Subject: MCP surface area calculation

From: Jason B. McPhate

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This memo presents a quick calculation of the total MCP surface area based on the rather hexagonally shaped pores of the Incom substrates. The calculation is presented as well as a table of total areas for several MCP configurations (pore size, open area ratio, and MCP dimensions).

Figure 1 is an optical image of a 40 µm pore Incom substrate put on the PSEC blog by Herve Grabas on 14-April-2009. Two hexagons have been overlaid on this image to represent the pore size, d, and pore spacing, x, characteristics. The labeled values in this figure are used in the following calculations. If the length of the pores is $l = \gamma d$ (where γ is the l/d ratio), then the surface area of a single pore is

$$s_P = 6tl = 2\sqrt{3}\gamma d^2 .$$

The open area per pore, a_O, and total area encompassed by a single pore including associated pore walls, a_T, are given by,

$$a_O = \frac{\sqrt{3}}{2} d^2 \qquad \text{and} \qquad a_T = \frac{\sqrt{3}}{2} x^2 .$$

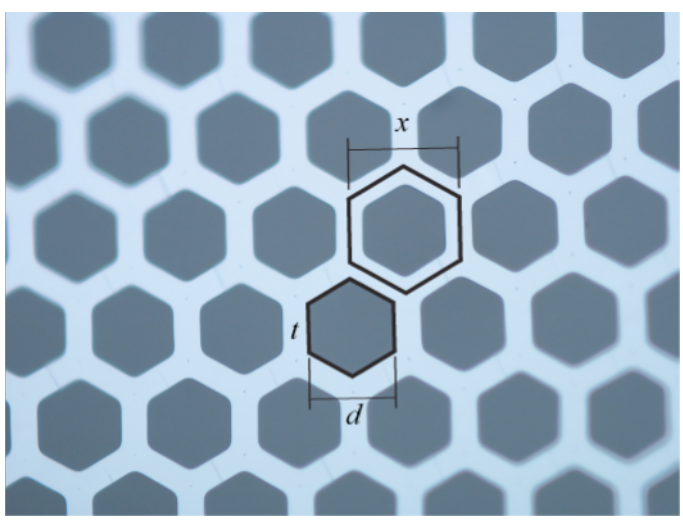

Figure 1: Annotated image of the face of an Incom 40µm pore substrate. Pores are hexagons with sides of length t, "diameters" of d, and spacing of x. Picture from the PSEC blog (credit: Herve Grabas),

The open area ratio of the MCP is the ratio of these, $\alpha \equiv a_O/a_T$, so the pore spacing can be rewritten as $x = d/\sqrt{\alpha}$.

If the surface area of the top or bottom of the blank MCP (sans pores) is A_B, then the number of pores in the MCP is $N_P = A_B/a_T$. For a round MCP of diameter D or a square MCP of side W the blank areas and circumferences are

$$A_B = \frac{\pi}{4}D^2;\ \ C_B = \pi \mathrm{D} \quad \text{or} \quad A_B = W^2;\ \ C_B = 4W.$$

The total surface of the MCP is the sum of the top and bottom web surface areas, A_W, the edge surface area, A_E, and the total pore surface area, A_P. Given the above this can be written,

$$A_{Total} = 2A_W + A_E + A_P = 2(1-\alpha)A_B + lC_B + N_P s_P,$$

and with some substitution from above this becomes,

$$A_{Total} = 2(1-\alpha)A_B + \gamma d C_B + 4\alpha\gamma A_B.$$

Interestingly, the pore diameter cancels from the last term. As the edge area term is nearly negligible, the total surface area is independent of pore size. Furthermore, since the pore area term dominates and $\alpha \approx 3/4$, to first-order the total surface area can be approximated, $A_{Total} \approx 3\gamma A_B$.

The above formula (non-approximation) was used to calculate the total surface areas of several configurations of MCPs that will be used for the LAPP project. The results (in cm^2) are shown in the last column of Table 1.

Table 1: Calculated total surface areas for several MCP configurations that will be used during the LAPP project.

MCP Type	*d (μm)*	*γ = l/d*	*α*	*A_{Total} (cm^2)*
33mm diam	40	40	0.65	881
	40	40	0.83	1,120
	20	60	0.65	1,317
8in square	40	40	0.65	43,244
	20	60	0.65	64,712