Extrusion Coating Method for 2D Patterned Films

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Abstract

Solution processing of patterned films enables a broad spectrum of emerging technologies, including wide-area electronics, microfluidics, and chemical sensors. Coating from solution is well-suited to roll-to-roll (R2R) manufacturing, with potential advantages to scalability, cost, and waste minimization. However, traditional methods such as inkjet and gravure printing present significant tradeoffs among pattern capability, material selection, and auxiliary manufacturing steps. Here, we develop an extrusion-based pattern processing method, which offers a unique combination of broad material compatibility and digital pattern control. This extrusion-on-demand (EOD) method is conceptually simple, highly scalable, and requires no pre- or post-processing steps. Patterning principles and requisite flow actuation concepts are presented and applied to produce a tool implementation for EOD. To characterize process capabilities and fundamental phenomena, patterned films of aqueous polyvinyl alcohol (PVA), and conductive polymer poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS), are produced on flexible polyethylene terephthalate (PET) substrate.

Deposition flow and pattern output are observed *in-situ* and characterized in terms of four characteristic pattern features, shown in Figure 1. In this experimental treatment, particular attention is paid to factors affecting feature size and process sensitivity. Feature sizes ranging from 375 μm to 3.2 mm are demonstrated, based on process inputs, which are adjustable in real-time. Additionally, *in-situ* microscopy of the deposition region reveals localized flow phenomena that can be readily correlated to pattern output. Throughout these phenomena, the defining key physical feature is an array of discrete localized coating beads, which can develop independently or interact to form pattern features. Dimensionless analysis reveals consistent trends relating inertial, viscous, and interfacial forces. Together, these observations offer significant insight into the underlying physical mechanisms unique to EOD coating, and an early framework for extending simple deposition behavior to more complex cases.

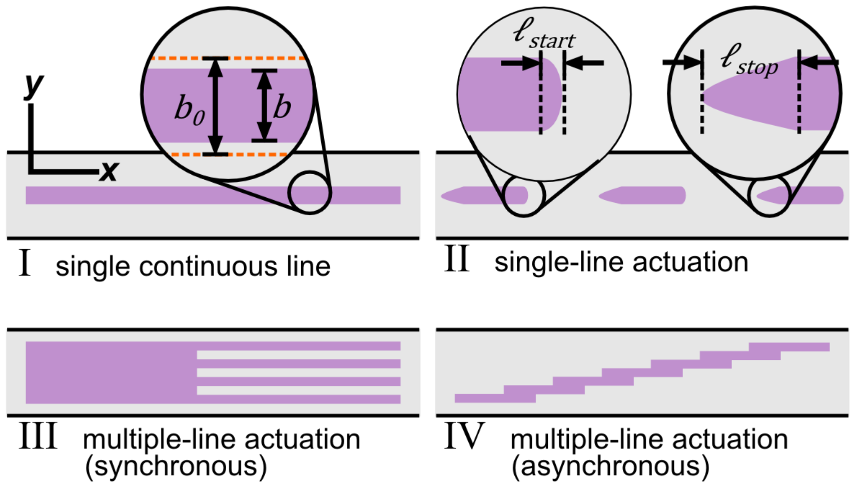

Figure 1: Four characteristic pattern features used to characterize the performance of the EOD coating tool.