Lab-on-a-Chip

Electronic Supplementary Information

Synthetic microfluidic paper: high surface and high porosity polymer micropillar arrays

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Plotting theoretical limitation to capillary collapse of straight micropillar arrays

For straight pillars in square patterns capillary collapse occurs when

$$\frac{32\sqrt{2}\,\gamma\,h^3\cos\theta}{3\,d^4\,E}f(r) > 1 \tag{S1}$$

in which d, h and p are pillar diameter, height and pitch, respectively, E is the Young's modulus, θ is the equilibrium contact angle, γ is the liquid-vapour interfacial energy, and $f(r)$ is a function of $r=p/d$:

$$f(r) = \frac{1}{r-k}\left(\sqrt{\frac{2}{k^2-1}} + \sqrt{\frac{1}{2k^2-1}}\right) \tag{S2}$$

$$r = \frac{1}{k}\left(\frac{\sqrt{2}(k^2-1)^{-\frac{1}{2}} + (2k^2-1)^{-\frac{1}{2}}}{\sqrt{2}(k^2-1)^{-\frac{3}{2}} + 2(2k^2-1)^{-\frac{3}{2}}}\right) + k \tag{S3}$$

Equation (S3) can be simplified as a linear equation when $r > 1$, as seen in **Figure S1**.
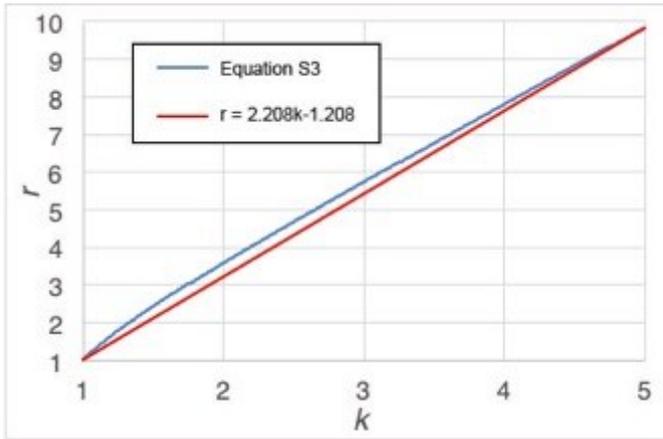
Figure S1. *Plot of k against p for r and its linear approximation r = 2.208k-1.208*

For practical pillar $r < 10$, the equation is approximated as $r = 2.208\,k - 1.208$ by connecting points at $k = 1$ and 5. This approximated form is inserted in Equation (S1) and (S2) and the following equation is obtained:

$$E = \frac{32\sqrt{2}\gamma\cos^2\theta h^2}{3d^4}\frac{1.8278}{r-1}\left(\sqrt{\frac{2}{0.2992r^2 + 0.4955r - 0.7949}} + \sqrt{\frac{1}{0.5984r^2 + 0.9909r - 0.5898}}\right) \tag{S4}$$

Equations S4 is used to plot the theoretical limits in Figure 2a and Figure S3. The following constants are used: E_{OSTE} = 5.5 MPa as measured by DMA, butyl acetate equilibrium contact

angle on OSTE $\theta = 5.8°$ as measured by goniometer, and liquid-vapour interfacial energy, $\gamma = 0.025$ Nm^{-1} as found in literature[25].
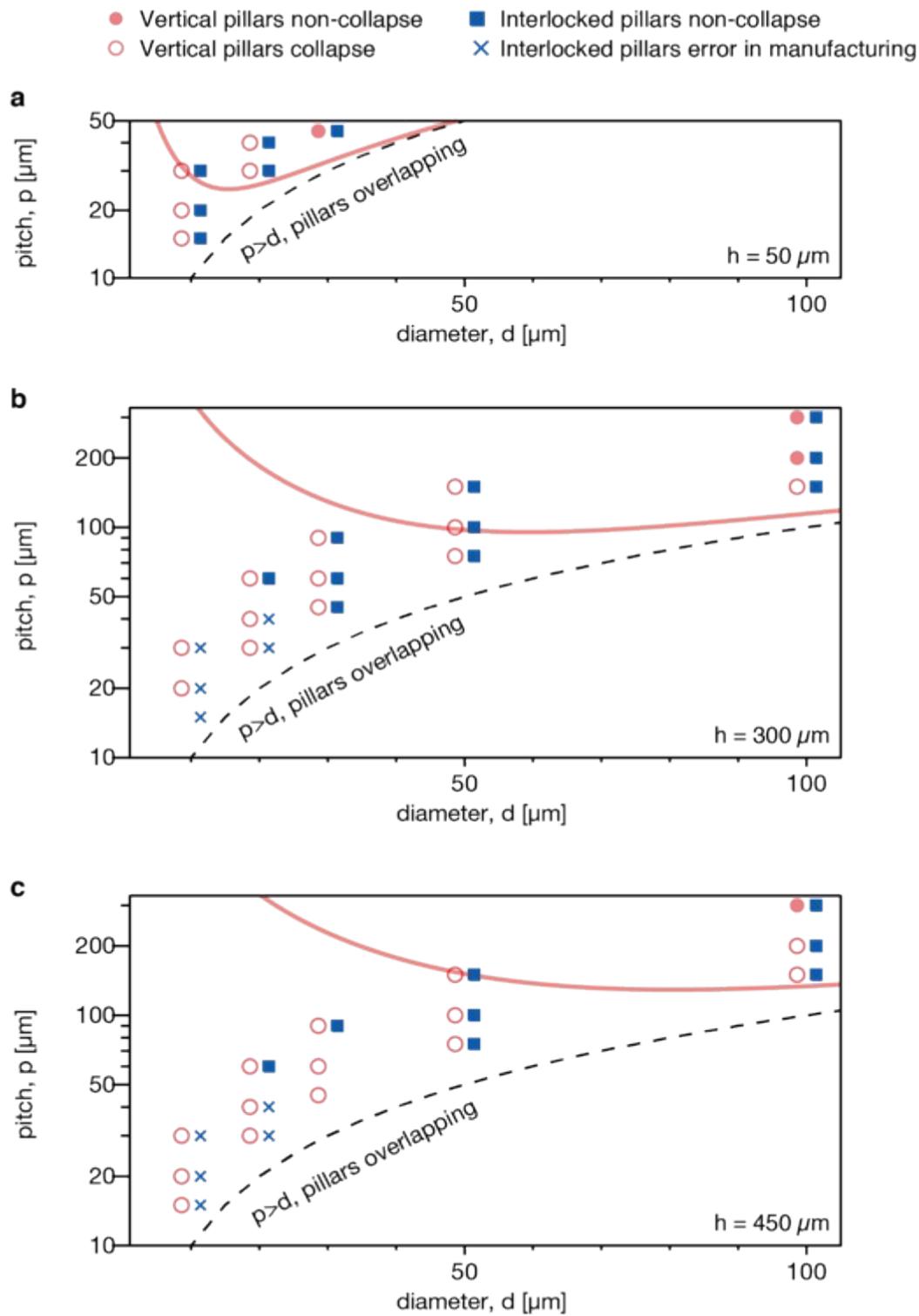
a

Block2
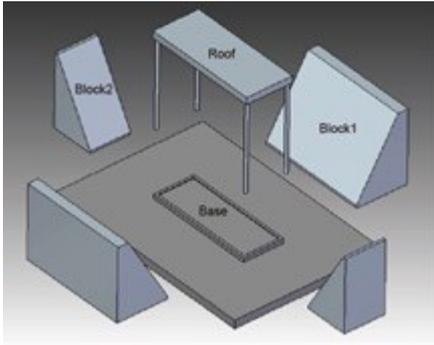
Roof

Block1

Base

b

Figure S2. *Manufacturing setup. (a) A 3D-sketch of the setup showing the roof, base, and the four angled blocks where mirrors are attached. (b) Photograph of the setup.*

Figure S3. *Capillary collapse for straight pillar arrays and interlocked pillar arrays for (a) h=50 μm, (b) h=300 μm, and (c) h=450 μm. The solid red line indicates the theoretical limit of capillary collapse for straight pillars,[11] and the grey dashed line is the regime when pillars are overlapping since p > d. The diameters of pillars tested are 10, 20, 30, 50, and 100 μm but for clarity the symbols are separated slightly in the plot.*