# Multiphase Extrusion Coating: Deposition Phenomena in Periodic Film Structures

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**Abstract**

Patterned multi-layer film architectures represent a powerful additive manufacturing paradigm. Although traditional solution processing methods provide a rich selection of pattern features appropriate for flexible electronics, displays, sensors, and related devices, single layers comprising multiple materials present additional unexplored possibilities. In this talk, we discuss an extrusion-on-demand (EOD) approach to produce alternating-line structures in a single step. Highlighting examples of alternating line structures in emerging technologies, we propose that a more diverse array of patterning techniques is possible with EOD, and that the simplicity of these techniques make them commercially disruptive.

Analytical and experimental approaches are described for heterogeneous EOD. First, the equilibrium structure of a coated film comprising two immiscible fluid phases is considered. Young's Equation for wetting is used to compare the interaction of adjacent immiscible phases to the equilibria of each phase in isolation. This comparison is illustrated graphically in Figure 1. We show how this relatively simple analytical treatment carries fundamental implications for the material and process requirements of heterogeneous EOD coating.

These predictions are compared to experimental results with dual-material films deposition on a flexible polyethylene terephthalate (PET) substrate at 25˚C. Periodic line features ranging on order of 100 microns to 1 millimeter are coated from aqueous polyvinyl alcohol (PVA), polydimethylsiloxane (PDMS) and polystyrene (PS) in cyclohexane. Extrusion flow and pattern output at the deposition region output are imaged *in-situ* using a custom roll-feed imaging system (RFIS). Correlations are provided relating process inputs, coating bead shape, and feature size, which are consistent with previous literature in narrow stripe extrusion coating. Dimensionless and dimensional analysis suggests significant influence from viscous, inertial, and interfacial tension differences across coating fluid phases. Flow phenomena exclusive to heterogeneous EOD are described and shown to be consistent with the earlier analytical discussion. Together, these results provide meaningful insight towards the feasibility of extrusion coating as a method to produce heterogeneous alternating-line films.

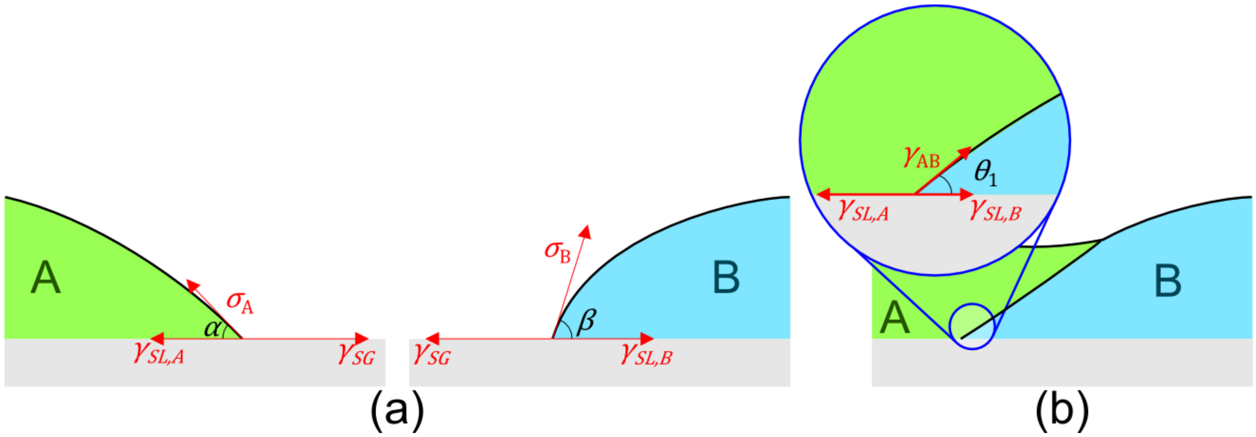


**Figure 1 : The static force balance of a contact line, described by Young's Equation for wetting, can be extended from fluid phases in isolation (a) to predict the equilibrium configuration of dual-phase heterogeneous films (b).**