Introduction

A review SEM is a scanning electron microscope (SEM) used for observing defects and surface shape of semiconductor devices. This SEM has various features: It can be installed in a semiconductor clean room and can observe wafers without cleaving them. It can navigate to defect coordinate positions obtained by defect-inspection systems using light or an electron beam. In recent years, it is equipped with an Auto Defect Review (ADR) function.

The JWS-3000 is a high-performance review SEM that can observe the entire surface of 200 mm and 300 mm wafers, tilted up to 45°. Figure 1 is an external view of the JWS-3000. The features of the JWS-3000 are described below.

Features of Instrument

High resolution observation

As shrinkage of semiconductor devices progresses, users of review SEMs demand higher resolution. The JWS-3000 incorporates a newly designed strong-excitation conical objective lens that is based on a semi-in-lens used for a field-emission (FE) SEM. In addition, a bias voltage up to −1.5 kV can be applied to the substrate (in Super Fine mode). These improvements achieve a high resolution of 3 nm at an accelerating voltage of 1 kV.

Figure 2 shows comparative images of contact holes at an accelerating voltage of 1 kV, taken with a conventional instrument, the JWS-8755S (Fig. 2 (a)) and the JWS-3000 (Fig. 2 (b)). The resolution of the JWS-8755S is 5 nm at 1 kV, but inferior to 3 nm achieved with the JWS-3000. Figure 2 (b) clearly shows a more highly resolved contact-hole image than Fig. 2 (a).

Since resists and low-k materials on wafers are damaged by a high-accelerating-voltage
electron beam, users of review SEMs demand low-accelerating-voltage observation. Figure 5 shows that the JWS-3000 can provide high resolution at low accelerating voltages, compared with conventional instruments. In conventional SEMs, resolution deteriorates when the accelerating voltage is low (Fig. 5 (a)). In the JWS-3000, Super Fine mode allows observation with relatively high resolution even at low accelerating voltages (Fig. 5 (b)). The JWS-3000 can reduce the accelerating voltage down to 100 V.

**Improved ADR and automatic functions**

The JWS-3000 has an improved ADR function. In order to detect defects even on flat samples using the ADR function, the Auto Focus function has been enhanced (Fine Auto Focus). Auto Focus using image processing and a wafer-height sensor make ADR possible even for samples on which focusing is difficult (see Fig. 6). That is, wafers subjected to chemical mechanical polishing (CMP) and bare silicon (Si) wafers can be easily focused for ADR analysis. In addition, improvements to the stage and image acquisition expand the defect-review throughput up to 900 DPH (defects per hour) or more (when a JEOL standard sample is used).

**Imaging of height information on defects**

In high-accuracy classification of defects, height information on defects is sometimes useful. For this purpose, it is valuable to carry out tilt observation, or to acquire SEM images showing “shadows” of defects using multiple detectors. The JWS-3000 can perform both tilt observation and acquisition of shadow images. Tilt observation has conventionally been carried out manually, because automatic observation provided insufficient accuracy of stage positioning and took a long time to...
correct wafer position along with stage tilt. In contrast, the JWS-3000 has an improved stage-positioning accuracy for tilt observation, which is achieved by correcting the stage-stop position using the height information on the wafer surface. This improvement makes tilt ADR analysis easy (Fig. 7).

Furthermore, for the acquisition of shadow images, the JWS-3000 incorporates two detectors (right and left) inside the objective lens. These detectors selectively detect electrons emitted in the oblique directions, enabling the JWS-3000 to obtain shadow images (see Fig. 8). Since the length of a shadow depends on the height of the defect, the shadow image offers height information on defects.

Imaging of simple electrical defects

Review SEMs can observe not only defects in shape but also simple electrical defects. If a semiconductor device has a simple electrical defect, when a wafer is illuminated with an electron beam, a voltage difference arises on the wafer surface and this difference is detected as a voltage contrast. Figure 9 shows comparative voltage-contrast images of a wafer on which contacts are buried, taken with the JWS-3000. Figure 9 (a) is an image obtained using the left detector, and Fig. 9 (b) shows an image obtained using the upper detector. Since the upper detector of the JWS-3000 is sensitive to the sample potential, Fig. 9 (b) demonstrates that simple electrical defects can be detected by means of the upper detector. This detector is also suitable for observation of the bottoms of contact holes (see Fig. 10).

Employment of new systems

The JWS-3000 employs a graphical user interface system that runs on a PC (see Fig. 11). New features such as a recipe wizard are introduced, making instrument operation easy. The JWS-3000 also adopts a system that supports remote operation. Using this system, users can control the instrument from outside of a clean room.

Summary

We have briefly explained the JWS-3000 high resolution review SEM. This review SEM achieves high resolution at low accelerating voltages by the employment of a newly designed electron optical system. This instrument also has improved automatic-observation functions in addition to the highly regarded manual observation of the JWS series. The JWS-3000, incorporating many new features presented in this paper, will be expected to play an important role in defect observation of semiconductor devices, as well as in surface-shape observation of wafer surfaces.
Fig. 9. Voltage-contrast images taken with the JWS-3000.

Fig. 10. Images of the bottoms of contact holes taken with the JWS-3000.

Fig. 11. New graphical user interface.