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List of Symbols

Nomenclatures

A	Effective area of heat sink (m^2)
c_p	Specific heat ($J/kg \cdot K$)
d_h	Hydraulic diameter (mm)
f	Friction factor
g	Gravitational acceleration (m/s^2)
h	Heat transfer coefficient ($W/m^2 \cdot K$)
h_{ch}	Height of channel (mm)
J	Comparison factor (heat transfer coefficient to pressure drop ratio) ($m/s \cdot K$)
k	Thermal conductivity ($W/m \cdot K$)
k_m	Heat sink thermal conductivity ($W/m \cdot K$)
L_{ch}	Length of channel (mm)
n	Shape factor
Nu	Nusselt number
P_p	Pumping power (W)
Pr	Prandtl number
Q	Heat flux (W/m^2)
\dot{Q}	Heat transfer rate (W)
Re	Reynolds number
R_{th}	Thermal resistance (K/W)
S_{gen}	Total entropy generation rate (W/K)
T	Temperature ($^{\circ}C$ or K)
u, v, w	Velocity (m/s)
\dot{V}	Volume flow rate (lpm)

vol	Volume
w_{ch}	Width of channel (mm)
x, y, z	Cartesian coordinates

Greek symbols

α	Acceleration (m/s^2)
Δp	Pressure drop (Pa)
η	Efficiency
μ	Dynamic viscosity (Pa. s)
ν	Kinematic viscosity (m^2/s)
ϕ	Volume concentration (%)
ρ	Density (kg/m^3)
Ψ	Stream coefficient
ε_{th}	Thermal effectiveness

Subscripts

1	first
2	second
bf	base fluid
ch	channel
dr	drift
f	fluid
in	inlet
l	liquid
m	mean
nf	nanofluid

out	outlet
p	particle
s	surface

Abbreviations

Ag	Silver
AgNO ₃	Silver nitrate
Al ₂ O ₃	Alumina nanoparticle
AlN	Aluminium nitride
AR	AR (ratio of height and width of channel, i.e. h_{ch}/w_{ch})
Au	Gold
CFD	Computational fluid dynamics
CNT	Carbon nanotube
COP	Coefficient of performance
CTAB	Cetyl trimethyl ammonium bromide
Cu	Copper
CuO	Copper oxide nanoparticle
DAS	Data acquisition system
DI	Distilled
EG	Ethylene glycol
Fe ₂ O ₃	Ferric oxide
FOM	Figure of merit
GNP	Graphene nanoplate
GO	Graphene oxide
HEG	Hydrogen-exfoliated graphene
ID	Internal diameter

IEP	Isoelectric point
JCPDS	Joint Committee on Powder Diffraction Standards
MCHS	Mini channel heat sink
MEPCM	Microencapsulated phase change material
MgO	Magnesium oxide
MWCNT	Multi-walled carbon nanotubes
ND	Nano diamond
OD	Outer diameter
PCM	Phase change material
PEC	Performance evaluation criteria
PG	Propylene glycol
rGO	Reduced graphene oxide
SAE	Society of automotive engineers
SDS	Sodium dodecyl sulfate
SDBS	Sodium dodecyl benzene sulfonate
SEM	Scanning Electron Microscopy
SiC	Silicon carbide
SiO ₂	Silicon oxide
SIMPLE	Semi-implicit method for pressure linked equations
SLS	Sodium lauryl sulfate
SWCNT	Single-walled carbon nanotubes
TiO ₂	Titania nanoparticle
TEM	Transmission electron microscopy
TiO ₂	Titania nanoparticle
UDF	User defined function

vol%	Percentage volume concentration
wt. %	Percentage weight concentration
XRD	X-ray diffraction
ZnO	Zinc oxide
ZnSO ₄	Zinc sulfate