Selective surface fabrication using instability patterning

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This work presents a micro-patterned surface material structured by an instability patterning process. The structured material produced may be employed in solar energy applications with the object of improving the efficiency of the collector by increasing the absorption of incident radiation.

The use of structured surfaces for solar coatings has been widely studied, and is based upon the principle that structures that are of a comparable scale to the wavelength of the incident radiation can absorb that radiation effectively. The scale or wavelength of the structures that are produced using instability patterning can be tailored by changing the voltage, manufacturing geometry and dielectric properties of the fluid (Equations 1 and 2). In this project the fluid used was a crosslinkable resin and using a variety of voltages between xxx and xxxa number of different patterns were produced (Figures 1 and 2). It was chosen as it had a low cost, excellent mechanical properties and good chemical resistance, so it would be a good material for a solar device coating.

The manufacturing process uses a capacitor implementation (Figure 3). The cross linkable resin is spin coated onto one of the plates of the capacitor and the electric field which is created between the two plates when a voltage is applied destabilizes the surface of the resin. This destabilization leads to the electrohydrodynamic growth of regular arrays of protrusions or ‘pillars’ in the fluid which, over a characteristic time determined by the field and resin composition and thickness, extend across the gap between the plates (Figure 4). The fluid is then solidified, setting the structures in place.

The manufacturing method eliminates the need for expensive lithography, etching or sputter coating techniques and could be used with a wide range of materials and it has the potential for use in many fields that require structured and patterned surfaces.

To the authors’ knowledge the use of the resin in this process is novel and presents new challenges to be resolved. Current work is focusing on decreasing the scale of the pillars by suitable control of the applied voltage and the dielectric properties of the materials used; work is also in progress to find the optimum conditions that will result in an even pillar array. Future work will concentrate on optimizing the output of a solar device using these coatings.

$$\lambda = 2\pi \sqrt{\frac{\Upsilon U}{\varepsilon_0 \varepsilon_p \left(\varepsilon_p - 1\right)^2}}\, E_p^{\frac{-3}{2}}$$

$where\ \Upsilon = surface\ tension\ U = voltage\ \varepsilon_0 = permitivity\ of\ a\ vacuum$
$\varepsilon_p = relative\ permitivity\ of\ fluid\ E_p = electric\ field\ in\ the\ fluid$ Equation 1

$$E_p = \frac{U}{\varepsilon_p d - \left(\varepsilon_p - 1\right) h}$$

$where\ d = electrode\ spacing\ h = fluid\ thickness$

Equation 2

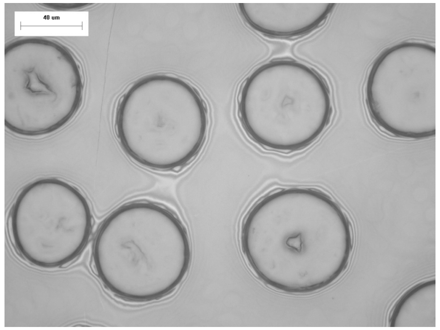


Figure 1. Crosslinkable resin surface fabricated using 30V

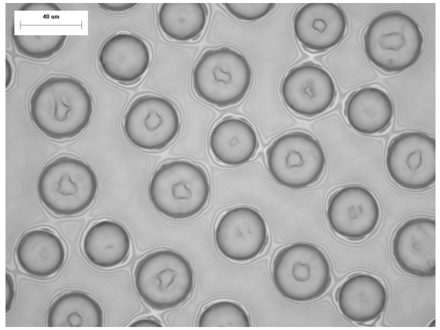


Figure 2. Crosslinkable resin surface fabricated using 60V

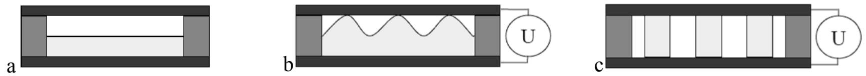
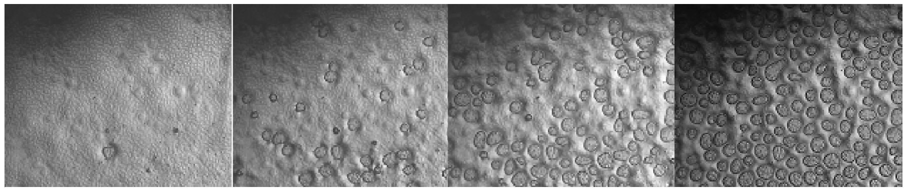


Figure 3. Schematic of capacitor patterning process (black-electrodes, dark grey-spacers, light grey resin) a. no applied voltage b. initial instability b. evolved pillars



a b c d

Figure 4. Real time development of an array of pillars at time a. 0 secs b. 2 mins c. 8 mins d. 30 mins