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Fourier Transform Infrared Spectroscopy-guided Identification of Foreign Materials

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***Abstract**—The identification of the nature of foreign materials (FM) provides direction on the determination of the source, and guidance on the mitigation or elimination of its occurrence. Herein, we identified the most probable composition of the FMs found on adhesive tape or trays, in a semiconductor assembly floor. Fourier transform infrared (FTIR) spectroscopy was used to identify the composition of the unknown samples, through database matching. The database is a locally built library of spectra of materials available in the production floor. The results show successful identification of the FMs.*

***Keywords**— Foreign material, FTIR, database, hit rate.*

I. INTRODUCTION

The industry megatrend in high complexity sensing such as the time-of-flight technology, retina scanning, fingertip sensing, facial recognition, adaptive and cognitive technology, among others drive the aggressive innovation of optoelectronic devices [1-2]. In parallel to the development of advanced optoelectronic devices, novel materials are developed at an exponential rate, supporting the growth of this megatrend [3-4]. Hidden in the trivial factors of a successful new optoelectronic product introduction, such as project management, process development, supply chain integration, automation and human competency development, is the foreign materials (FM) management (FMM). The presence of FM affects the product functionality such that it results in surface non-recognition due to the blockage of the transmitted signal, or the feedback signal [5-9]. The criticality of FMM cannot be denied, however it is often overlooked during the new product introduction (NPI).

Fourier Transform Infrared (FTIR) spectroscopy is a powerful analytical technique in identifying organic species based on the distinct response of functional moieties to the infrared source. The vibrational response (in terms of wavenumber) is indicative of the presence of a specific functional group, which in turn can be used to ascertain the composition of the unknown sample. Quantitatively, material identification could be achieved based on similarity of the spectrum of an unknown sample with the spectrum of standard samples built in a local database.

Herein, we report the identification of six unknown FM samples through FTIR spectroscopic database matching. The results are used to guide the operational intervention for the FMM.

II. EXPERIMENTAL DETAILS

The received unknown samples were imaged using an optical scope (Olympus SZ61) prior to FTIR analysis using Bruker Hyperion Tensor II. The samples are analyzed as received through the micrsocopy-FTIR feature of the equipment. A pre-built FTIR database containing an extensive library of spectra of materials is used as a reference. The Bruker built-in algorithm is used to match the spectrum of the unknown sample with the spectra available in the database, wherein a hit rate is reported. The hit rate is used as an identifier to determine the most probable composition of the unknown sample.

III. RESULTS AND DISCUSSION

Two samples were received wherein FM were found sticking to an adhesive tape. Optical inspection was performed as shown in Fig. 1. Sample 1 shows a globular FM, while sample 2 shows a fibrous material.

Fig. 1. Optical images of received samples containing FM on adhesive tape.

The spectrum of the globular FM found on the adhesive correlates with the spectrum of a wafer ring sticker paper at a hit rate of 81.8 % (Fig. 2). Wafer ring sticker is a cellulose-based material coated with an adhesive layer, and used as the base material containing the details of the wafer being processed.

The spectrum of the fibrous FM found on the adhesive correlates with the spectrum of the cleanroom apparel fiber at a hit rate of 97.7 % (Fig. 3). The cleanroom apparel fiber is possibly emanating from the wear of the apparel during use. The repeated mechanical abrasions during use could result in the disentanglement of the fiber or portions of the fiber, which could eventually be dislodged from the fabric and contaminate the device.

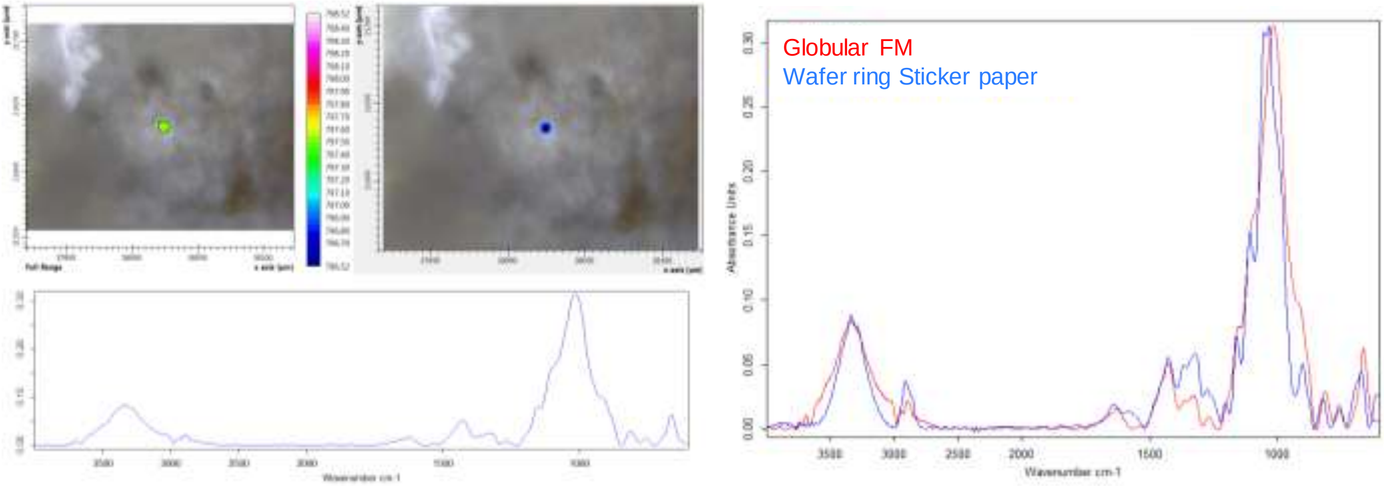

Fig. 2. Optical images and FTIR spectra of the globular FM and the reference wafer ring sticker paper.

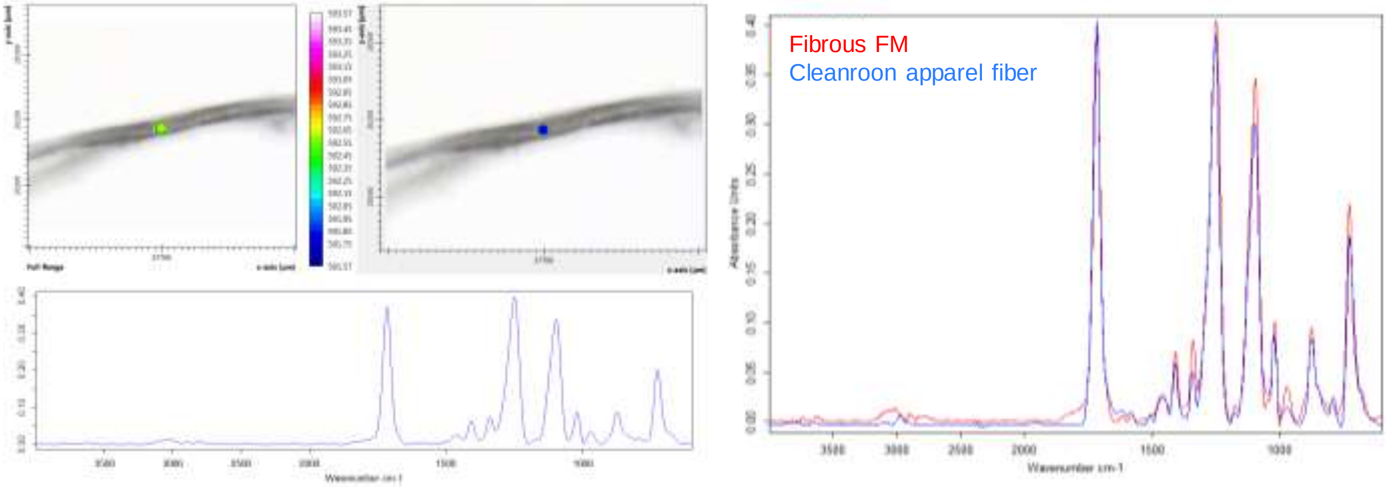

Fig. 3. Optical images and FTIR spectra of the fibrous FM and the reference cleanroom apparel fiber.

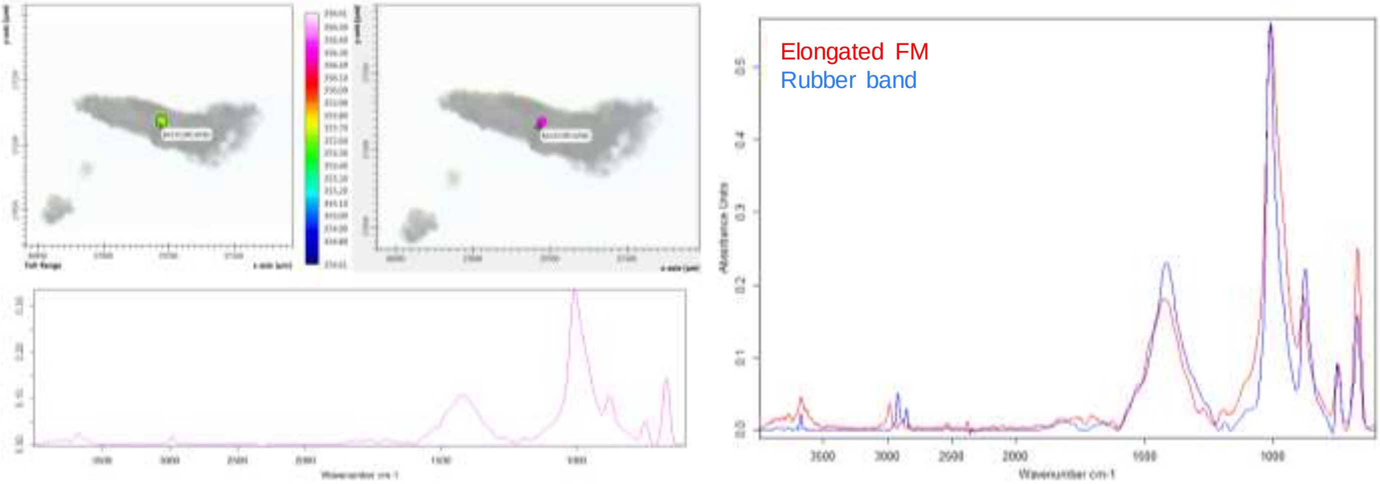

Fig. 4. Optical images and FTIR spectra of the elongated FM and the reference rubber band.

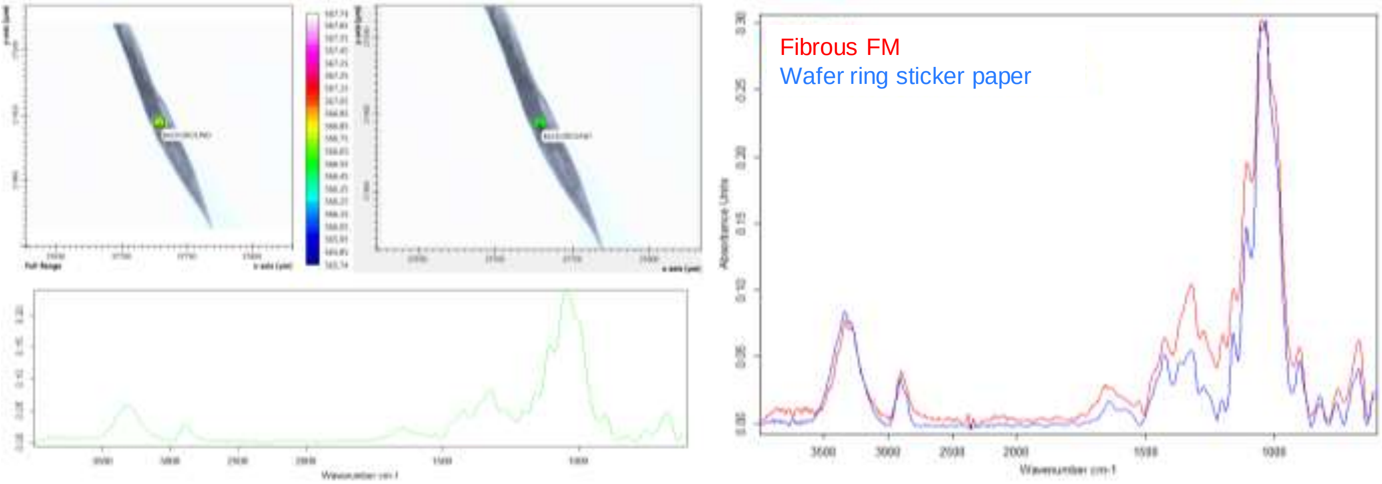

Fig. 5. Optical images and FTIR spectra of the fibrous FM and the reference wafer ring sticker paper.

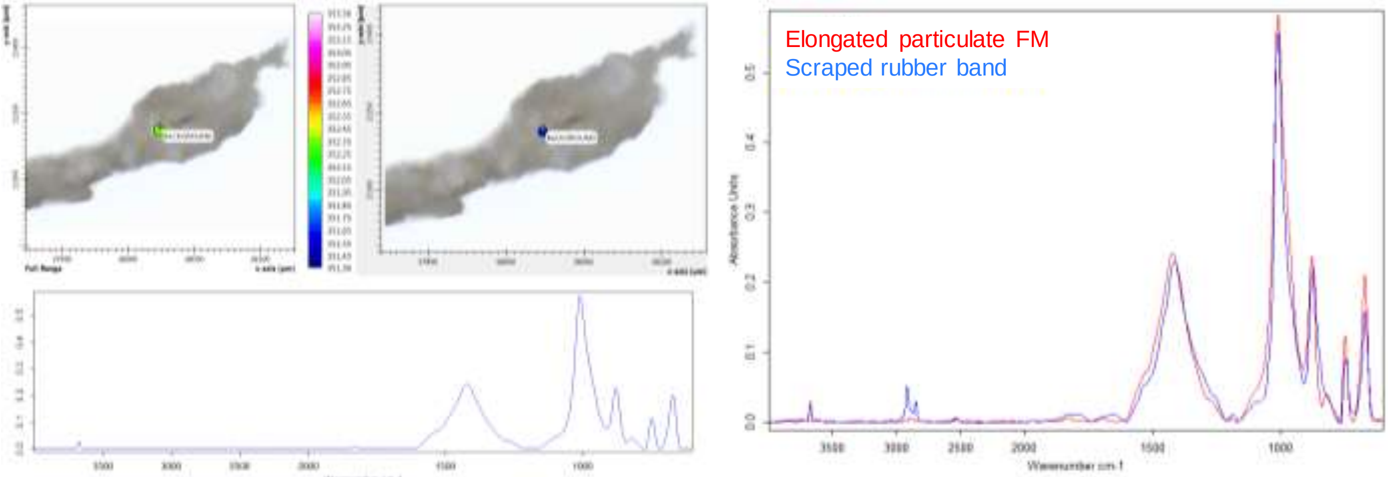

Fig. 6. Optical images and FTIR spectra of the elongated particulate FM and the reference scraped rubber band.

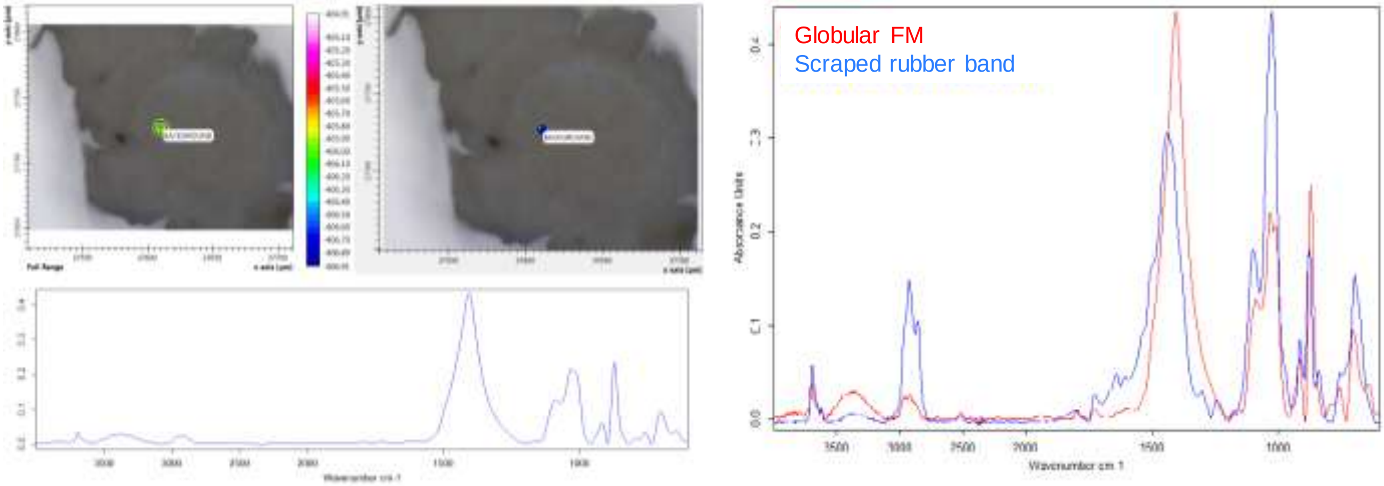

Fig. 7. Optical images and FTIR spectra of the globular FM and the reference scraped rubber band.

FM samples from trays used to store the devices during the assembly process were also analyzed. Fig. 4 shows the spectrum of the fibrous FM found on the tray which correlates with the spectrum of the reference rubber band at a hit rate of 76.2 %. Rubber bands are used to tie-up trays to prevent devices from being scattered.

The spectrum of the fibrous FM found on the tray correlates with the spectrum of the reference wafer ring sticker paper at a hit rate of 96.1 % (Fig. 5). It is possible that the FM is already present in the device during the wafer attach process, and the FM was not dislodged during the assembly process. This is an example of a non-mobile FM, which is more preferred than the mobile FM. Mobile FMs are difficult to manage because of the unpredictable occurrence and the non-probabilistic localization on surfaces.

The spectrum of the elongated particulate FM found on the tray correlates with the spectrum of the reference scraped rubber band at a hit rate of 85.9 % (Fig. 6). As mentioned, the occurrence of rubber band FMs are expected due to the intrinsic susceptibility of the material to wear and tear.

The spectrum of the globular FM found on the tray correlates with the spectrum of the reference scraped rubber band at a hit rate of 80.8 % (Fig. 7).

These results reflect the applicability of FTIR-guided identification of foreign material. The results were used to identify operational intervention such as the substitution of rubber bands with metal straps to lock-in trays and prevent units from scattering, the use of a different sticker paper material which are more stable against wear and tear, and the identification of the lifetime of cleanroom apparel.

IV. CONCLUSION

FTIR is a powerful tool in identifying fingerprints of certain materials. This capability is exhibited in the identification of 6 types of foreign materials found on adhesive tapes and trays used in the production floor. The nature of these FMs were identified, guiding the intervention to prevent the occurrence of these FMs which can affect the functionality of the devices manufactured.

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