Optimization Under Uncertainty of Manifold Microchannel Heat Sinks

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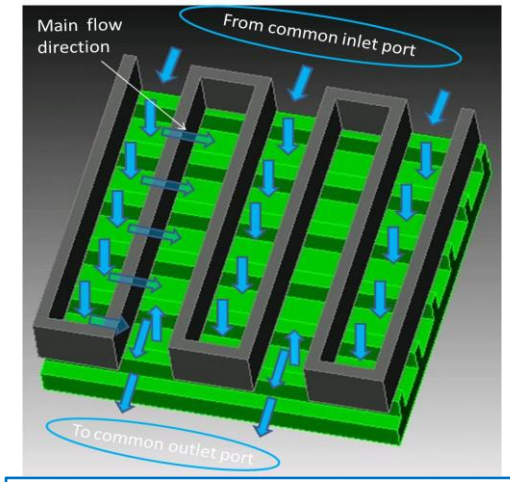
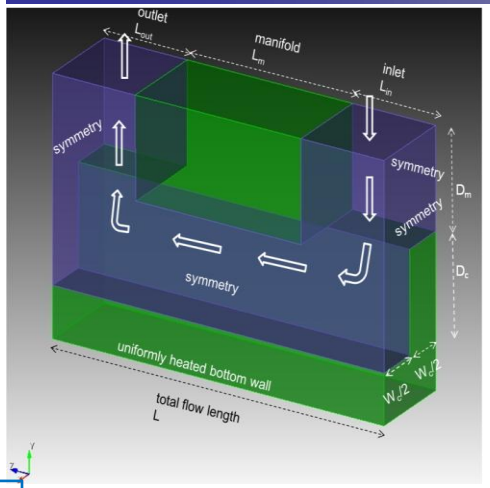
MOTIVATION

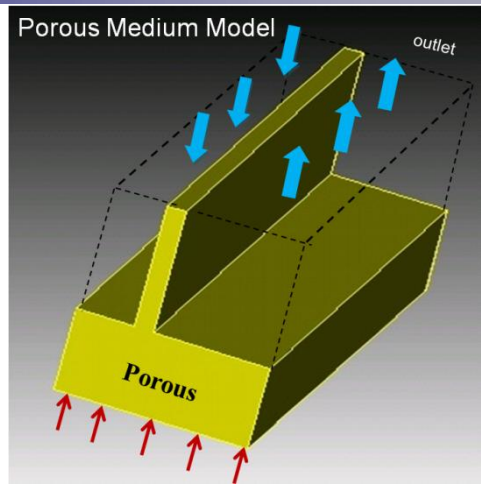


- Enhanced performance over microchannels due to manifolds
- Inherent geometric uncertainties affect optimized design

APPROACH : COMPUTATIONAL DOMAIN



Unit Cell Model



Porous Medium Model

Modeling Tool : CUBIT 13.0
Solver : Ansys FLUENT 13.0

Solid domain: Silicon
Coolant fluid: Water

OBJECTIVE

INPUT VARIABLES

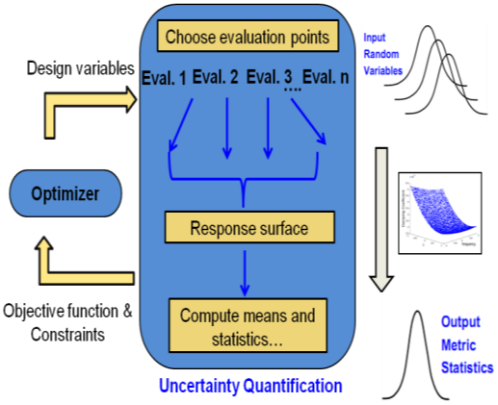
- Channel Width (W_c)
- Channel Depth (D_c)
- Inlet Length (L_{in})
- Outlet Length (L_{out})
- Manifold Length (L_m)
- Manifold Depth (D_m)

OUTPUT PARAMETERS

- Pressure Drop (ΔP)
- Heat Transfer Coefficient (h)

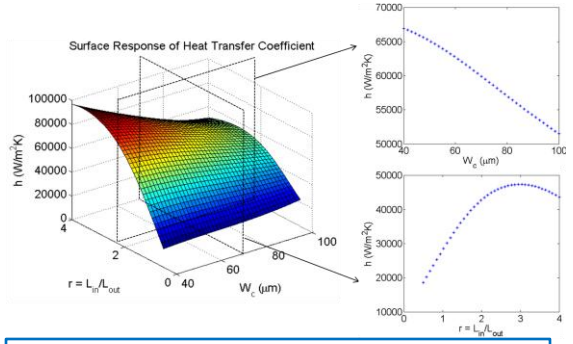
Optimization of inputs for desired output performance

OUU APPROACH



$$OF = w_1\left(h/h_{\max}\right) - w_2\left(\Delta P/\Delta P_{\max}\right)$$

SURFACE RESPONSE



- Heat transfer coefficient decreases with increase in W_c
- Heat transfer coefficient reaches a maximum at r ~ 3.

OPTIMIZATION RESULTS

Condition	Deterministic (Unit Cell)		Probabilistic (Unit Cell)		Probabilistic (Porous Medium)	
u = 0.03 m/s	W_c (μm)	L_{in} (μm)	W_c (μm)	L_{in} (μm)	W_c (μm)	L_{in} (μm)
$0.7(h/h_{max}) + 0.3(-\Delta P/\Delta P_{max})$	28	245	24	209	28	202
$0.5(h/h_{max}) + 0.5(-\Delta P/\Delta P_{max})$	33	234	27	180	31	184

- Probabilistic optimization predicts different optimal geometry, more robust than deterministic
- Results from porous medium model match unit cell model within specified uncertainties