Measuring Laminate Thickness with No Sample Preparation

Both metallic and polymeric coatings play vital roles across a variety of industries, and these coatings must be sufficiently characterized in terms of their constitution, orientation, and thickness as all these variables significantly affect the properties of the coating. For example, in the medical device industry, coatings must be at minimum characterized for uniformity, constitution, hydrophobicity/hydrophilicity, and biocompatibility. Paint finishes are analyzed to determine hardness, hydrophobicity, and adhesion strength. Interestingly, and especially if the coating is nontransparent, measuring layer thickness is rather convoluted. Techniques such as Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM) could be used to determine layer thickness if the analyst cracks the sample to expose the layer, but these techniques are destructive, sampling size becomes an issue, and of course no molecular information is obtained (although an SEM/EDX could be used to map some elements on the exposed surfaces).

Considering its ability to measure coating thickness and determine molecular structure and orientation, Confocal Raman Microscopy (CRM) is extraordinarily well-suited to characterize polymeric coatings. Furthermore, since the excitation source uses visible light, CRM is nondestructive and coatings can be characterized without damaging the sample (provided the laser power is low enough to prevent sample degradation). Due to its confocal design, the microscope only obtains data from samples in the focal plane of the microscope, and for transparent samples CRM can obtain vertical information at a resolution of 500 nm.

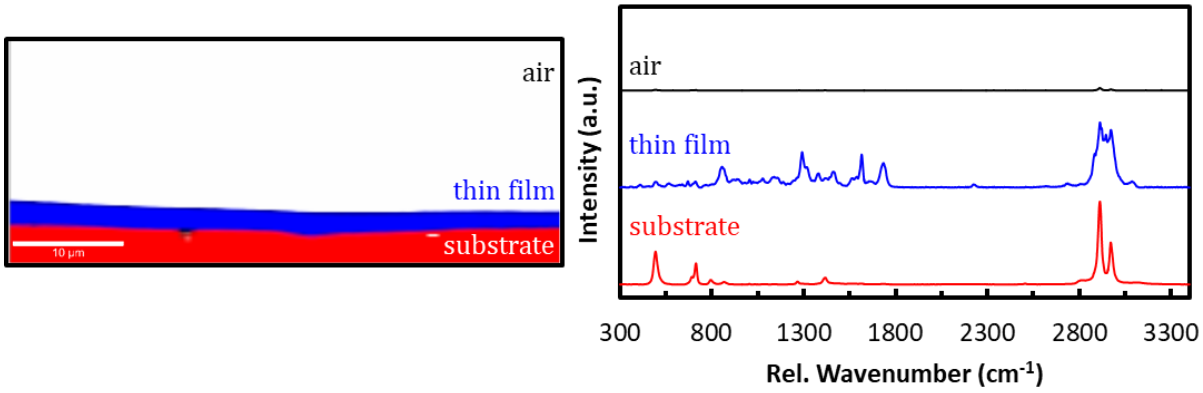

Figure 1**.** A confocal Raman image obtained from a depth scan of nail polish (blue) on a polysiloxane substrate (red). The depth scan covered a 50 µm x 20 µm range at a pixel number of 20,000 and an integration time of 84 ms. The excitation laser wavelength was 531.7 nm with a 100x lens (NA = 0.9). The basis spectra (right) were obtained by selectively averaging spectra from the three sections of the depth scan. Vertical axes are equivalent for all three bases spectra.

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To illustrate how confocal Raman microscopy can characterize layer thickness, a thin layer of clear nail polish was brushed onto a polysiloxane substrate. The sample was then imaged using a WiTec 300RA CRM. A depth scan (50 µm x 20 µm) was performed, and the spectra of selected areas inside the depth scan were averaged to create three basis spectra. Each basis spectrum corresponded to one of the known constituents of the system: air, nail polish (which is a collective mixture of many substances), and the polysiloxane substrate. Spectral processing of the basis spectra can create an overlay to illustrate the spatial relationship of all three components of the system. The resulting image is shown along with the corresponding basis spectra in Figure 1.

As can be seen from Figure 1, not only can the structures of the three component system can be elucidated using CRM, but the thickness of the nail polish coating can be calculated. In this case the thickness of the layer is non-uniform, decreasing from 2.2 µm to 1.7 µm over the 50 µm investigated. This is visually supported in Figure 1 by the thinning of the blue layer from left to right. A non-uniform layer thickness was chosen intentionally to illustrate the resolution imaging power of CRM. Layer thickness is calculated using the 1700 cm^{-1} band on the nail polish spectrum. By plotting the intensity of the band as function of the vertical position on the image, the layer thickness can be calculated using the full width at half maximum distance.