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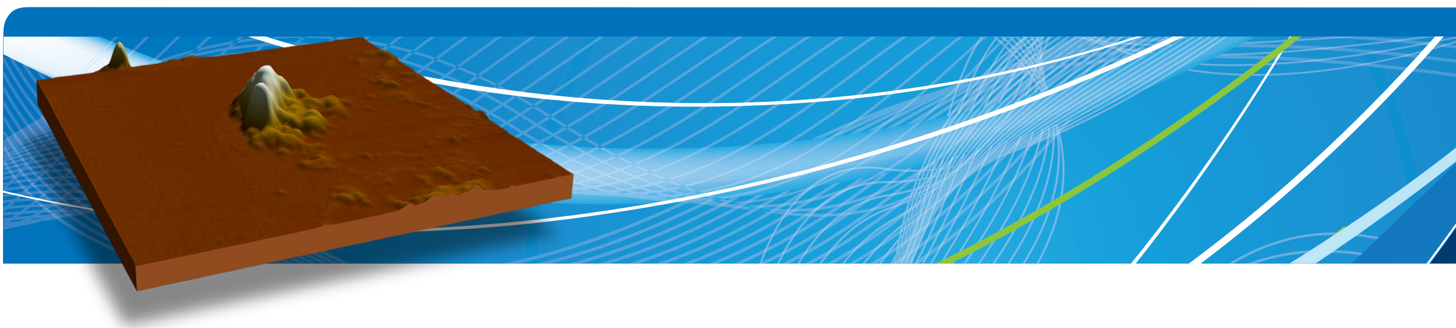

Application Note #103

Nanoscale IR Spectroscopy of Organic Contaminants

- AFM-IR uniquely and unambiguously identifies organic nano-contaminants on wafers, media and slider substrates
- nanoscale IR Spectroscopy directly correlates to FTIR libraries
- Simultaneous nanoscale chemical and property mapping information

Organic nano-contaminants are a serious defectivity issue for semiconductor and data storage companies where current characterization techniques have limited capabilities. This note describes the application of the nanoIR2-FS™ to the measurement of such defects. The nanoIR2-FS system is based on a scientific breakthrough technique of acquiring IR spectra at spatial resolutions down to sub 10 nm, enabling researchers to obtain nanoscale chemical fingerprints of their material. The spectra generated using Bruker nano's patented AFM-IR™ technique correlate extremely well with traditional FT-IR spectra, and are thus comparable to standard IR libraries. In addition to chemical analysis, the nanoIR2-FS provides complementary mechanical, thermal, and structural property information with nanoscale spatial resolution.

Introduction

Organic based nano-contaminants are a common defect type found in micro-electronics manufacturing processes, including semiconductor, data storage, and LED. These types of organic contaminants are a serious defectivity issue for manufacturers as they cause yield issues, process delays and can lead to scrap product.

The contaminants arise from a variety of sources, including chemical processing, cleaning techniques, airborne molecular contamination, wafer transfer and handling, as well as the degree of human interaction with the processes. Significant efforts are expended in the prevention and detection of defects; however, for many of these defects, there is still a significant class, including organic nanocontaminants, where unambiguous identification is difficult to obtain using existing instrumentation, due to insufficient resolution or even damage to the sample during measurement.

AFM-IR not only enables precise chemical identification of contaminants, but can also provide mutliple property analyses with nanoscale resolution.[1]

Organic Nanocontamination of Bare Silicon Wafer

To demonstrate nanoscale chemical characterization capabilities on the nanoIR2-FS, contaminated silicon wafers were prepared using known materials typical of those found in semiconductor fabriation environments and analyzed. For each sample, pping AFM-IR imaging was used to locate the contaminants, followed by subsequent AFM-IR measurements.

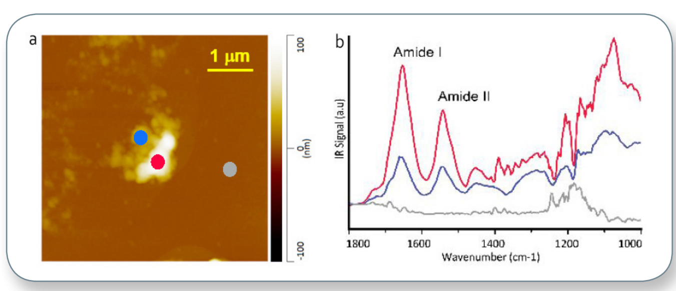

Figure 1. AFM height image (a) and corresponding AFM-IR spectra (b) of organic residue on a silicon wafer show clear Amide I and II bands, indicating human skin residue. The colored line spectra corresponded to colored measurement pixels in the AFM image.

The AFM height image, shown in figure 1a, illustrates the thickness variation (20-100nm) of the contaminant reside (human skin tissue) on the wafer. AFM-IR spectra were then collected at sites with variable sample thickness (Fig. 1b). As expected, the observed IR intensities differed with sample thickness; however, the overall signal to noise ratio is sufficient to accurately identify the material, even at 20nm thickness, reflecting the excellent sensitivity in detection of thin samples.

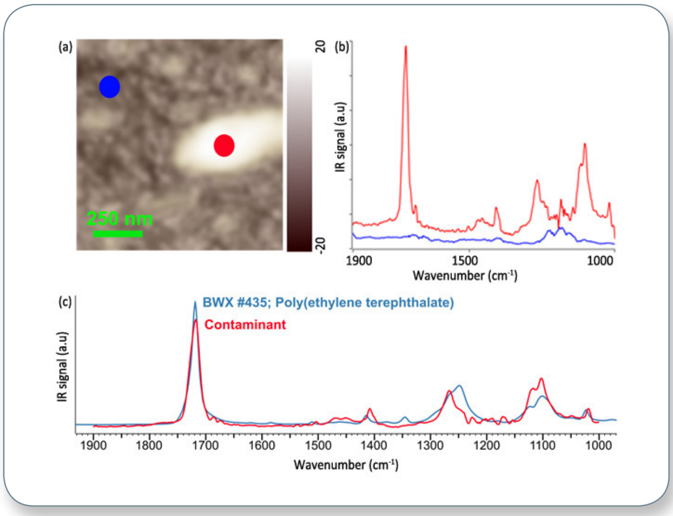

Figure 2. AFM height image (a) and resulting nanoIR spectra (b) from a contaminant on a bare silicon wafer. The resulting match from the FTIR library identifies the contaminant as Poly(ethylene terephthalate).

New FASTspectra capabilities on the nanoIR2-FS enable faster acquisition of spectra over the full IR tuning range, allowing for a reduction in spectral acquisition time by a factor of 10. This achievement, illustrated in figure 2, still enables accurate FTIR spectra to be collected. The AFM-IR spectra from the sample were compared against a common FTIR database (KnowItAll, Bio-Rad Inc.). The ~30 nm tall contamination residue was positively identified as polyethylene terephthalate (PET), a polymer typically used in polyester fabrics.

Conclusion

In this note, the nanoIR2-FS was used to successfully identify nanoscale organic contaminants in manufacturing of semiconductors. These study results show that nanoscale IR spectroscopy is a powerful tool to accurately characterize defects in semiconductors and other electronic devices.

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