-line wet etch/cleaning system without any degradation in wet etch process.

CONCLUSIONS

In order to improve the efficiency in the space required for the installation of equipments and to reduce the fabrication cost of semiconductor/display panel, a new in-line wet etch/cleaning system was established with a reverse moving function of glass substrate. After wet etch process in various moving modes, the etch distributions and averages were obtained and compared from the wet etched ITO glass substrates by measuring the thickness of remaining ITO. From the comparison and the analysis of normal mode that the substrate moves in a single direction and reverse moving modes that the substrate moves back and forth in a specific section, it was possible to conclude that the reverse moving mode is superior to the normal mode in etch rate and is compatible to the normal mode in etch uniformity while reducing the space needed in the manufacturing.

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