JAS-WPA Series
Wafer Surface Particle Analyzer

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Introduction

A review station employing an optical microscope and a wafer review SEM (scanning electron microscope) has been used extensively as morphology-observation-based particle and defect inspection tools for yield management in the manufacturing process of semiconductor devices and LCD panels. Recently, an element analysis system consisting of a wafer review SEM installing an EDS and tools permitting FIB milling have appeared on the market, and are contributing to the identification of component elements and the structural analysis of particles and defects. In the particle analysis, however, even the element analysis methods, which are effective for analyzing particles consisting of simple elements such as metals, have insufficient ability to identify particles consisting of compounds (particularly organic compounds) having complex structure. In such cases, it is necessary to rely on morphological classification, and even skillful engineers feel it difficult to perform accurate substance identification. To overcome this problem, JEOL employs an entirely new approach, and is manufacturing and supplying the JAS-WPA series of wafer surface particle analyzer, which is a defect review tool for analyzing fine particles on the surfaces of wafers, based on Micro Raman Spectrometer. The outline of this instrument is given below together with measurement examples.

Outline of the Instrument

This instrument combines a laser Raman spectrometer and a review system for wafer inspection based on an optical microscope. The overall photograph of the instrument is shown in Figure 1. The review system has a wafer transfer function, an XY stage shift function that is linked to the positional information of defect (corresponding to the coordinate files of KLA/Tencor, Hitachi Electronics Engineering, and so on), and an auto focus function, enabling defective particles to be easily captured within the visual field of microscope. Overall, this instrument is a defect analysis tool having the function for observing the Raman scattering spectrum generated from a particle irradiated by a laser beam, in addition to the normal particle review function. The spectrum acquired by the Raman spectroscopy is characteristic of the substance concerned, and thus permits qualitative analysis. This spectral analysis method is particularly suitable for identifying specific compounds. The spatial resolution related to Raman measurement depends upon the wavelength of laser used and also the condensing rate (magnification) of the objective lens. When a diode laser (wavelength 532 nm) is used and the magnification of the objective lens is 150° , an irradiation beam diameter of 0.7 µm is attained. This instrument comes with high performance Windows-based software having various data-processing functions and a report-making function for improved processing of spectrum data, together with library-search software based on the spectrum comparison. Thus it enables even inexperienced persons to easily determine the substances contained in a particle. Furthermore, an extremely high rate of substance identification can be achieved by combining the customer’s own database with the database constructed by JEOL.

The following is the actual work procedure for particle analysis.
1. The wafer is extracted from the carrier by a robot arm, and then after global alignment it is transferred to the XY stage. (Compatible with all types of wafers: including 125/150/200 mm, V-notch and OF.)
2. The XY stage moves the particle accurately into the field of view of the microscope, based on the XY coordinate data sent from the defect inspection system. (Linked to the defect coordinate file. The XY stage positional accuracy: 1.5 µm.)
3. The pinpoint laser-beam irradiates the particle through the objective lens, to cause Raman scattering. (The laser irradiation power is only several hundred of µ W; therefore, the particle is almost undamaged.)
4. A spectrum is acquired by an ultra-high-sensitivity Raman spectrometer, and the com...


Fig. 2. μm size of particle was measured by WPA and identified as polypropylene.

Fig. 3. Another sub-μm size of particle was measured by WPA and identified as amorphous carbon.

Fig. 4. Results of polypropylene and amorphous carbon analyzed by EDS.

Fig. 5. Results of various size of polystyrene particles analyzed by WPA.

Example of Particle Analysis

Figures 2 and 3 show analysis examples of polystyrene particles on a bare wafer. A satisfactory spectrum was obtained in the measurement period of several tens of seconds. From the results of the library-search (output to the third possibility shown on the right side of the chart), the particles were identified as polypropylene (the component elements are C and H) and amorphous carbon (the component element is C alone). The same specimen was subjected to the element analysis using SEM + EDS, and the results obtained are shown in the chart of Figure 4. In the EDS analysis, hydrogen cannot be detected, and so only carbon is detected in the both kinds of particles. Therefore, they are identified as the same kind of particle. On the other hand, it can be seen that the Raman spectroscopy enables both kinds of particles to be clearly differentiated from each other. In this case, it is found that polypropylene comes from the wafer case, and amorphous carbon comes from the etcher, enabling appropriate dust preventive countermeasures to be taken. In addition, this method can identify a variety of substances, both organic and inorganic compounds. Examples of identifiable organic substances include various plastic materials (Teflon, polyester, acrylic resin, etc.), oils and fats (hydrocarbons, silicones, fluorine-contained compounds, etc.), and human proteins. Examples of identifiable inorganic substances include products of reactions between acids and alkalis such as film-degeneration substances typified by silicates, sulfates and nitrates. The WPA is a reliable tool that clarifies the cause of occurrence of defects and particles.

Limit Size in Measurement

Figure 5 shows the results obtained from the scattering measurement of polystyrene particles of various size on a wafer. From this data, it can be seen that the spectrum can be obtained even for a 0.2 μm sized particles. When the beam diameter is larger than the particle diameter or the laser beam passes through the particle, the signal will be interrupted by the spectrum originating from the silicon substrate. However, by removing this interference using spectrum subtraction, it is possible to detect only the spectrum signal generated from the particle itself. Such data processing can be implemented as an automatic function. Effective use of this function enables to analyze plastic and carbon (amorphous carbon, graphite) particles with 0.2 μm or less in size.

Future Development

We intend to produce a lineup of dedicated wafer inspection systems compatible with 300 mm wafers. The spatial resolution of the order of sub-micrometers and excellent qualitative analysis capabilities offered by the Raman spectroscopy can be utilized for the analysis of particles not only on wafers but also on masks and FPD (flat panel display). For this reason, we are currently studying the manufacturing of a highly versatile model capable of coping with various kinds of specimen shapes.