Tapping Mode and Phase Imaging Study of a Multi-Component System

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Specifications

Instrument:
Digital Instruments Explorer

Accessories:
Linearized 10µm z-scanner

Scan Modes:
Topography Mode &
Phase Imaging Mode

Samples Type: 2 sample lots, each a 3-component mixture:

1. Matrix material - polypropylene
2. Conditioning additive - EDPM)
3. Coloring additive - carbon black

The Technique

The AFM is a microscope without lenses that operates by the physical interaction between a mechanical stylus-probe and the sample surface. Using TappingMode™, an AFM can not only image topographic features it also can map the spatial variation in surface elasticity using a method that is termed as Phase Imaging. This technique operates by detecting the phase shift associated with the probe's resonance and its proximal interaction with the sample. As such, Phase Imaging is quite effective for mapping the sub-micron properties of multi-component polymer systems based on the relative elasticity of individual components.

Application Issues

Automotive parts are engineered for specific performance characteristics and both the proportion and distribution of chemical components within those parts are a critical issue. In this study, a 3-component mixture is examined by comparing two different manufacturing lots. The 3 chemical components are added in equivalent proportions between the two lots, but the pigment has a different degree of crystallinity within the two lots. The task at hand is to resolve the three distinct chemical components and then determine the sub-micron distribution of the carbon black relative to EDPM and poly-propylene. The samples were prepared by cutting across bulk specimens with an uncoated razor blade and then mounting the samples with the cut faces pointing up.

Results

Phase Imaging was quite successful in resolving the 3 chemical components within both sample lots. Figure 1 is an example of the rather striking microstructure of this 3-component mixture.

Textural details not only appear clear, the image quality has a SEM-like appearance. Of course, a SEM could never do this! The poly-propylene consists of interwoven strands forming the matrix, whereas, the EDPM appears as teardrop & oval blobs (> 200nm in length) that are distributed evenly throughout the polypropylene matrix.

The carbon black consists of particulates much smaller (40nm dia.) than the EDPM, and they are slightly brighter than EDPM in the Phase Image. The topography image also outlines the different phases; however, there is no significant image contrast to distinguish them based on physical properties. Close examination of Figure 2a suggests that the carbon black within lot #1 is clustered around the polypropylene regions.

A comparison of lots 1 and 2 (Figure 2) shows that while the carbon black is in fact clustered around the EDPM in lot #1, the carbon black in lot #2 is more evenly dispersed relative to the distribution of the EDPM; however, the carbon black particles in lot #2 still tend to cluster amongst themselves.

Conclusion

Phase Imaging, used in conjunction with intermittent-contact mode, is quite effective in resolving the sub-micron distribution of individual chemical components with complex polymer systems.

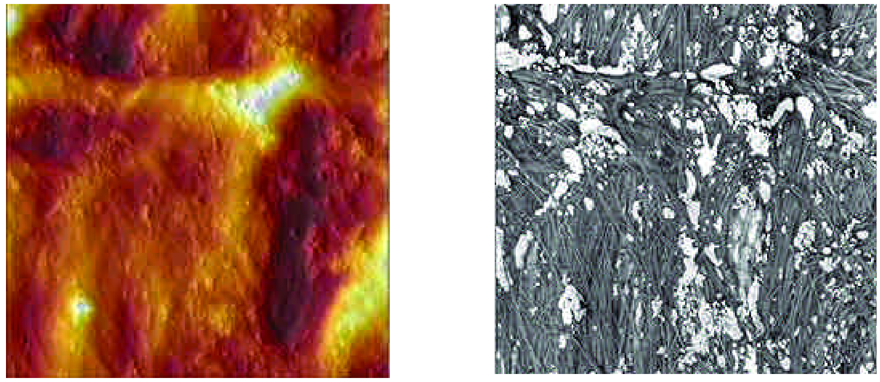

Figure 1. 5μm x 5μm scan of a 3-component mixture. Topography left and Phase Imaging right.

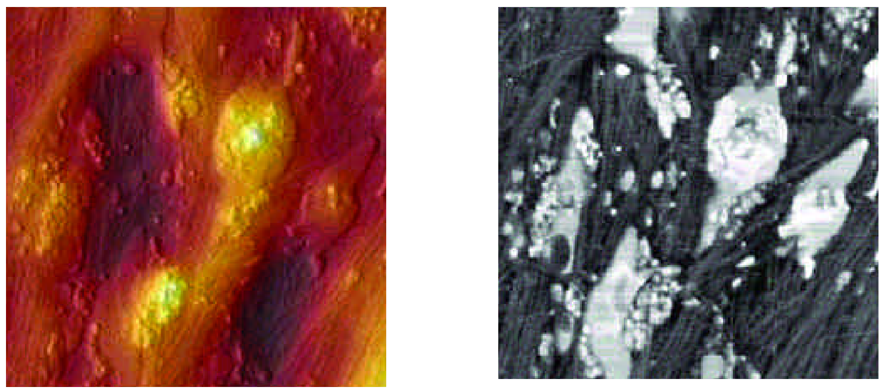

Figure 2. Lot 1 2μm x 2μm images. Topography left, Phase Imaging right.

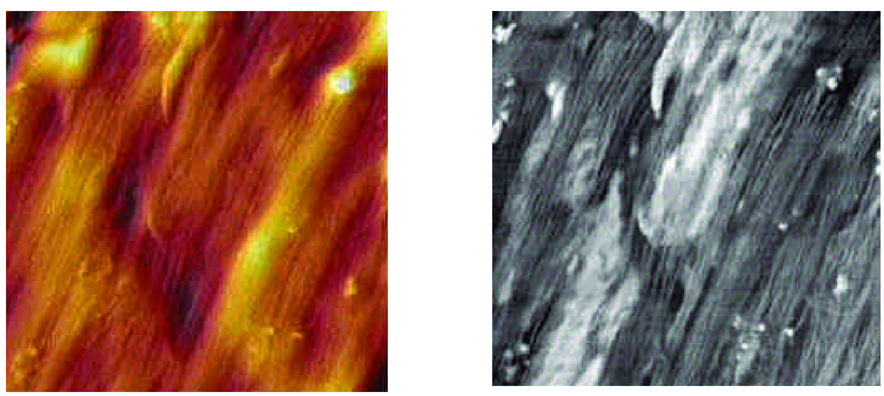

Figure 2. Lot 2 2μm x 2μm images. Topagraphy left, Phase Imaging right.

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