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Time-of-Flight Secondary Ion Mass Spectroscopic Analysis of Surface Contamination

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Abstract— *The identification of the nature of surface contaminants is important in designing the corrective actions to prevent the recurrence. Herein, Fourier transform infrared (FTIR) spectroscopy and time-of-flight secondary ion mass spectroscopy (TOF-SIMS) were used to analyze oil-like residue on the surface of an IC die. The results indicate that the true source of the oil residue is the ionizer, and eliminated the possibility of compressor oil. Correct identification of the source resulted in the elimination of the contaminant directly from the source.*

Keywords— *Contaminants, surface analysis, FTIR, TOF-SIMS, oil.*

I. INTRODUCTION

The analysis of surface contaminants in complex materials such as silicon integrated circuits is a challenging task due to the inherent intricacy of the base material. Surface analytical techniques such as energy dispersive spectroscopy (EDS), Fourier transform infrared (FTIR) spectroscopy, Auger electron spectroscopy (AES), time-of-flight secondary ion mass spectroscopy (TOF-SIMS) and X-ray photoelectron spectroscopy (XPS) are advanced analytical tools often used to study surface contaminates. Depending on the nature of the contaminant established from preliminary analysis, the appropriateness of the method is established.

Herein, an oil residue was found to contaminate the surface of a die sample. FTIR and TOF-SIMS analyses were used to ascertain the nature of the contaminant. Results provided direction in the problem resolution, which is the mitigation of the oil from the source.

II. EXPERIMENTAL DETAILS

Optical inspection of dice prior assembly flagged the occurrence of oil-like surface contaminant. Process mapping identified two possible oil sources, the ionizer oil and the compressor oil. FTIR analysis using Bruker Hyperion Tensor II was used as preliminary analysis focusing on oil filter, mirror die and reject die. IONTOF TOF.SIMS[5] (Time-of-Flight Secondary Ion Mass Spectrometer) equipped with a Reflectron TOF Analyser and EDR Secondary Ion Detector, using Bi+ primary beam was used for the 2^{nd} level analysis to compare the oil-like residue with the compressor oil and ionizer oil. Hitachi S4000 Scanning Electron Microscope (SEM) was used to image the ionizer cathode.

III. RESULTS AND DISCUSSION

Oil-like residues at localized regions on the wafer surface was detected during optical inspection prior assembly. FTIR spectroscopy was performed on mirror die, good and affected dice, oil, filter and simulated oil on die pad. Comparative analysis shows that signatures of oil residues are present on the filter, mirror die and reject die. As a reference, oil was placed on a good die (oil on pad) to check the signature of oil on the surface. The method was not able to differentiate based on the nature of the oil. Hence, it was recommended to perform TOF-SIMS analyses to check if the oil from the source and the suspected contaminant in the ionizer cathode are similar, and determine which material is the contaminant on the surface.

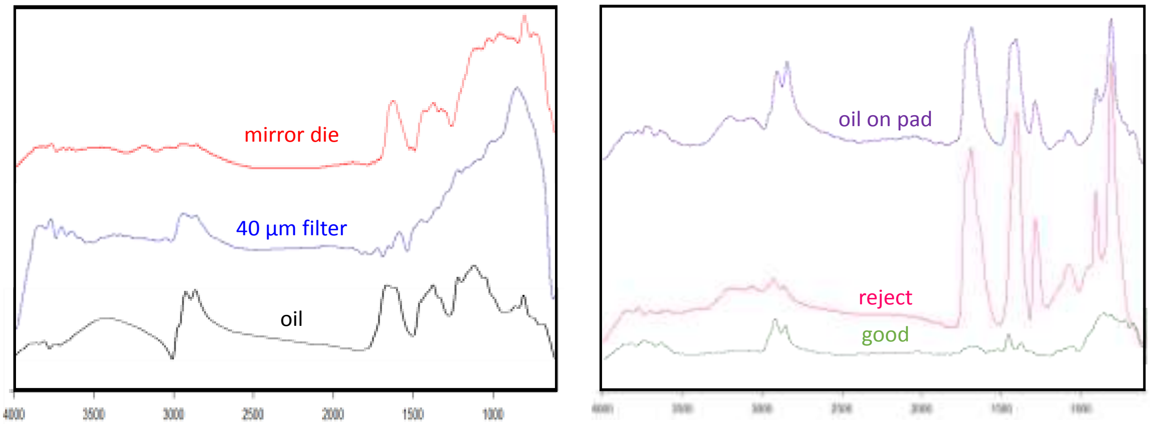

Fig. 1. FTIR spectra of reference, contaminated and suspected materials.

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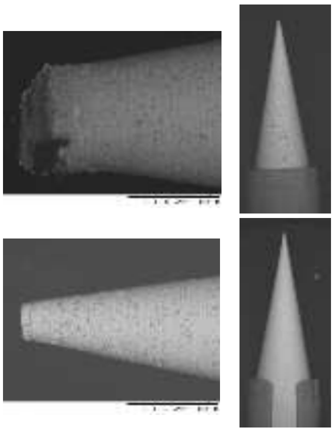

Fig. 2. Representative SEM images of used (top) and unused (bottom) ionizer nozzles.

Suspecting that the oil is coming from the ionizer, the focus of the analysis was shifted to the ionizer cathode. SEM images of the ionizer cathode were imaged to compare if structural features are altered during ionizer use. Fig. 2 shows that the the ionizer cathode is tapered during use. The increase in the surface area of the tip was observed in used ionizer, resulting in larger area available for accumulation of contaminants. Accumulation of contaminants is evident in the TOF-SIMS spectra of used ionizer cathode (higher intensity of mass fragment) as shown in Fig. 3.

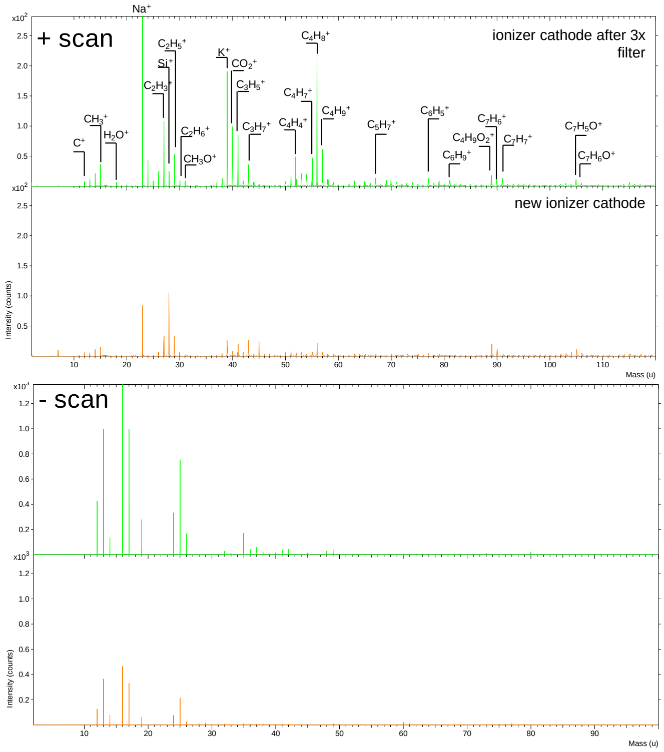

Fig. 3. TOF-SIMS spectra of the ionizer cathode nozzle; new ionizer (orange) and used ionizer (green).

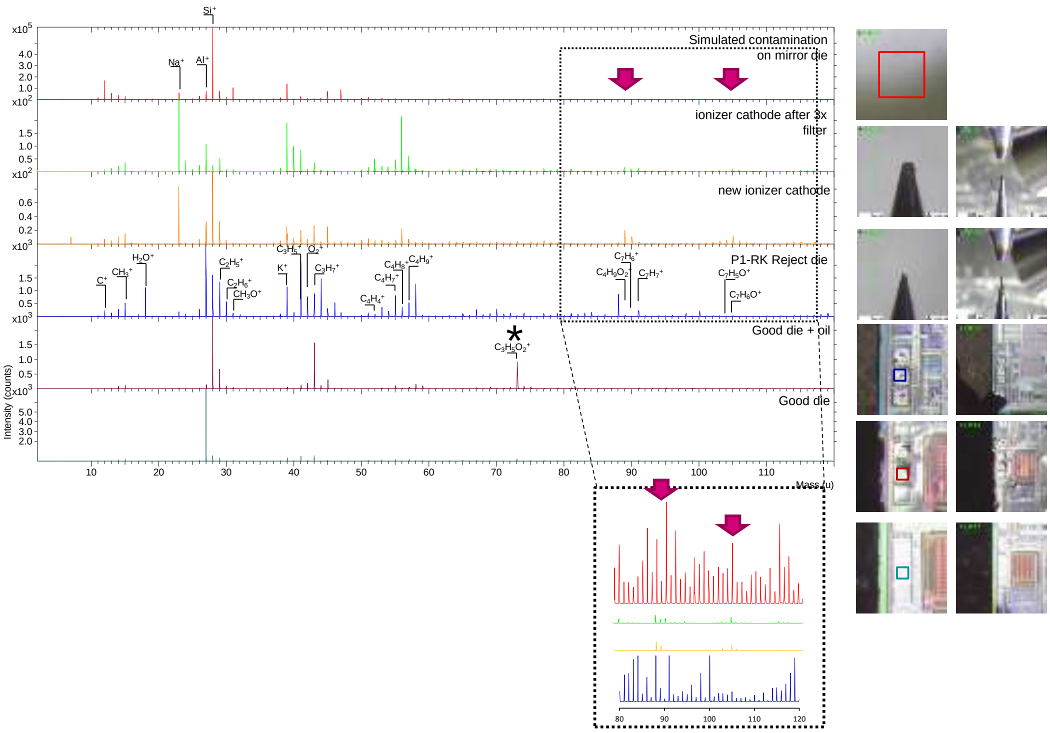

Fig. 4. Positive scan TOF-SIMS spectra of (bottom-top) good die, good die with oil, reject die, new ionizer cathode, used ionizer cathode and simulated contamination on mirror die with corresponding image of the ROI. Inset: blow-up region for clarity.

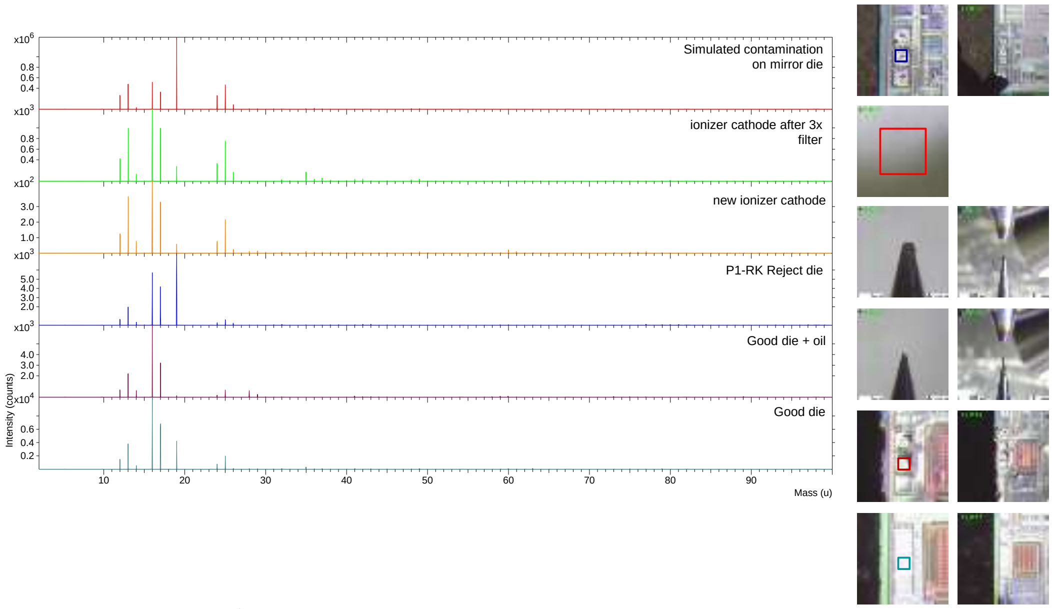

Fig. 5. Negative scan TOF-SIMS spectra of (bottom-top) good die, good die with oil, reject die, new ionizer cathode, used ionizer cathode and simulated contamination on mirror die with corresponding image of the ROI.

Comparative analysis of the positive fragments (Fig. 4) indicate that the most likely source of the surface contamination is the ionizer oil. The inset shows the peaks that are present only in samples exposed to the ionizer indicating that the ionizer is the source (or medium) of the contaminant. The compressor oil fragment (*) is not present in other samples confirming that the contaminant on the die surface is not the compressor oil. Comparative analysis of the negative fragments (Fig. 5) does not provide distinctive information. However, the positive scan is sufficient in the speciation of the oil-like residue found on the die surface.

IV. Conclusion

FTIR and TOF-SIMS analyses were performed to determine the nature and source of the oil-like contaminant on the die surface. IR peaks of the contaminated surfaces and oil appear to be similar but could not provide sufficient information on the nature of the oil contaminant. TOF-SIMS results indicate that the contaminant on the die is not the same as the compressor oil. Moreover, the contaminant initially present on the ionizer increases with use, and the contaminant on the dice has similar signatures with the contaminant on the ionizer (characteristic mass fragments) indicating that the ionizer is the source (or medium) of the contaminant.

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