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Process Windows for Patterned Particulate Coatings

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A variety of coated products require patches or patterns of coating to be formed during the coating process. Flexible electronic devices, for example, are composed of patterns of functional materials on a flexible substrate. The continuous processing of these devices in a "reel-to-reel" fashion is frequently stated as a goal[1]. While there are several processing routes currently under exploration, this research concerns the use of chemically functionalized substrates (e.g., hydrophobic, hydrophilic) as a platform for simultaneous coating and patterning. Past research in on this topic has focused mainly on the dropping liquids onto patterns[2]; the few attempts at coating onto these surfaces have involved either ultralow coating speeds designed for assembly of monodisperse particles[3] or unspecified speeds[4]. The primary goal of this research is to find process conditions for creating uniform patterned coatings on chemically functionalized substrates using a dip coating process.

Silicon substrates with a pattern of hydrophilic lines and hydrophobic spacings were prepared using photolithography and treatment with a self assembled monolayer. The methods for substrate preparation were similar to those described by Fustin and coworkers[3]. These chemically patterned substrates were then dip-coated with an aqueous dispersion of silica nanoparticles. The surface pattern consists of hydrophilic lines varying in width from 5 to 50 μm with hydrophobic spacings that are half, equal and twice the hydrophilic widths. Lines are 40 mm in length and oriented vertically during dip coating. Withdrawal rates for coating ranged from about 1 to 400 mm/sec, and dispersion concentration varied from 2.5 to 20 wt% silica (150 nm aggregates). Two different dispersions were used: anionic silica and cationic silica.

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The effects of withdrawal rate and dispersion concentration on coating microstructure and pattern quality were characterized by optical microscopy and SEM, and the results used to define a "coating process window". For a given withdrawal rate, there is a minimum dispersion concentration needed to create a uniform layer of particles on the hydrophilic lines. Below this minimum, the coating is thicker near the edges of the hydrophilic line, due to segregation during drying. For a given dispersion concentration, there is a maximum withdrawal rate above which the excess entrained suspension at the tail of the 40 mm line obscures part of the pattern. The coating window limits and microstructures are also affected by the type of silica particle, the hydrophilic line width, and the hydrophobic spacing. Complete details will be given elsewhere.[5]

References:

1. See for example: JA Rogers, ZN Bao, A Makhija, P Braun, "Printing process suitable for reel-to-reel production of high-performance organic transistors and circuits," *Advanced Materials* **11** (1999) 741-745. M Chason, DR Gamota, PW Brazis, K Kalyanasundaram, J Zhang, KK Lian, R Croswell, "Toward manufacturing low-cost, large-area electronics," *MRS Bulletin*, **31** (2006) 471-475,

2. See for example: Z. Huang, P Wang, A MacDiarmid, Y Xia, G Whitesides, "Selective deposition of conducting polymers on hydroxyl-terminated surfaces with printed monolayers of alkylsiloxanes as templates," *Langmuir* **13** (1997) 6480-6484. F Fan, K Stebe," Size-selective deposition and sorting of lyophilic colloidal particles on surfaces of patterned wettability," *Langmuir* **21** (2005) 1149-1152.

3. C Fustin, G Glasser, H Spiess, U Jonas, "Parameters influencing the templated growth of colloidal crystals on chemically patterned surfaces," *Langmuir* **20** (2004) 9114-9123.

4. M Heule, U Schönholzer, L Gauckler, "Patterning colloidal suspensions by selective wetting of microcontact-printed surfaces," *Journal of the European Ceramic Society*, **24** (2004) 2733- 2739.

5. T. Reynolds and L. F. Francis, publication in preparation.