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Subcooled Flow Boiling

NOMENCLATURE

A	area, m^2
B	fin height, m
Bo	Boiling number, $Bo=\frac{q}{G \cdot i_{fg}}$, dimensionless
c_p	specific heat, J/kg°C
D	hydraulic diameter of rectangular-channel, m
E	enhancement factor
F	pin-fin factor for the effects of fin geometries, dimensionless
Fr	Froude number, $Fr_l = \frac{G^2}{\rho_l^2 \cdot g \cdot D_h}$, dimensionless
G	mass flux, kg/m^2s
g	acceleration due to gravity, m^2/s
H	height, m
h	heat transfer coefficient, $W/m^2 \cdot K$
I	measured current from DC power supply, A
i_{lv}	enthalpy of vaporization, $J/kg \cdot K$
Ja	Jacob number based on ΔT_{sat}, $Ja = \frac{\rho_l \cdot C_{pl} \cdot \Delta T_{sat}}{\rho_v \cdot i_{lv}}$, dimensionless
Ja'	Jacob number based on ΔT_{sub}, $Ja' = \frac{\rho_l \cdot C_{pl} \cdot \Delta T_{sub}}{\rho_v \cdot i_{lv}}$, dimensionless
k	thermal conductivity, $W/m \cdot K$
L	length, mm
$\dot{m}$	mass flow rate, kg/s
N	number of micro-pin-fins
N_{ac}	Active nucleation site density, n/m^2
N_{conf}	Confinement number, $N_{conf} = \frac{(\sigma/g \cdot \Delta\rho)^{0.5}}{D_h}$, dimensionless

Nu	Nusselt number, $Nu = \frac{h \cdot L}{k}$, dimensionless
P	system pressure, kPa
Pr	Prandtl number, $Pr = \frac{\mu \cdot C_p}{k}$, dimensionless
Q	heat transfer rate, W
q"	average imposed heat flux, W/cm^2
R	resistance of the electric-heater
Re	Reynolds number, $Re = \frac{G \cdot D}{\mu}$, dimensionless
S	fin space between two adjacent fins, m
T	temperature,℃
V	coolant FC-72 flow velocity, m/s
V	measured voltage from DC power supply, V
W	width, m

Greek Symbols

ΔT	temperature difference, ℃
ρ	density, kg/m^3
μ	dynamic viscosity, $N \cdot s/m^2$
ν	specific volume, m^3/kg
σ	surface tension, N/m
α	void fraction, dimensionless
ε	relative heat loss, dimensionless
ϕ	contact angle
ϕ_s	static contact angle

Subscripts

ave	average
c,h	from heater surface to cooper surface
chip	chip surface
cop	copper
cs	cross-section of rectangular-channel
d	diameter
e	effective
f	fin
fin	mean bubble departure frequency
g	gas
h	hydraulic
i	at the inlet of the test section
in	at the inlet of the test section
i,o	at inlet and exit of the test section
l	all-liquid nonboiling heat transfer
lv	liquid phase to vapor phase
m	average value for the two phase mixture or between the inlet and exit
mica	mica
n	net power input to the coolant FC-72
n	active nucleation site density
o	at the outlet of the test section
p	preheater
pool	pool boiling
r	coolant FC-72
s	surface
sat	saturated state for coolant FC-72

sp single-phase convective heat transfer

sub subcooled state for coolant FC-72

t total

t-g thermal-grease

tp two-phase boiling heat transfer

v vapor

w wall

w water

1ϕ single-phase

2ϕ two-phase