Total reflection X-ray fluorescence spectrometer

TXRF 3800e

1. Introduction

Total reflection X-ray fluorescence (TXRF) spectrometry is widely used in semiconductor manufacturing processes for nondestructive analyses of metallic contamination on wafer surfaces. Sensitivity requirements for such devices have increased in recent years. Currently, metallic contamination in advanced device manufacturing processes is controlled to 10^8 atoms/cm^2. In a conflicting trend, the growing diversification of semiconductor devices has generated demand for low-cost equipment with advanced functionality rather than sensitivity. The TXRF 3800e is a low-cost, total reflection X-ray fluorescence spectrometer with advanced functions that meets these demands.

2. Low cost

2.1. Sealed X-ray tube

The TXRF 3800e incorporates a sealed X-ray tube to reduce the frequency of filament changes and X-ray source maintenance compared to conventional equipment, thereby improving uptime.

2.2. SDD (Silicon Drift Detector)

The TXRF 3800e is equipped with an SDD (Silicon Drift Detector) that requires no liquid nitrogen cooling. This detector eliminates labor charges associated with liquid nitrogen replenishment as well as the initial investment for peripheral equipment, such as a liquid nitrogen generator. Operating costs are therefore lower.

2.3. Single-target, dual-beam system

Two types of excitation X-rays are software-selectable: W-Lβ (9.67 keV) and H.E. (High Energy excitation X-rays obtained by monochromatizing the 24 keV portion of the continuous spectrum). Switching excitation X-rays allows optimized measurement of various elements with a single X-ray tube, ranging from transition elements to heavy elements. This reduces operating costs compared to conventional systems based on multiple X-ray tubes. Figures 1 and 2 show typical measurement examples.

2.4. Reduced space requirements

The TXRF 3800e has a footprint of 1 m×1 m (main unit) for the most effective use of valuable clean room space.

3. Multifunction

3.1. Sweeping-TXRF

Sweeping-TXRF capability, optional with the TXRF 3800e, enables high-speed, full-surface mapping. Figure 3 shows a measurement example. Full-surface measurements with this function make it possible to detect contamination on wafer surfaces that might otherwise be missed by conventional five-point or nine-point measurements.

3.2. ZEE-TXRF

ZEE-TXRF capability, standard with the TXRF 3800e, enables zero edge exclusion measurements, right up to the wafer edge. As shown in Figure 3, ZEE-TXRF

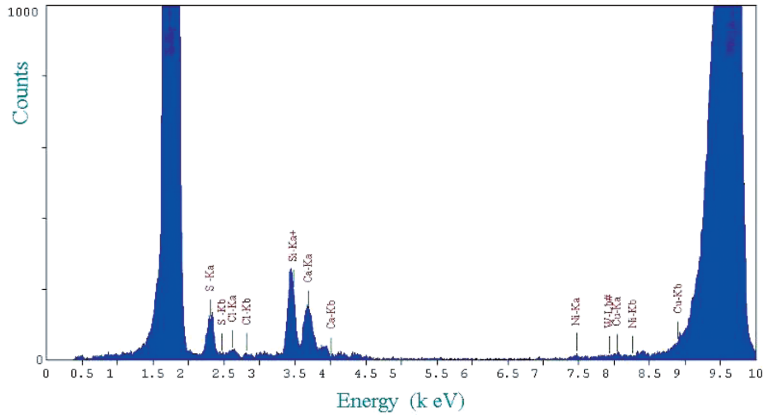

Fig. 1. Measurement using W-Lβ X-rays (transition elements).

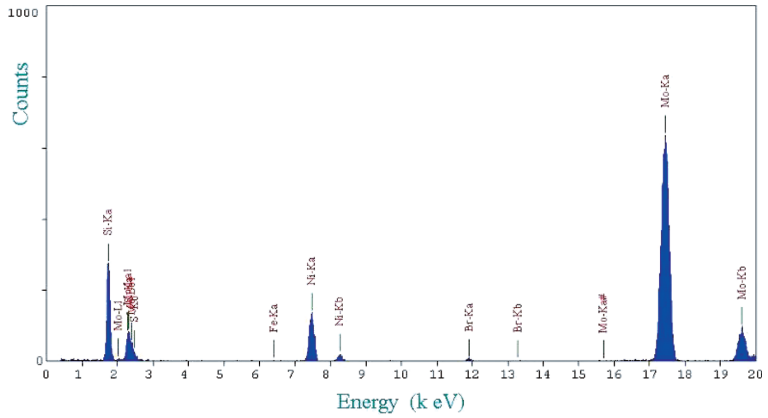

Fig. 2. Measurement using W H.E. (heavy elements).

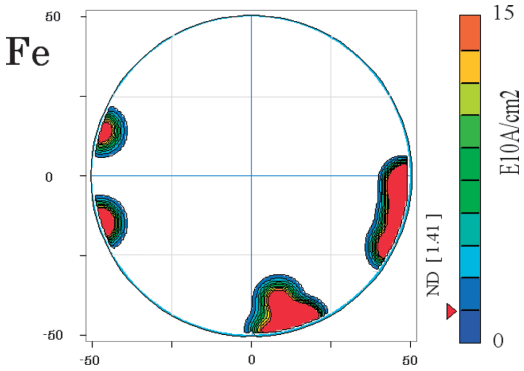

Fig. 3. Sweeping-TXRF measurement result.

Table 1. Detection limits for representative elements.
(Unit: atoms/cm^2)

	Fe	Ni	Cu	Hg
TXRF 3800e	1.6×10^9	1.6×10^9	3.2×10^9	2.0×10^{10}

is capable of detecting contamination at the wafer edge that is overlooked by conventional equipment.

4. Performance

4.1. Detection limits

Table 1 shows the detection limits of the TXRF 3800e for representative elements. For most of the elements, the TXRF 3800e offers a detection limit of the order of 10^9 atoms/cm^2.

Table 2. Repeatability (including angle adjustments).
(Unit: 10^{10} atoms/cm^2)

n	K	Fe	Ni	Cu
1	89.99	2.27	4.66	8.74
2	81.52	1.93	5.09	9.74
3	82.42	2.42	4.56	9.31
4	81.42	2.41	5.87	8.36
5	84.13	1.10	5.71	8.02
6	81.83	2.08	4.90	8.54
7	94.46	2.14	5.35	9.62
8	88.17	2.08	4.59	8.84
9	97.59	1.67	4.70	9.97
10	91.58	1.27	5.19	9.67
Average	87.31	1.94	5.06	9.08
Maximum	97.59	2.42	5.87	9.97
Minimum	81.42	1.10	4.56	8.02
Sigma	5.92	0.46	0.47	0.67
R(%)	18.52	68.30	25.90	21.44
RSD (%)	6.78	23.55	9.23	7.36

4.2. Repeatability

Table 2 shows the results of repeatability measurements (ten repeats including incident angle adjustments) for a sample with contamination levels of the order of 10^{10} atoms/cm^2, contamination levels typically encountered in real-world processes.