liquid in the capillary features. A general form of above equation can be:

$$\Delta p = \frac{\sigma}{R} + F_{surface}A_{surface} = \pm\sigma y''(1+y')^{-3/2} + F_{surface}A_{surface}$$

[0267] For this analysis, we will assume $F_{surface}=0$

[0268] The capillary niche is shown here:

[0269] The liquid surface is described by y=y(z). The pressure outside the liquid is constant at p_a. The pressure inside the liquid is a function only of z, p=p(z). Therefore, the pressure difference is $p(z)-p_a$, which is the capillary pressure difference:

$$p(z)-p_a=\Delta p=\sigma y''(1+y'^2)^{-3/2}$$

[0270] Differentiating this with respect to z gives

$$\frac{dp}{dz} = \sigma y'''(1+y'^2)^{-3/2} - \sigma y''\frac{3}{2}(1+y'^2)^{-5/2}(2y'y'')$$

[0271] From hydrostatics, we have

$$\frac{dp}{dz} = -\rho g$$

[0272] where,

[0273] ρ=density of liquid, kg/m^3

[0274] g=acceleration due to gravity, m^2/s

$$y'''(1+y'^2) - 3y'y''^2 + \frac{\rho g}{\sigma}(1+y'^2)^{5/2} = 0$$

[0275] is the differential equation that describes the liquid-vapor interface in a capillary

[0276] The boundary conditions are:

[0277] 1) y(0)=w

[0278] 2) y'(0)=y'(h)=cot(θ)

[0279] where,

[0280] w=Width of the capillary structure

[0281] h=height of the capillary structure

[0282] θ=Contact angle with the surface

[0283] Examples of Capillary Features

[0284] Capillary features either are recessed within a wall of a microchannel or protrude from a wall of the microchannel into the flow path that is created above the microchannel wall. Laser cutting is one method to create recessed features. The features create a spacing that is less than 1 mm, more preferably 250 microns or less, still more preferably a spacing of 100 μm or less. Protruded features may be produced by roll forming or knurling methods.

[0285] Capillary features, those features used to hold liquid substances, have been successfully fabricated by the following manufacturing methods: Laser etching, which is a method by which a laser creates features into the surface of material by regulating the speed and power of the laser, to remove base material and create the intended feature. A second method used to successfully fabricate capillary features is by Electrical Discharge Machining (EDM). This process uses a small diameter wire to make the intended feature by burning away a conductive base material. Lastly, capillary features have been fabricated by roll forming of the intended features into thin material. This process is similar to knurling features into round parts, except instead of round parts flat material is used. This process requires a round tool, with the features made into it, to be placed on the base material. As the tool moves over the material, features are created, as the tool uses applied pressure to move the base material.

[0286] The features may take any geometry and are defined by having at least one dimension (length, width, or depth) that is below a critical dimension for fluid retention. The critical dimension is a function of the fluid and surface interface properties (see modeling section).

[0287] Preferred ranges for capillary feature depth (as defined as recessed or protruded distance normal to the direction of gravity) are less than 2 mm. More preferrably less than 1 mm. Most preferably from 0.01 mm to 0.5 mm. It should be noted that the microchannel itself can exert a capillary force, however this force is aligned with gravity and the channel is open to partial draining of the washcoating fluid. A natural liquid height will be retained within the microchannel above the fluid reservoir level after draining as a result of capillary forces from the channel. It should further be noted that this height may well be less than the desired coating length of the microchannel.

[0288] The preferred range for the width of the capillary feature (as defined as the open distance parallel to the direction of gravity) is less than 2 mm. More preferrably less than 1 mm. Most preferably from 0.1 to 0.5 mm.

[0289] The length of the capillary feature may be any length and is preferrably orthogonal to the direction of gravity. The length may span the microchannel width or any fraction therin. In some embodiments, the length of the capillary feature may be longer than the width of the microchannel such that it spans multiple parallel microchannels. This may be particularly advantageous to form longer capillary features during the shim manufacturing process.

[0290] The wet coating thickness may substantially be the same as the depth of the capillary feature. The dry coating thickness will be substantially reduced, as the bulk of the coating liquid solution is usually aqueous or organic liquid that is removed on drying. In some embodiments, the final dry coating thickness may range from about 1 micron to 250 microns. A preferred range of coating thicknesses is from about 5 microns to about 25 microns. When capillary features are present, coating thickness is averaged with appropriate deductions or additions for the depth of the capillary features.

[0291] The length of a horizontally-aligned capillary feature is defined from the direction perpendicular to the microchannel length. The depth is the distance which the