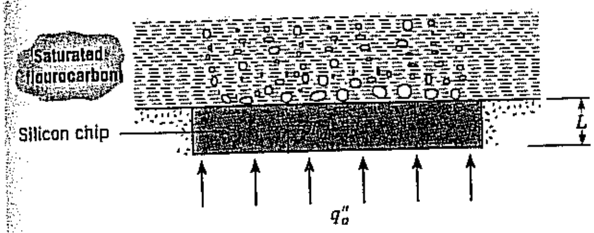
ME 146 Boiling Homework
from Incropera & DeWitt

10.6 Estimate the nucleate pool boiling heat transfer coefficient for water under atmospheric pressure in contact with mechanically polished stainless steel when the excess temperature is 15°C.

10.20 A silicon chip of thickness $L = 2.5$ mm and thermal conductivity $k_s = 135$ W/m · K is cooled by boiling a saturated fluorocarbon liquid ($T_{sat} = 57°C$) on its surface. The electronic circuits on the bottom of the chip produce a uniform heat flux of $q''_o = 5 \times 10^4$ W/m², while the sides of the chip are perfectly insulated.



Properties of the saturated fluorocarbon are $c_{p,l} = 1100$ J/kg · K, $h_{fg} = 84{,}400$ J/kg, $\rho_l = 1619.2$ kg/m³, $\rho_v = 13.4$ kg/m³, $\sigma = 8.1 \times 10^{-3}$ kg/s², $\mu_l = 440 \times 10^{-6}$ kg/m · s, and $Pr_l = 9.01$. In addition, the nucleate boiling constants are $C_{s,f} = 0.005$ and $n = 1.7$.

What is the steady-state temperature T_o at the bottom of the chip? If, during testing of the chip, q''_o is increased to 90% of the critical heat flux, what is the new steady-state value of T_o?

10.33 For forced convection boiling in smooth tubes, the heat flux can be estimated by combining the separate effects of boiling and forced convection. The Rohsenow and Dittus–Boelter correlations may be used to predict nucleate boiling and forced convection effects, with 0.019 replacing 0.023 in the latter expression. Consider water at 1 atm with a mean velocity of 1.5 m/s and a mean temperature of 95°C flowing through a 15-mm diameter brass tube whose surface is maintained at 110°C. Estimate the heat transfer rate per unit length of the tube.

If we wanted a more accurate analysis, we would need to follow the procedures in section 6.4.3 of our textbook.