Application Note SI-00705

FT-IR Microscopy and Imaging for Failure Analysis in Electronics Manufacturing

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Introduction

The electronics industry relies heavily on failure analysis (FA) to maximize productivity and to minimize downtime. Traditionally, FA has revolved around indirect methods that attempt to use changes in system function to elucidate deficiencies in the manufacturing process or, more recently, advanced microscopy methods such as Scanning Electron Microscopy (SEM) or Transmission Electron Microscopy (TEM) that can help identify the atomic composition of contaminants observed on a given analytical sample.

FT-IR spectroscopy and imaging holds great potential in addressing the FA needs of the electronics industry. The ability of FT-IR to identify the chemical composition of a foreign material holds the potential for increasing the quality of work in FA applications, reducing manufacturing downtime and increasing the efficiency and productivity of manufacturing operations. FT-IR microscopy and imaging allow the power of FT-IR spectroscopy to be deployed on much smaller scales than traditional macroscopic FT-IR measurements. To date, very little molecular spectroscopy has been used for materials identification in these situation.

Instrumentation

All measurements were performed with a Varian Stingray FT-IR Imaging System consisting of a Varian 7000 FT-IR equipped with a 600 UMA microscope. The microscope was configured with both a single-point, narrow-band MCT detector and a 64 x 64 pixel or a 128 x 128 pixel Lancer Focal Plane Array detector. Detector selection was provided by a software-controlled flipper mirror. The microscope was equipped with a Ge micro-ATR objective and a grazing angle objective. Spectral backgrounds were run using a gold mirror.

Sample Preparation

All samples were measured as received with no additional preparation. All measurements were performed with the microscope in reflectance mode.

Results and Discussion

FT-IR Microscopy

A number of samples were presented for analysis. Sample 1 was from a pad area on a printed circuit board (PCB). The sample contained obvious contamination as shown in Figure 1. The spectrum obtained from this material is shown in Figure 2. A search of the spectrum in Varian's spectral libraries illustrated a match with inorganic oxides such as those that could be formed by solder.

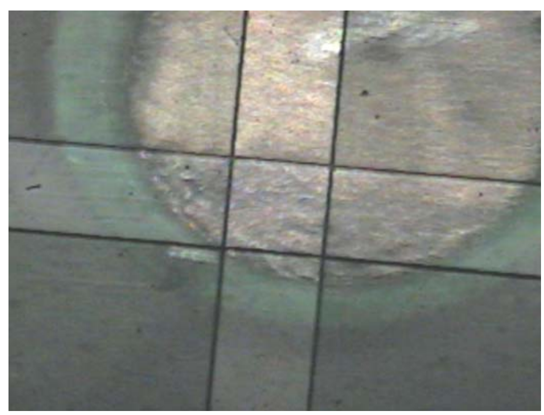

Figure 1. Visible image of Sample 1 including ViewThru apertures of the Varian microscope. Analysis area is represented by the square box formed by the four aperture blades in the image centre.

Another sample was presented with visible contamination as shown in Figure 3. The reflectance spectrum from this sample is shown in Figure 4. Based on earlier published results[1] and knowledge of the sample, this contaminant appears to represent solder mask on the PCB board. Further investigation of the specific solder masks used in the manufacturing of this PCB board is warranted for a definitive identification.

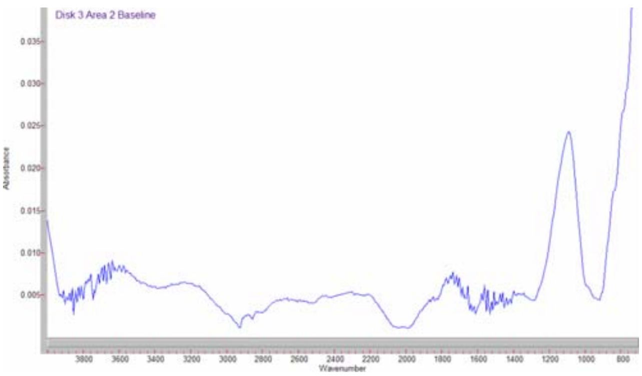

Figure 2. FT-IR reflectance spectrum from Sample 1. Measurement was acquired at 8 cm^{-1} spectral resolution and 512 scans.

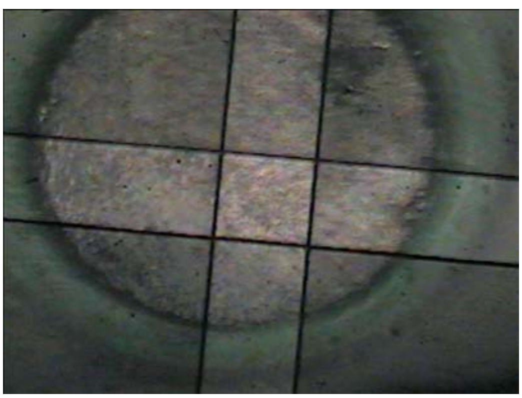

Figure 3. The visible image of Sample 2 including ViewThru apertures of the Varian microscope. Analysis area is represented by the square box formed by the four aperture blades in the image centre.

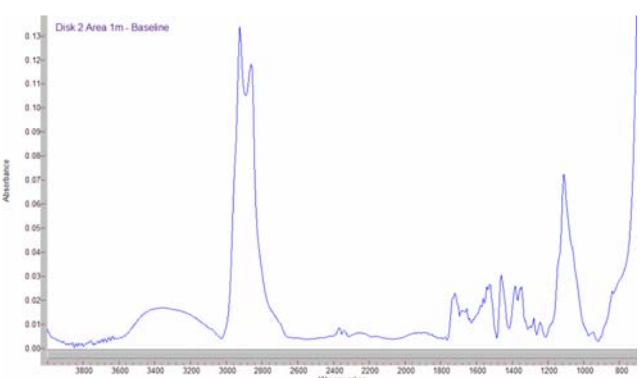

Figure 4. FT-IR reflectance spectrum from Sample 2 Measurement was acquired at 8 cm^{-1} spectral resolution and 512 scans.

FT-IR Imaging

FT-IR imaging may also be used to investigate the spatial distribution of contaminants on a PCB board. FT-IR images generally represent the spatial distribution of a particular spectral band on or in a sample. As a result, the spatial distribution of chemically-specific materials may be determined in a relatively rapid fashion. Figure 5 shows the FT-IR image obtained from the entire pad shown in Figure 3. The image was generated by imaging the intensity of the 2927 cm^{-1} absorption band, representing the distribution of some organic material on this pad. This image demonstrates that the highest level of contamination was located in the lower left corner of the pad.

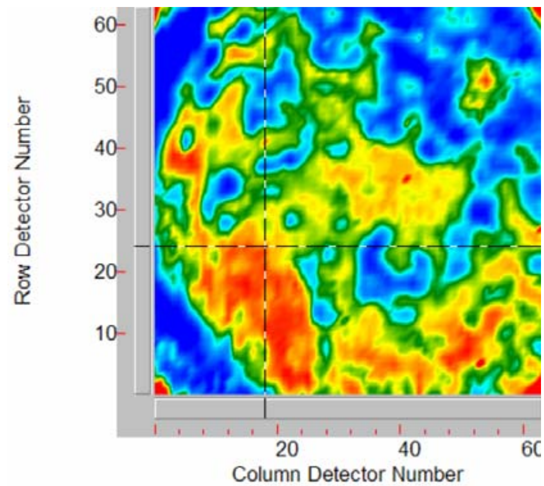

Figure 5. FT-IR reflectance image of Sample 2 (at 2927 cm^{-1}) using a 64 x 64 Lancer FPA.

FT-IR imaging may also be used to locate contamination related to epoxy resin used in the packaging process. Figure 6 shows the visual image of a pad from a PCB board. Figure 7 shows the FT-IR image taken of this pad using the integrated intensity in the C-H stretching mode region to generate intensity profiles. Comparison of the spectra from the three regions in Figure 7 illustrates the power of FT-IR spectroscopy and imaging. Spectrum A was taken from a part of the pad that is normally covered with epoxy in the manufacturing process. Spectrum B represents the region on the pad where there should be no organic material and, as expected, there is no intensity in the FT-IR spectrum. Spectrum C represents a spectrum obtained from the area of contamination. Although it is lower in intensity than A, the general band positions and relative intensities demonstrate that this contaminant is a result of the epoxy being laid down incorrectly onto the pad.

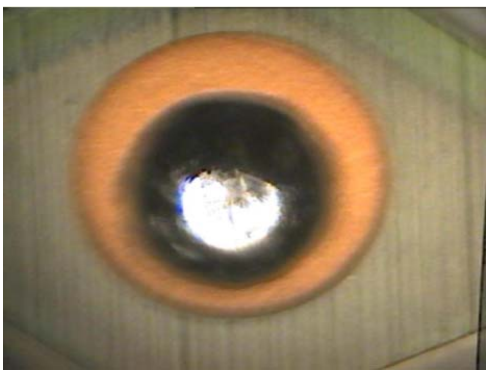

Figure 6. Visual image of pad from a PCB showing discoloration as a result of an error in the manufacturing process.

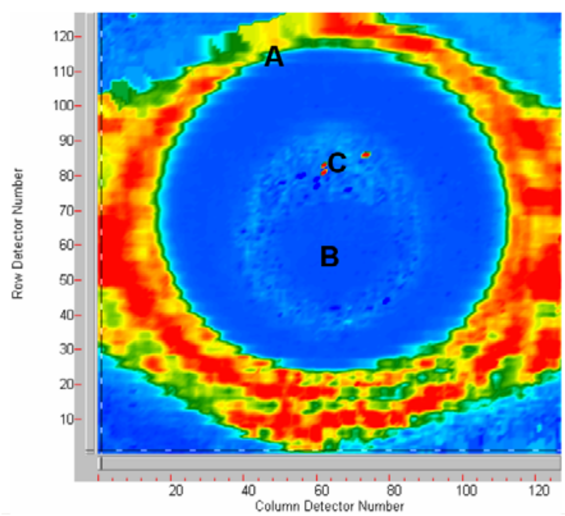

Figure 7. FT-IR image of Sample 3 (from Figure 6) illustrating the intensity of stretching in the C-H stretching mode region.

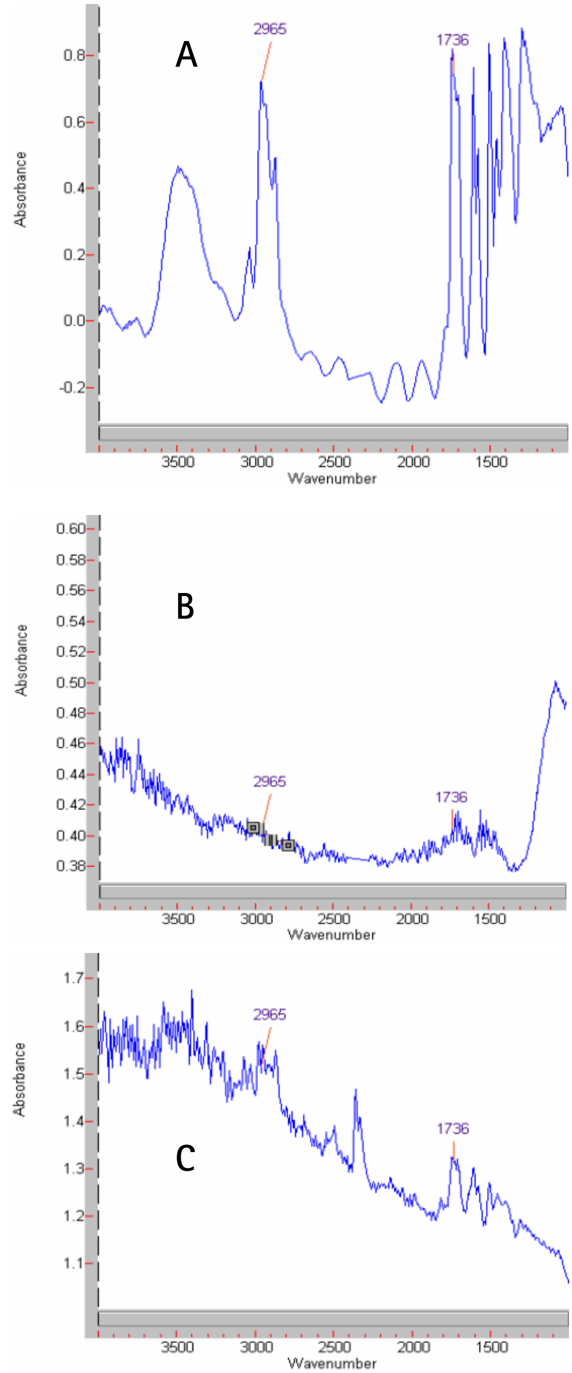

Figure 8. FT-IR reflectance spectra from points A, B, and C of Figure 7. Note the similarity (with lower intensity) of spectrum A compared with spectrum C.

Conclusion

FT-IR microscopy and FT-IR imaging provide information that may be used in FA applications related to electronics manufacturing. The implementation of spectral libraries, particularly with libraries specifically tailored to a manufacturer's samples of interest, is critical for the identification of unknown contaminants. The combination of FT-IR microscopy, imaging, and spectral libraries for identification provides a straightforward path to rapidly and efficiently resolve FA issues and to increase productivity in the manufacturing process.

References

[1] J.A. Serenson and S. Marongelli, *The Effect of Solder Mask and Surface Mount Adhesive Types of a PCB Manufacturing Process*, Universal Instrument Corporation.

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