Homework: Flow boiling heat transfer in microchannel with fins or cavities

Known : Liquid water with velocity U_{in} and temperature T_{in} flows into the microchannel. The bottom wall of the microchannel is subjected to a heat flux q. As the water is heated, vapor will be generated leading to the flow boiling heat transfer process.

Assumption: (1) laminar flow, (2) incompressible fluid, (3) constant fluid properties, (4) negligible radioactive and natural convective heat transfer from the micro channel heat sink.

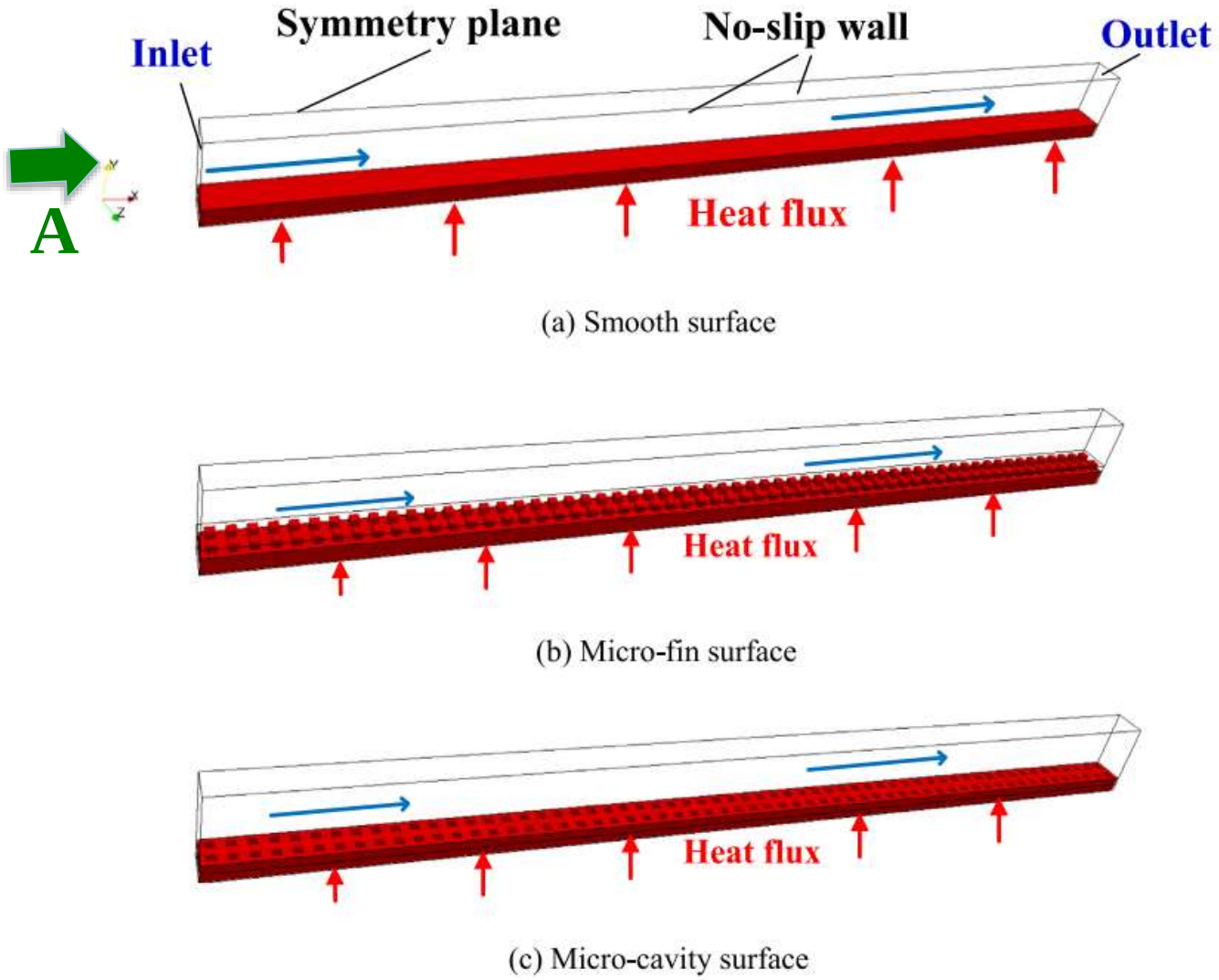

Fig. 1 Computational domain

1) The size of the fluid domain is 200μm× 200μm × 2000μm. (see Fig. 1)
2) The solid is Si and the fluid is water
3) Bottom heat flux q: 500kW/m^2
4) Inlet water velocity U_{in} : 0.5m/s
5) Inlet water temperature T_{in} : 373.15K
6) Saturation temperature: 373.15K
7) The contact angle is 60° for liquid
8) Channel outlet: fully developed boundary condition
9) The top wall and front side wall are non-slip and adiabatic.
10) Due to the symmetry, half of the channel can be simulated. Thus, the back surface is symmetry plane
11) The evaporate rate and condensation rate are 0.1.

Thermophysical properties of water and Si.

Parameters	Water		Si
	Liquid	Vapor	Solid
ρ (kg/m^3)	958.35	0.59817	2300
ν (m^2/s)	2.94×10^{-7}	2.04×10^{-5}	-
c_p (J/kg/K)	4215.7	2080	700
k (W/m·K)	0.67909	0.025096	150
T_{sat} (K)	373.15		-
h_{lv} (kJ/kg)	2256.4		-
σ (N/m)	0.05891		-

Table 1

Summary of the dimensions of the micro-structured surface.

Parameter	Variable	Dimension (μm)
Base height	H_{base}	50
Fin height	H_{fin}	25
Fin length	L_{fin}	25
Fin width	w_{fin}	25
Cavity depth	H_{cavity}	25
Cavity length	L_{cavity}	25
Cavity width	w_{cavity}	25
Distance between fins or cavities	w_{dis}	25

Table 2

1) The properties of solid (Si), liquid water and water vapor are listed in Table 1.

2) The height of the base of the microchannel is 50 μm. The structural parameters of the fins or cavities are listed in Table 2.

Question

1) Analyze the evolution of temperature at the bottom wall, velocity, pressure, and two-phase flow fields in the domain.
2) Plot the curves for the heat transfer coefficient, pressure drop, averaged bottom wall temperature, and vapor saturation in the domain with *X* axis as time.
3) Investigate effects of inlet velocity and bottom wall heat flux on the flow boiling heat transfer process.
4) If possible, change sizes of fins or cavities in Table 2, and investigate their effects on flowing boiling heat transfer.