Numerical Heat Transfer Project

Jet impingement can be applied to many fields, including the impinging of high temperature/pressure air flow during rocket launch, the cooling of blades in steam turbines, the drying of food, and the cooling of electronic devices. Specifically, in terms with single-phase cooling for electronic devices, jet cooling can achieve excellent thermal performance.

The jet cooling for electronic components is described as follows. As shown in the schematic diagram in Fig.1, the coolant vertically impinge the heated chips through arranged square jet holes, and waste coolant is discharged from both end sides of channel. The overall numerical model and corresponding dimensions are presented in Fig. 2. The size of Pyrex substrate is: 12 mm×1.9 mm×1 mm (length×width×height). Rectangular Titanium electrode is deposited on Pyrex substrate by CVD method as heat source, and its size is 400 μm×1500 μm×100 nm as showed in Fig. 2(c). Then, 2 μm-thick SiO_2 is deposited on the surface of the Pyrex substrate and covers the Titanium electrode as an insulating layer. Finally, a 210 μm-thick microchannel is formed by bonding vinyl sticker between the bottom SiO_2 layer and the top jet orifice (The thickness of vinyl sticker is neglected). It is noted that top jet orifice is not presented in Fig. 2(a), and it is unnecessary to be considered in simulation process. Hence, we assume that the volume flow rate is evenly distributed into each jet hole.

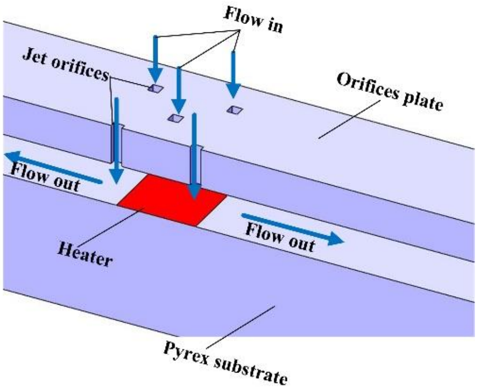
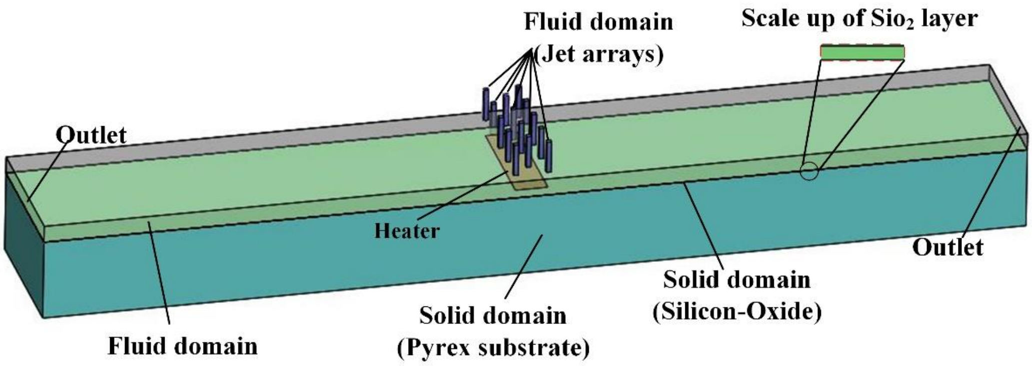
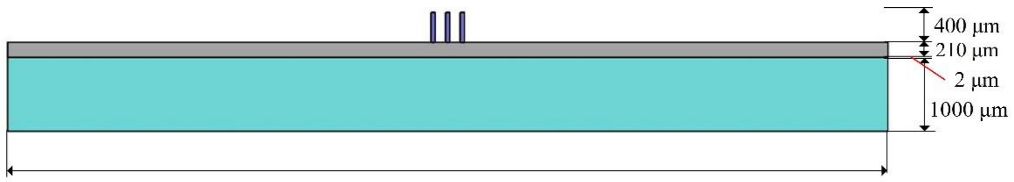


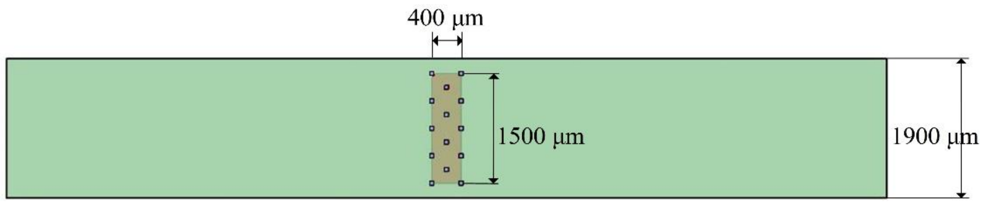
Fig. 1 Schematic Diagram



(a) Overall Model of Simulation



(b) Front View



(c) Top View

Fig. 2 Dimension of Numerical Model

Three jet hole arrangements are presented in Fig. 3 (a), (b) and (c), and the red rectangles and black squares are the heat source area and the jet holes, respectively. Jet patterns in Fig. 3(a) and Fig. 3(b) include 13 staggered jet holes and 14 staggered jet holes, respectively. Jet patterns in Fig. 3(c) includes 15 inline jet holes.

The volume flow rate are: 32 mL/min, 36 mL/min, 40 mL/min, 45 mL/min, 50 mL/min and the heat flux of heat source is 80W/cm^2. Additionally, HFE7000 is used as coolant and the inlet cooling temperature is 10°C. The thermophysical properties are listed in Table 1.

Task: Based on different tail number of student ID, tasks are divided into 5 groups. The tail number 0 and 5 calculate three jet patterns at rate 32 mL/min. Similarly, tail number 1 and 6 for rate 36 mL/min, 2 and 7 for rate 40 mL/min, 3 and 8 for rate 45 mL/min, 4 and 9 for rate 50 mL/min.

1. Calculate the average pressure drop and *Nu* via FLUENT.

2. Analyze flow and heat-transfer (interaction effects between adjacent jet holes, *Nu*, and local heat-transfer characteristics).

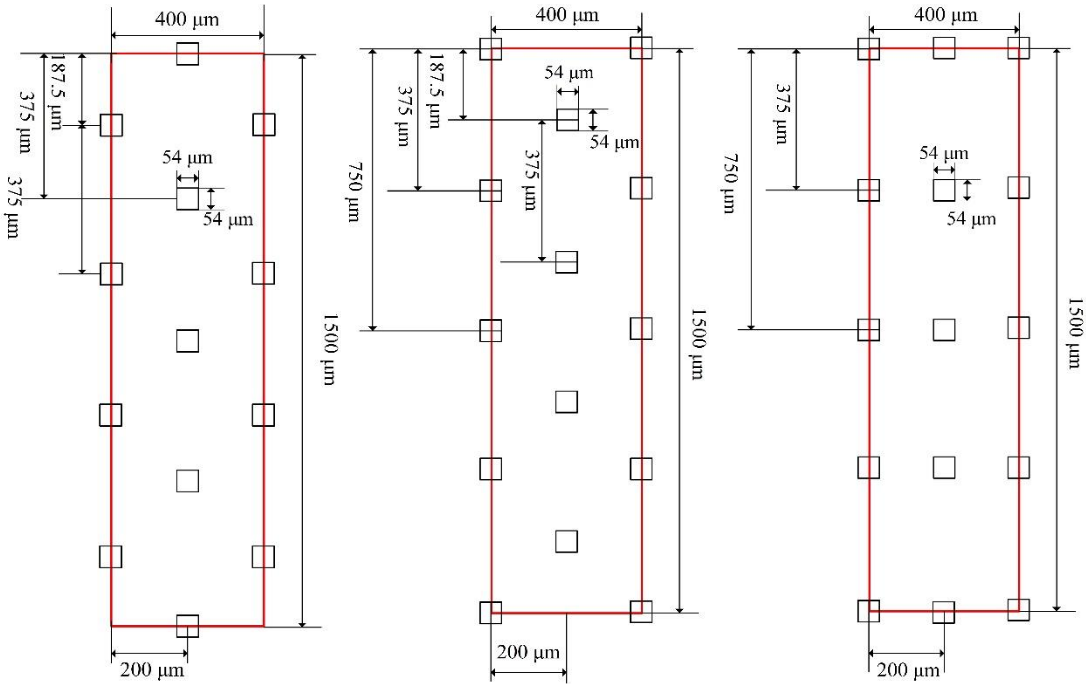
Tips:

(1) Symmetric model can be considered to reduce calculation time.

(2) The thickness of heat source is small, and it can be transformed into the volume heat source in FLUENT.

(3) The fluid flow in this project is turbulent.

(4) Proper near wall treatment should be considered carefully.



(a) Jet pattern-1 (b) Jet pattern-2 (c) Jet pattern-3

Fig. 3 Jet arrangement patterns

Table 1 Physical properties

	Density kg/m^3	Specific heat J/(kg·K)	Thermal conductivity W/(m·K)	Viscosity kg/(m·s)
HFE7000	1481	1300	0.07906	0.000565
SiO_2	2200	1000	0.6	–
Pyrex	2230	750	1.143	–