Anton Paar

Polymer Surface Characterization by AFM

Keywords:

atomic force microscopy, phase images, polymer surfaces, surface morphology

1 Introduction

The surface properties of polymeric materials are central to their behavior in formulation and manufacturing processes, as well as in their target applications.

The atomic force microscope (AFM) is a powerful tool for characterizing polymer surfaces at the nanoscale. It provides not only surface morphology, but also phase contrast between different components in polymer blends.

We report here the use of a new AFM, Tosca™ 400, to characterize polymer blends in terms of high-resolution morphology and phase images.

2 Experimental

Polystyrene (PS), poly(methyl methacrylate) (PMMA) and poly(styrene-butadiene-styrene) (SBS), were dissolved in toluene as 10 mg/mL solutions. The solutions were mixed to form three blends; PMMA/SBS, PS/SBS, and PMMA/PS in the ratios of 2:1, 1:1, and 1:1, respectively. The samples were spin-coated onto silicon wafers at 100 rps for 5 s. PMMA/SBS and PS/SBS were left to dry under ambient conditions, while PMMA/PS was annealed at 70 °C for 2 h. All AFM measurements were made under ambient conditions in dynamic-force mode.

3 Results and Discussion

The surface topography and the corresponding phase images are shown in Fig. 1 for the three polymer blends. All three are rather flat, with surface roughnesses of 18.7, 16.3, and 4 nm for PMMA/SBS, PS/SBS and PMMA/SBS, respectively. All three show phase separation, with PMMA/SBS showing the strongest phase contrast.

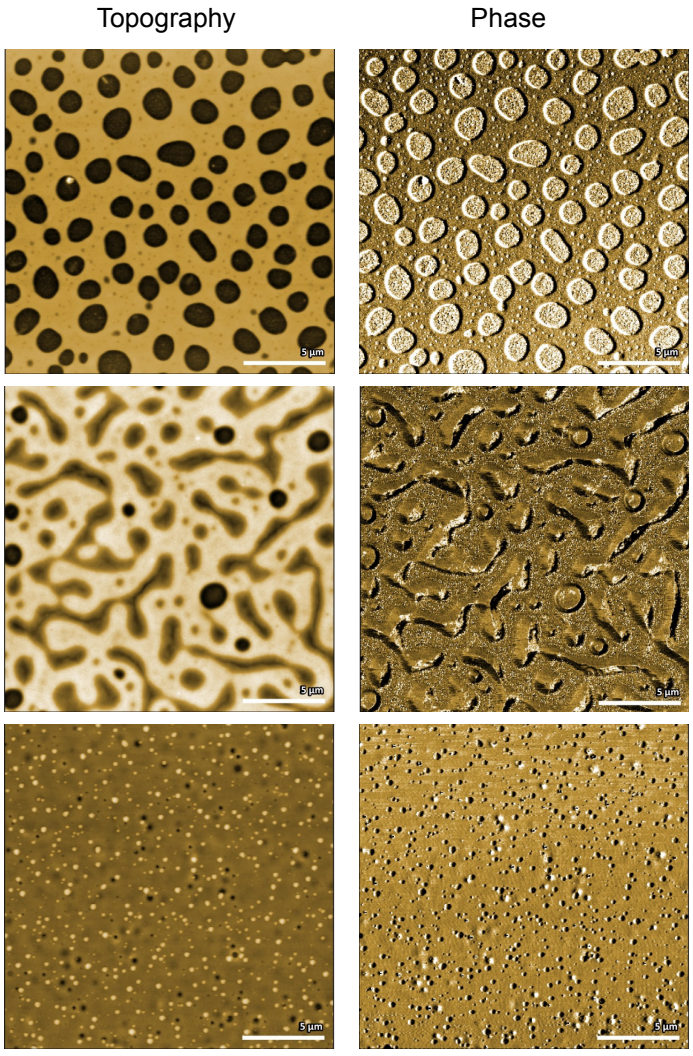
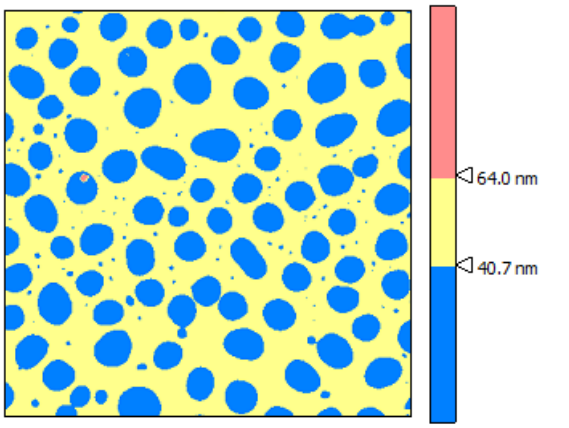


Fig. 1 Surface topography (left) and phase (right) of PMMA/SBS (top), PS/SBS (middle) and PMMA/PS (bottom)

The surface coverage of the different components can also easily be calculated by using our Tosca Analysis software. Fig. 2 shows that the components of the first blend, PMMA

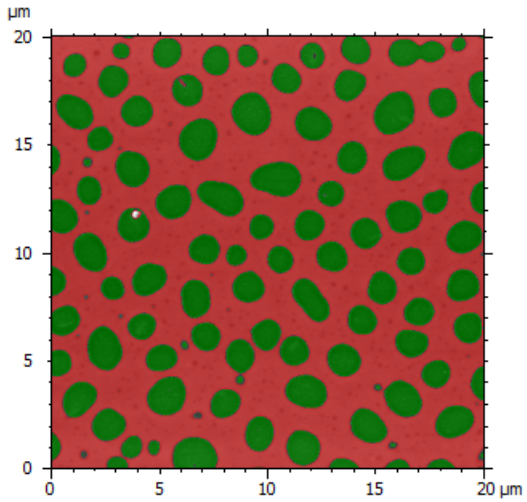
and SBS, have a surface coverage of 62.6 and 37.4 %, respectively, which is close to the bulk ratio 2:1. Impurities amount to less than 0.1 % (red).



Parameters	Unit			
Projected area	%	37.4	62.6	0.0179

Fig. 2 Calculation of the surface coverage of PMMA (green) and SBS (blue)

The first blend was also examined by using step-height analysis (Fig. 3), which showed a mean height difference between PMMA and SBS of 39.2 nm.



Differential parameters	P2 - P1	Unit
Zmean(higher) - Zmean(lower)	39.2	nm
Angle difference	0.00275	°

Plane parameters	Unit	Plane 1	Plane 2
Zmin	nm	0.00	35.9
ZMean	nm	10.4	49.5
Zmax	nm	25.0	64.5

Fig. 3 Height difference between PMMA (red) and SBS (green) by step measurements

4 Summary

Various polymer samples have been successfully characterized using the Tosca™ 400, the new AFM from Anton Paar. It provides an excellent capability for visualizing polymer surface structure and properties at the nanoscale.

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