Slot Die Deposition of Functional Films

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We report on the development of functional thin films using slot-die coating. Challenging aspects approached here are coating porous and pre-structured substrates. Two case studies are considered. In the first, a mesoporous sol gel layer is coated with a CO_2 responsive film for the fabrication of a highly sensitive sensor. In the second, a microlenses-covered wafer is coated with standard photoresist in order to implement multilevel photolithography.

There is increasing interest in new coating techniques for functional thin film. During the last decade, the development of advanced wet coating techniques has been underpinned by the flat panel display industry. Critical issues such as accuracy, cost, and scalability have been addressed. Materials have also been developed and optimized for specific deposition techniques [1]. Equipment and processes are now available and have been integrated in manufacturing chains in combination with vacuum deposition techniques.

Figure 1: photograph of a slot die deposition head.

Among the wet deposition techniques used in production, slot die coating has been employed in a wide range of domains for the fabrication of flat-panel displays, batteries, photovoltaics, OLEDs, and paper media to name a few. The liquid to be coated is delivered with an accurate flow rate using a coating head (slot die) and the sample is moved at a predefined speed. The final "wet thickness" depends only on the flow rate, the coating width and the speed, thus defining slot die coating as a pre-metered technique. In contrast to self-metered coating techniques such as dip-, spin- or blade-coating, the physical properties of the chosen liquid do not affect the final thickness of the coating. Other significant advantages of slot die coating is its very high throughput and very low material waste (<10%). Although this technique has been used in some applications to produce thick coatings (tens of micrometers), the emergence of new markets (TFT LCDs) led to the development of advanced slot die coaters for the fabrication of ultra-thin films (down to tens of nanometers).

In this project, slot die coating has been tested for coating various resins and formulations on porous and pre-structured substrates. More specifically, we have chosen to investigate two case studies representative of specific applications. In the first case, slot-die coating was applied to the fabrication of a CO2 sensitive patch. The starting substrate was an A4 sheet coated with a mesoporous layer. A formulation based on CO_2 responsive molecules has been developed. Our objective was to apply uniformly a thin coating of this formulation on the mesoporous matrix. The very large surface area of the mesoprous matrix leads to an enhanced sensitivity of the patch. The major advantages of slot die coating in this case study were the absence of mechanical contact on the mesoporous layer, the low material waste and the very low volume needed for the deposition. A slot die coated sample is presented in Figure 2a.

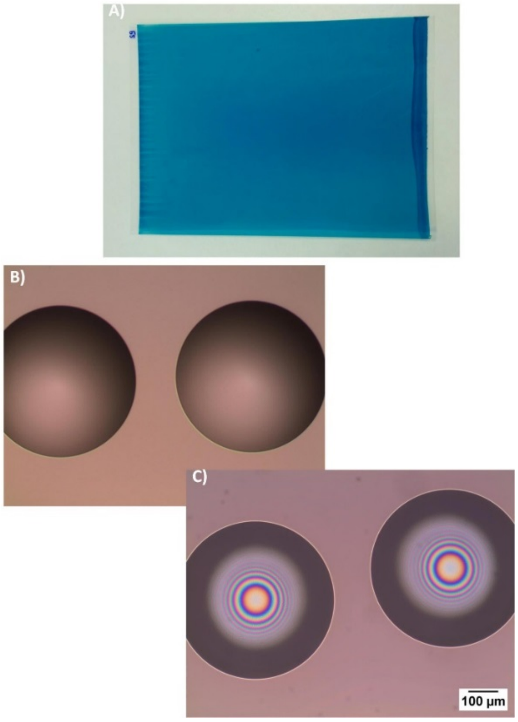

Figure 2: a) Mesoporous film coated with CO_2 sensitive layer. Optical images of microlenses before (b) and after photoresist coating (c).

In our second case study, the main objective was to coat a silicon wafer presenting an array of microlenses with a layer of photo resist. In contrast to spin-coating which is not well adapted to pre-structured substrates, slot die coating showed very promising results. A homogeneous coating over 150 mm wafers was obtained and its uniformity was not affected by the presence of the microlenses. An optical image of the coated microlenses is presented in Figures 2b and 2c. Further investigations will use slot die coating for other types of substrates presenting higher aspect ratio structure and will identify coating windows depending on the type of photoresist.

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[1] www.ixsenic.com