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Characterizing Cross Sections and Thin Structures Using NanoIR Spectroscopy

NanoIR is highly suited for identification of organic components that cannot be conventionally analyzed by other organic analysis techniques such as FTIR or Raman.

Introduction

Atomic force microscopy-based infrared spectroscopy (AFM-IR, NanoIR) provides vibrational spectroscopic information with high spatial resolution (<30 nm). As a result, NanoIR is highly suited for the identification of organic components in size regimes that cannot be conventionally analyzed by other organic analysis techniques such as FTIR, which is typically limited to tens of microns in analytical area, and even Raman, which is limited to approximately one micron in analytical area.

Discussion

In this example, two polymer structures were examined: 1) a cross section comprised of three polymers and 2) a thin polymer contaminant on a silicon wafer.

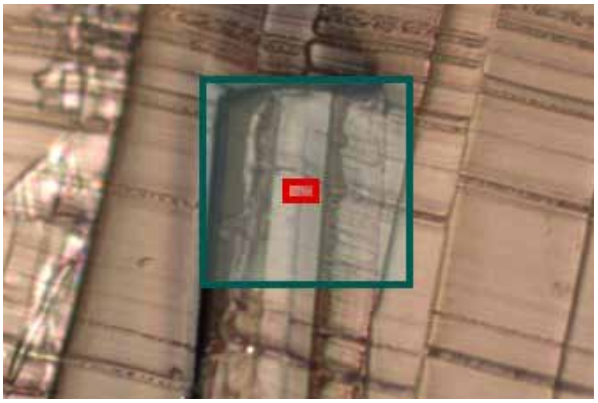

Figure 1: Optical image of the polymer cross section, blue box is the analysis size for FTIR and the red box shows the imaged region in NanoIR.

Polymer Cross Section

A polymer cross section (Figure 1) comprised of an ethylene vinyl alcohol polymer (EVOH) surrounded by polyamide (Nylon) was analyzed by NanoIR, with three sets of data showing the separation of distinct polymer layers: point spectra and chemical maps (Figure 2) as well as line-scan spectra (Figure 3). The NanoIR spectra taken from each of the layers show good overlap with FTIR reference spectra. Chemical maps can also be taken by measuring the absorbance across the imaged region at a fixed laser frequency. The maps taken at frequencies that are distinct to polyamide (1645 cm^{-1}) and EVOH (1050 cm^{-1}) confirm the distinct layers of the polymers in the cross section.

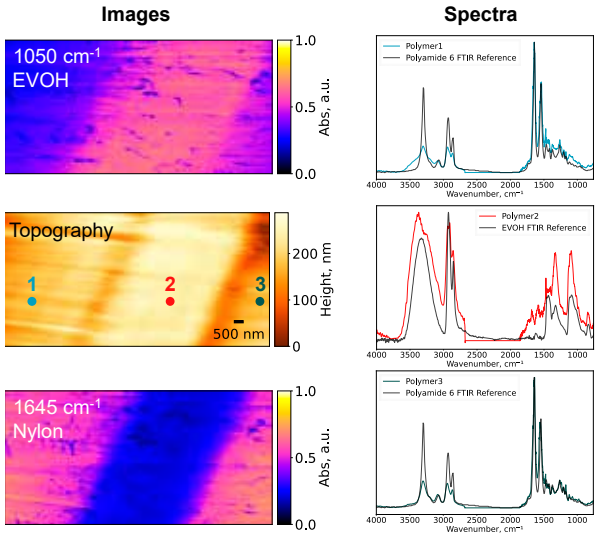

Figure 2: Height and chemical map images (left) and NanoIR spectra (right) taken from the polymer layers. Spectra are taken at the corresponding colored/numbered points in the height images (middle left), with additional FTIR references for comparison.

For more detailed characterization across interfaces, line spectra can be collected and directly analyzed or projected as a two-dimensional image to show the changes in spectral features across the interface. These spectra and projections reveal that there is a region of mixed Nylon and EVOH material across the two polymer layers.

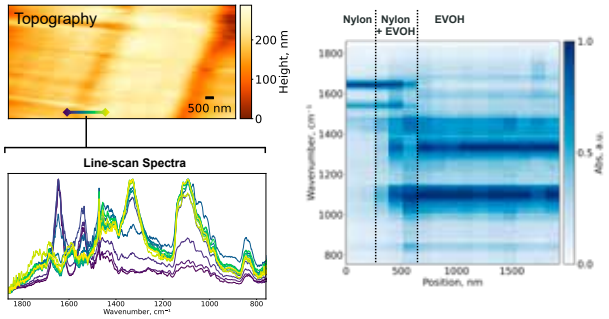

Figure 3: Height image (upper left) of the cross section with line spectra (lower left) taken across the interface between two of the layers. Spectra were taken at the corresponding colored locations. A two-dimensional projection of the spectra at different positions (right) reveals distinct regions of Nylon and EVOH with an interfacial region comprised of a blend of the two components.

Polymer Contaminant on a Silicon Wafer

A thin contaminant on a Si wafer was analyzed by NanoIR. The height image (Figure 4) reveals a contaminant that is approximately 100 nm wide and about 30 nm tall. Spectra taken on the contaminant using NanoIR reveal vibrations indicative of polystyrene and shows good overlap with the bulk polystyrene NanoIR spectrum (Figure 5). Chemical maps taken at vibrations corresponding to polystyrene (1490 cm^{-1}) confirm the polystyrene is found across the entirety of the contaminant and only from the contaminant.

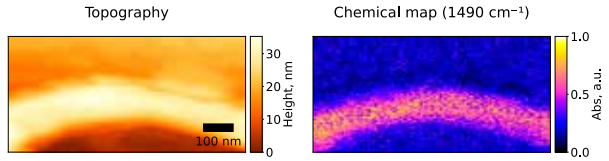

Figure 4: Height image (left) and chemical map (right) taken at 1490 cm^{-1} of a thin contaminant on a Si wafer.

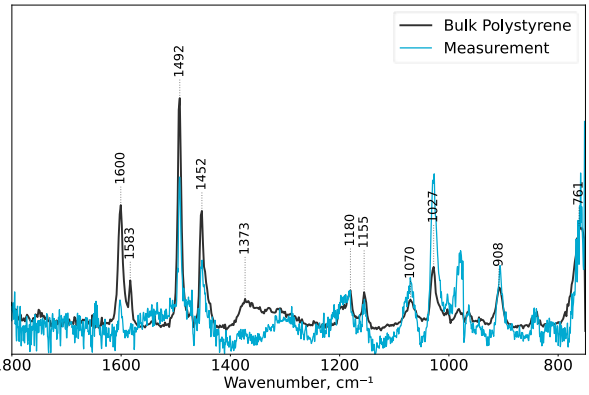

Figure 5: NanoIR spectra taken on the contaminant (blue) and from a bulk film of polystyrene (black).

Conclusion

NanoIR is a powerful technique for identifying the composition of organic components, and extends the capabilities of vibrational spectroscopic analyses by providing extremely high spatial resolution. NanoIR spectra show strong correlation with IR measurements and databases, enabling compound identification through a process analogous to FTIR, while chemical maps provide insight into the spatial distribution of different components.

Contact us today to learn more about our NanoIR capabilities and the other organic analysis services we have to offer.