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# Transient thermal behavior of a microchannel heat sink with multiple impinging jets

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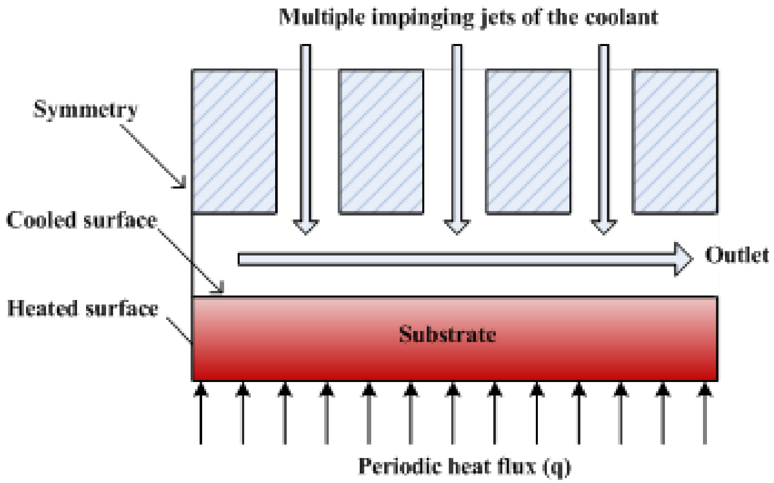
**Keywords:** Microchannel heat sink with impinging jet, Heat transfer, Sinusoidal heat flux, Sinusoidal inlet velocity, Phase lag

# Background and Main target

- Both microchannel heat sink and impinging jet have attracted wide attention for their excellent advantages in heat transfer performance, but seldom reports show the combination of microchannel heat sink and impinging jets.

- Various experimental results and steady state numerical simulations on microchannel heat sink with an impinging jet (MHSIJ) have also been published. However, to the best of our knowledge, there is little analytical and numerical work which has studied the effects of periodic heat flux and periodic jet velocity on the thermal performance of an MHSIJ.

- we performed a numerical analysis on an MHMSIJ being imposed by periodic jet velocities and heat fluxes, analyzed the transient fluid flow and thermal behavior, explored the effects of amplitude and period of jet velocity and heat flux, and also considered the effect of the physical properties of the substrate materials.



# Method

- the three-dimensional, unsteady Mass equation, Navier-Stokes equations, and Energy equation are used.
- The temperature-dependent thermal conductivity and dynamic viscosity are used for the numerical simulation.
- For different cases, sinusoidal heat fluxes are imposed on the heated surfaces and sinusoidal inlet velocities are imposed on the inlet of the impinging jets.

$$w = \bar{v} + A_v \times \sin\left(\frac{2\pi}{\tau_v} t\right) \quad m/s \qquad q = \bar{q} + A_1 \times \sin\left(\frac{2\pi}{\tau_h} t\right) \quad W/cm^2$$

# Results

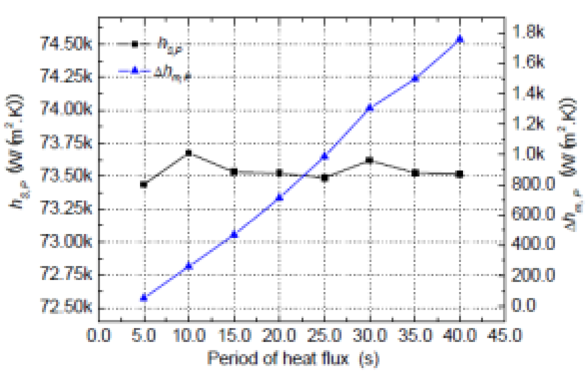



Fig. 8 The value of and $\Delta h_{m,P}$ variation at the cooled surface with the variation of period of the heat flux

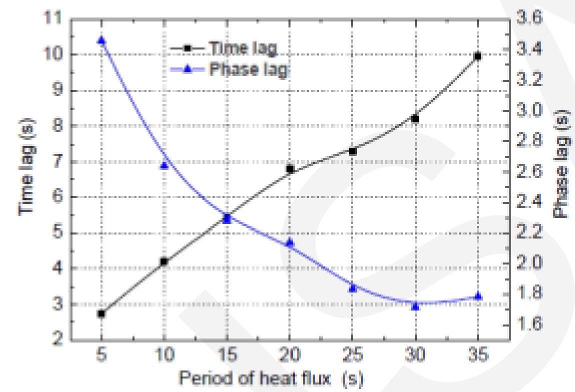



Fig. 9 The effect of period of heat flux ($\tau_h$) on the time lag and phase lag

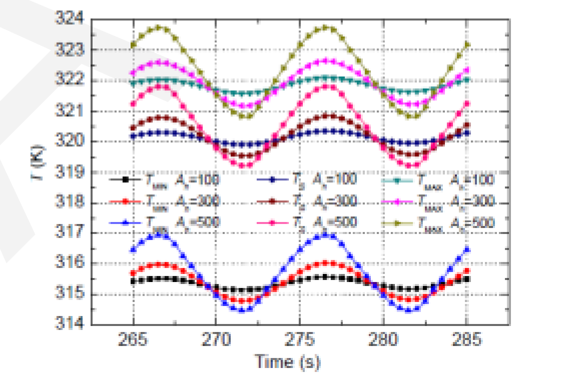



Fig. 10 The effect of the amplitude of heat flux on $T_{MIN}$, $T_s$, and $T_{MAX}$ at the cooled surface

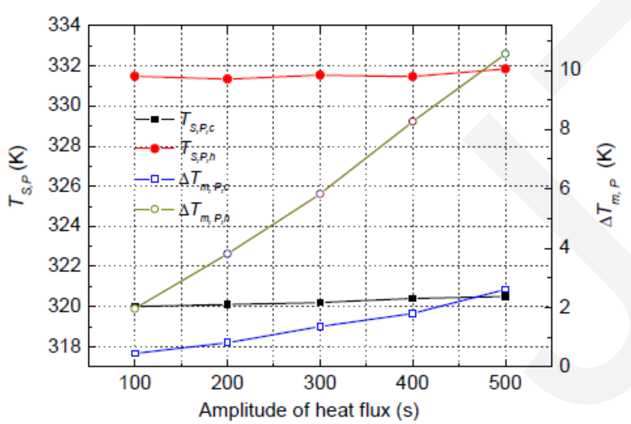



Fig. 12 The value of $T_{S,P}$ and maximum temperature variation at the cooled surface and the heated surface with the variation of amplitude of the heat flux

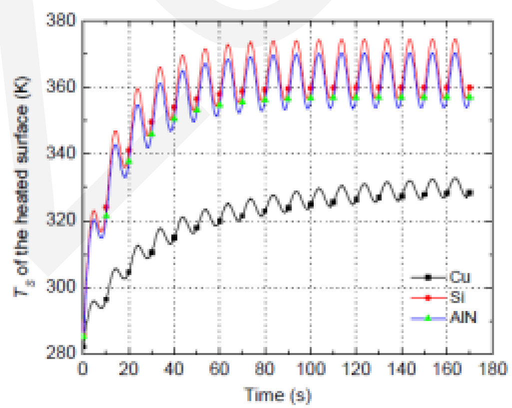



Fig. 14 The effect of substrate material on $T_s$ of the heated surface

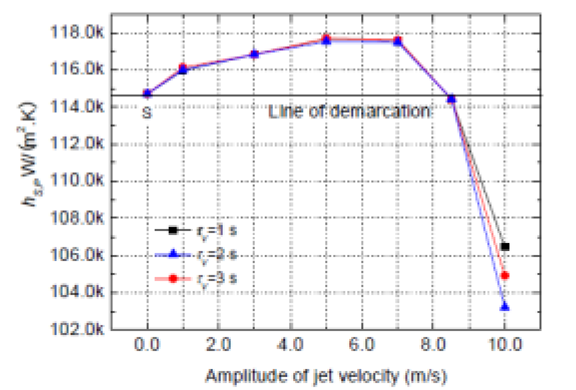



Fig. 17 The effect of period and amplitude of jet velocity on of the heated surface

# Conclusions

- The period of the periodic heat fluxes is a key parameter influencing the performance of the MHSMIJ. When periodic heat fluxes are imposed upon the heated surfaces of the MHSMIJ, the time lag will increase with increasing period, while the phase lag has an adverse trend.
- The amplitude of heat flux is another key parameter influencing the performance of the MHSMIJ. Increasing amplitude will not significantly affect the parameters like time lag, phase lag, and overall heat transfer coefficient, but will cause the system to fluctuate in temperature to a larger extent, which also degrades the performance of the MHSMIJ.
- The heat source material properties affect on the time lag and phase lag. When the material of the heat sink substrate is copper, the MHSMIJ has a larger $N_s$ and lower amplitude of temperature fluctuation.
- The amplitude of jet velocity significantly affects the transient heat transfer performance of the MHSMIJ as it greatly affects the thicknesses of the velocity and temperature boundary layers.

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