E-19-460
1, 2

Instructions

Replace words in brackets with your information. (Delete brackets.)

Double-check the grant number, report title, and names of investigator(s) and affiliation(s) for accuracy.

Supply up to three (3) keywords (30 characters max) to describe your report.

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35749-G7

Effect of Substrate-Polymer Interactions on Polymer Thin Film Dewetting

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1. polymers
2. thin film
3. combinatorial

Polymer thin films are critical to advanced materials including semiconductors, electronics packaging, optical devices, and future hybrid optoelectronic, MEMS, and sensor devices. Unfortunately these thin films can become unstable due to attractive van der Waals (VDW) interactions, resulting in dewetting. A failure to develop methods to control VDW instability places severe limits on the technological uses of thin films. To address this problem, this work characterizes fundamental issues associated with stabilizing VDW unstable *bilayer thin films.*

The hypothesis of bilayer stabilization is that a carefully chosen thin *intermediate* coating can stabilize the top layer thin film by adjusting the sign of the substrate-film VDW interaction. The objective of this work is to measure the stability conditions (film thicknesses resulting in stable bilayers) and compare these to a simple Hamaker constant (A_i) model.

The primary experimental difficulty is maintaining consistent substrate and film chemistry over the many samples needed to test this hypothesis. To overcome this limitation a combinatorial method that employs film thickness gradients to explore hundreds of thicknesses per experiment has been developed. A bilayer model has been selected and predicts that $A_{stabilizer} > A_{film} > A_{substrate}$ for bilayer stability to be adjustable with stabilizer thickness. We have demonstrated that a model bilayer system in which poly(4-hydroxystyrene) films thicker than 100 nm act as stabilizers for poly(styrene) 25nm thin films Current work centers on precise identification of the transition to stability for this system followed by comparison to the Hamaker model.

E-19-Y80
#3,4

35749-G7

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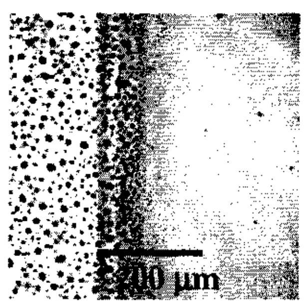
The patterning of semiconducting polymers at nanoscale dimensions is of tremendous interest for high capacity data storage media, computation, and communication devices. Unfortunately thin films can become unstable at thicknesses below 100 nm, due to attractive van der Waals (VDW) interactions. This problem is particularly severe in conducting and semiconducting polymers, which have large Hamaker constants. To address this problem, this work characterizes fundamental issues associated with stabilizing VDW unstable *bilayer thin films composed of semiconductor polybithiophene (PUBT) and insulator polystyrene (PS).*

A Hamaker model predicts that thin semiconductor / insulator polymer bilayers are stable only above minimum PUBT and PS thickness values, which are linearly related. The objective of this work is to test the Hamaker theory by measuring the stability conditions. A combinatorial method that employs film thickness gradients is used to explore hundreds of thicknesses per experiment. The Figure shows a library gradient sample with a thickness gradient in PUBT from nm to nm (left-to-right) capped with a 40 nm PS film. Note how the size of dewetted PS structures changes as a function of the PUBT undercoating. Based upon these results, a NSF Nanoscale Exploratory Research grant was awarded to the PI to continue this work.



Dewetted structures of a 40 nm PS layer on top of PUBT with thickness gradient from to left-to right on Si.