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Interfacial, Thin Film, and Structural Measurements to Facilitate Polymer Nanomanufacturing

CHRISTOPHER SOLES, NIST Polymers Division

There is a growing interest in coupling the relatively mature roll-to-roll manufacturing processes with advanced lithographic pattering methods to enable high volume manufacturing of technologies with the added functionality that can only be realized by nanoscale pattering. Nanoimprint lithography is particularly attractive for roll-to-roll processes because the patterning is achieved though a simple embossing technique that relies upon the mechanical deformation of a liquid, melt, or solid material via a squeeze-flow process. Embossing techniques on a roll-to-roll substrate are routinely encountered in the graphic arts community. The difference with nanoimprint lithography is that the printed features can be on the order of 10 nm or smaller. In this presentation we will look at some of the difficulties encountered when these roll-to-roll embossing processes are scaled to the nanoscale. In particular we will look at issues related to the viscous flow of high molecular mass polymer melts into the nanoscale cavities with high throughput. We will show how fast nanoscale squeeze-flow pattering can lead to significant plastic deformation of the polymer melt. This can have implications on the ability of the material to fill the mold and the residual stresses that are generated in the pattern through the imprint process. Techniques to quantitatively evaluate these processes will be discussed and related to fundamental concepts of polymer physics.