模擬微控制器焊接之熱傳分析

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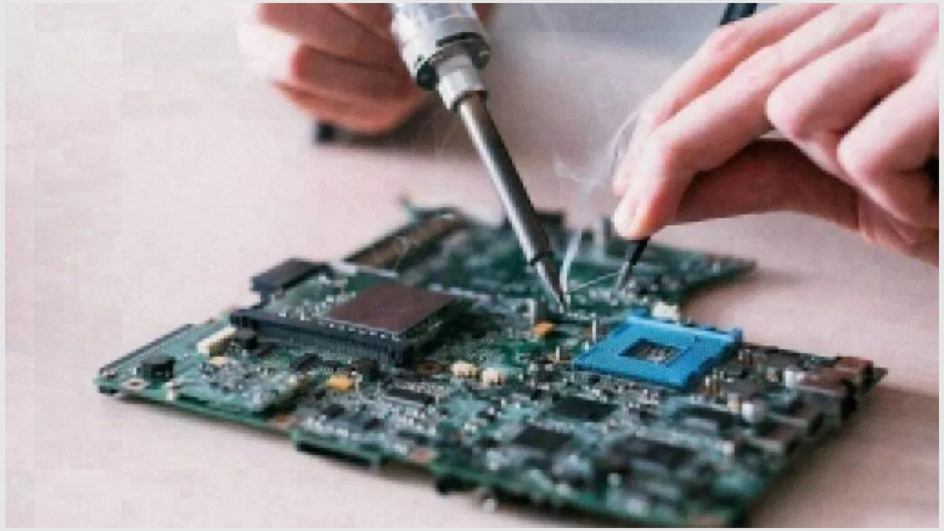
前言

- 焊接是電子製造的心臟，同時也是引起最多問題的過程!
- Applying such high temperature long enough to achieve adherence of solder to the oxidized surface causes the wire bonds inside ICs to degrade to an extent that would require decades of product use. The phenomenon is known as the “purple plague”

--Jim Smith, president of Electronics Manufacturing Sciences Inc

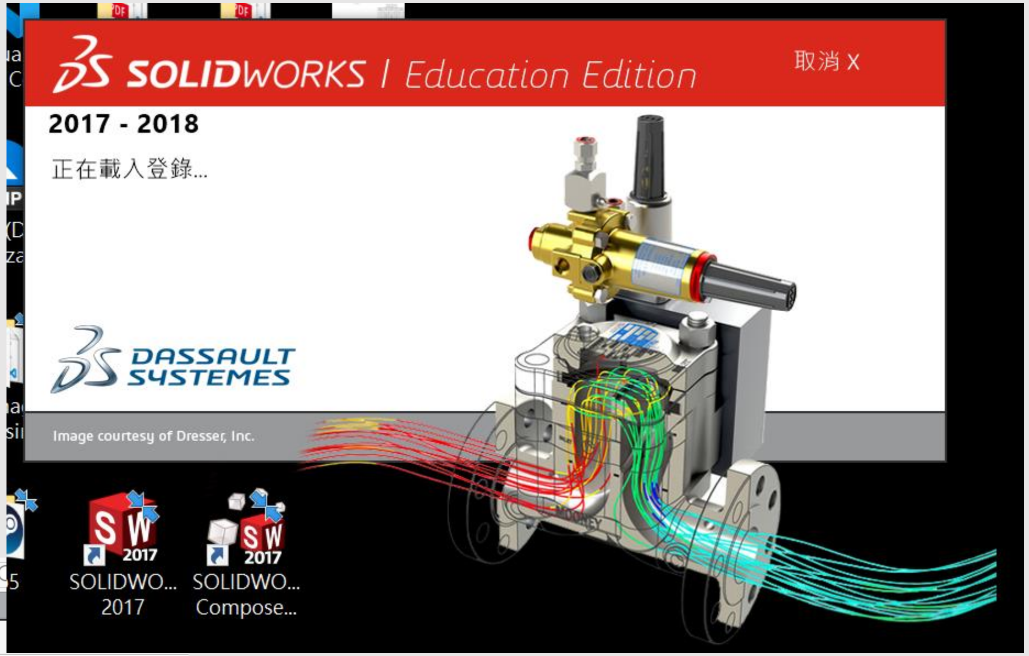
- ATMEGA328P: NTD$120
- 燒晶片就是在燒錢
- 有時候並不是電路接錯，而是在焊接時便已造成電路受損



材料與方法

所使用模擬軟體: **Solidworks 2017**

-- SOLIDWORKS Simulation 熱研究
-- SOLIDWORKS Flow Simulation



2017 - 2018

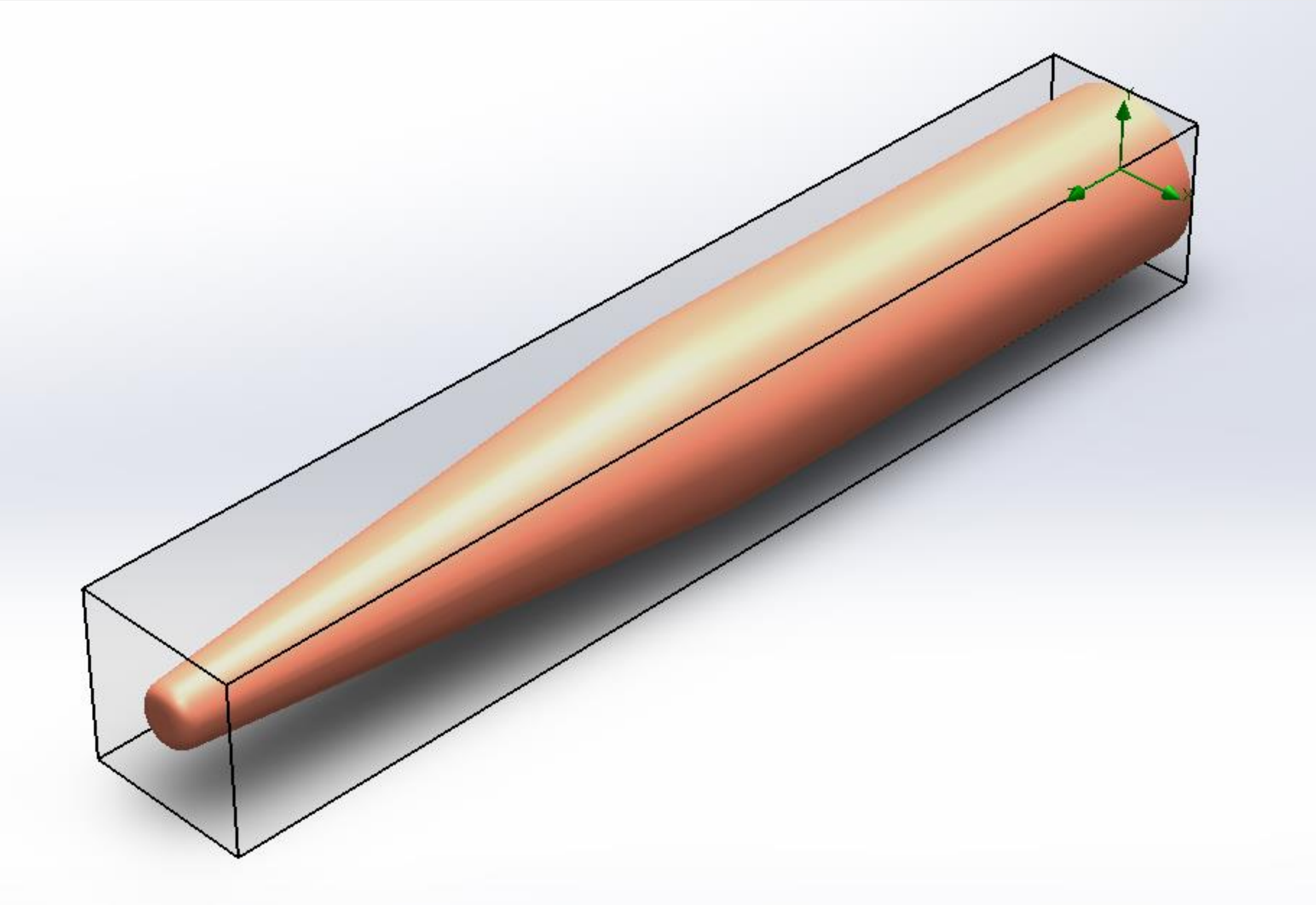
正在載入登錄...

Image courtesy of Dresser, Inc.

SOLIDWORKS Education Edition - 僅供教學使用

Mod.1 電烙鐵

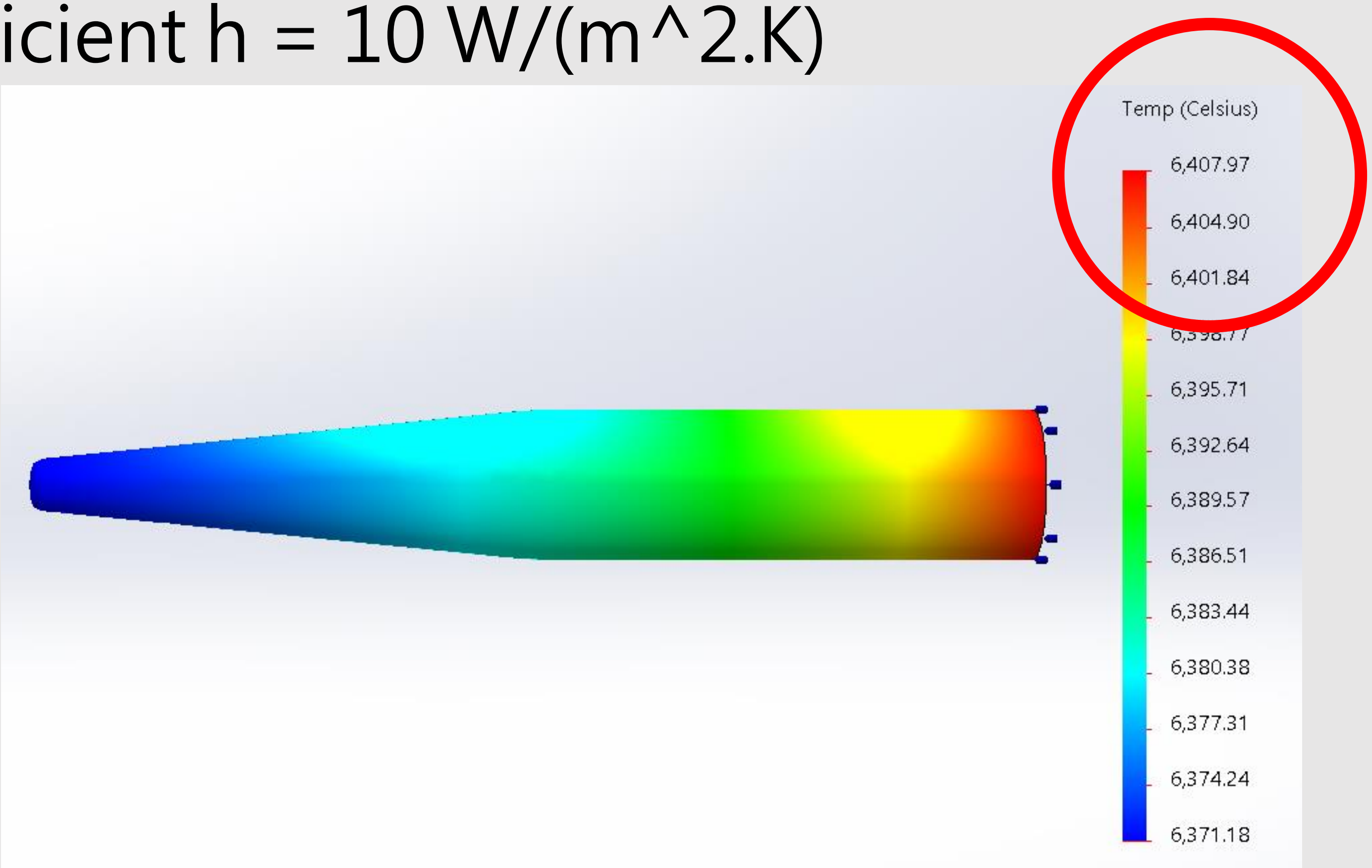
--**SOLIDWORKS** simulation



額定功率:約20~40 W
理想溫度:約300~400℃

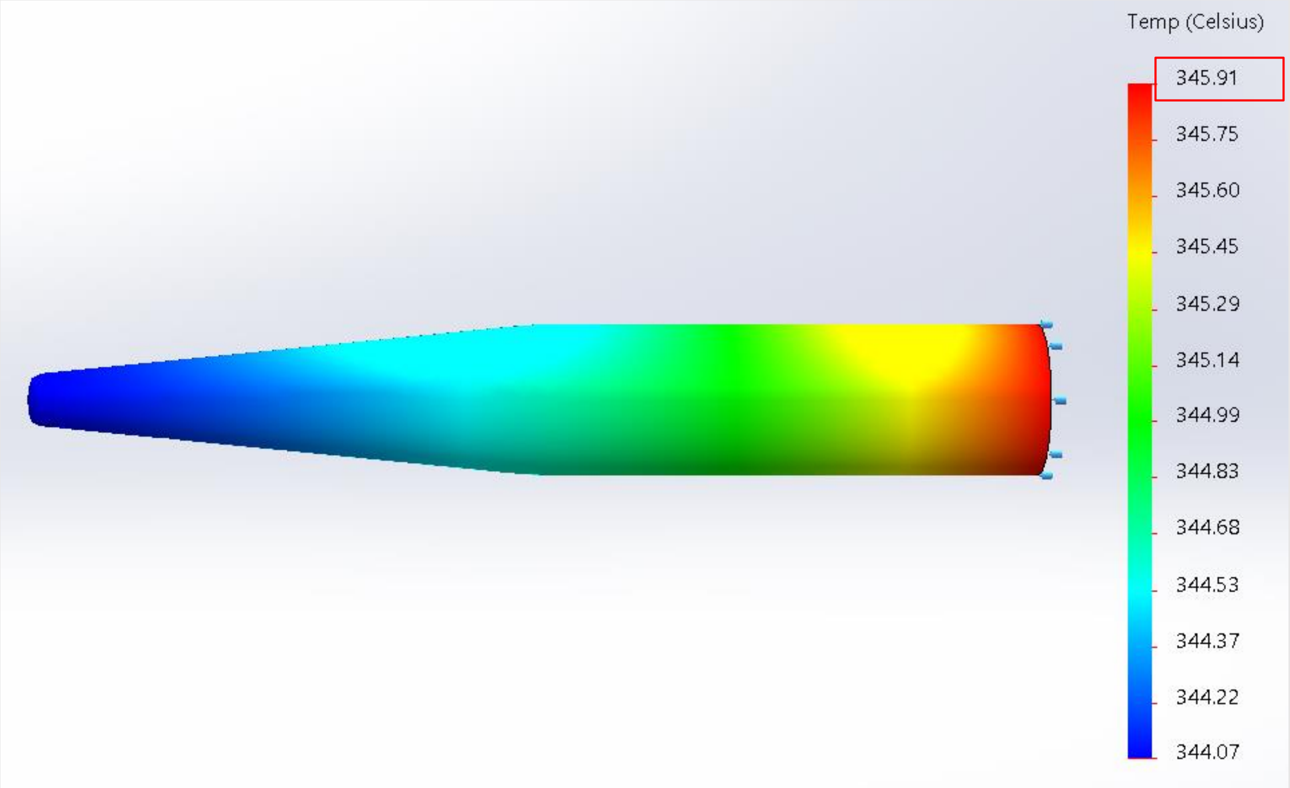
模擬假設

- **穩態分析**
- 材質:紅銅(熱導率k = 386.4 W/(m.K))
- Convection coefficient h = 10 W/(m^2.K)
- 熱功率P = 10 W



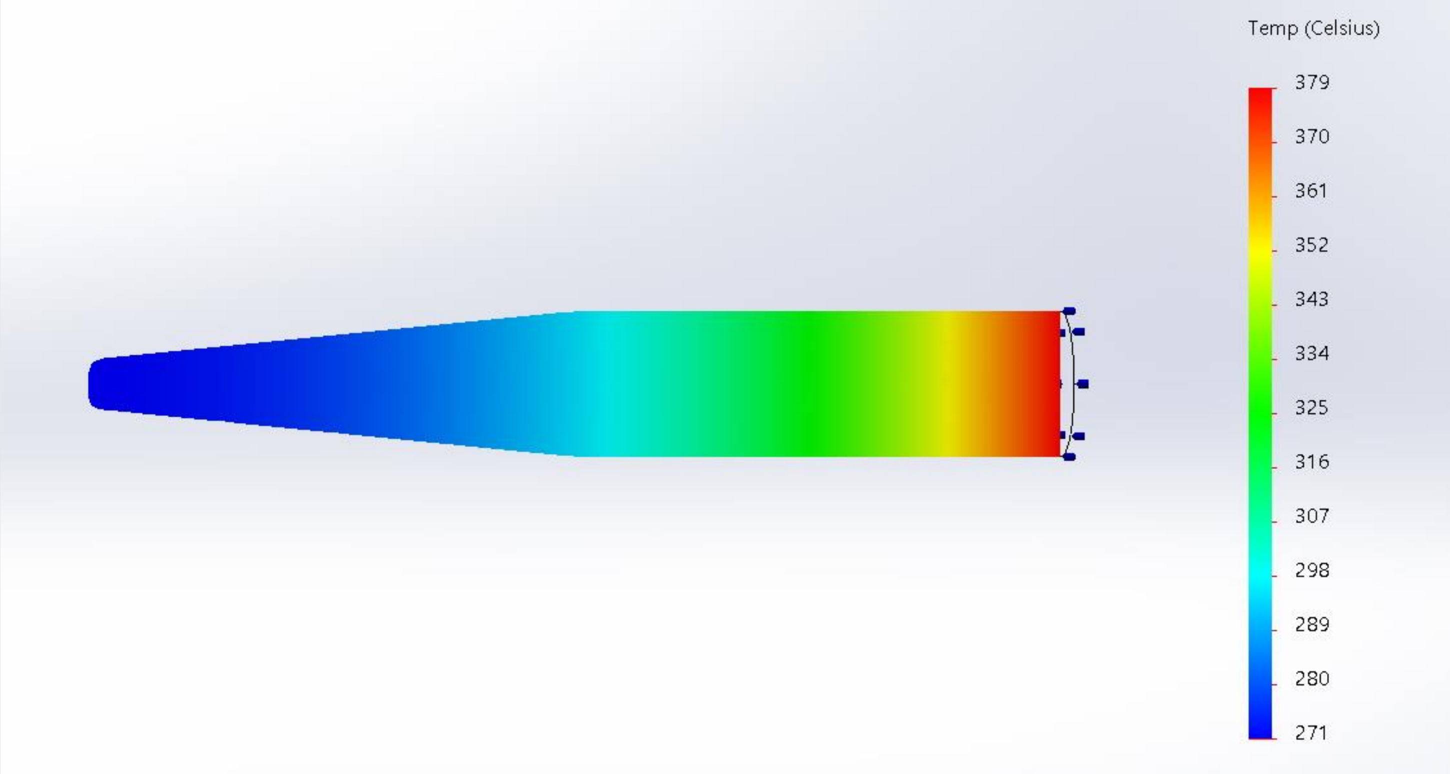
模擬假設

調整熱功率至P = 0.5 W

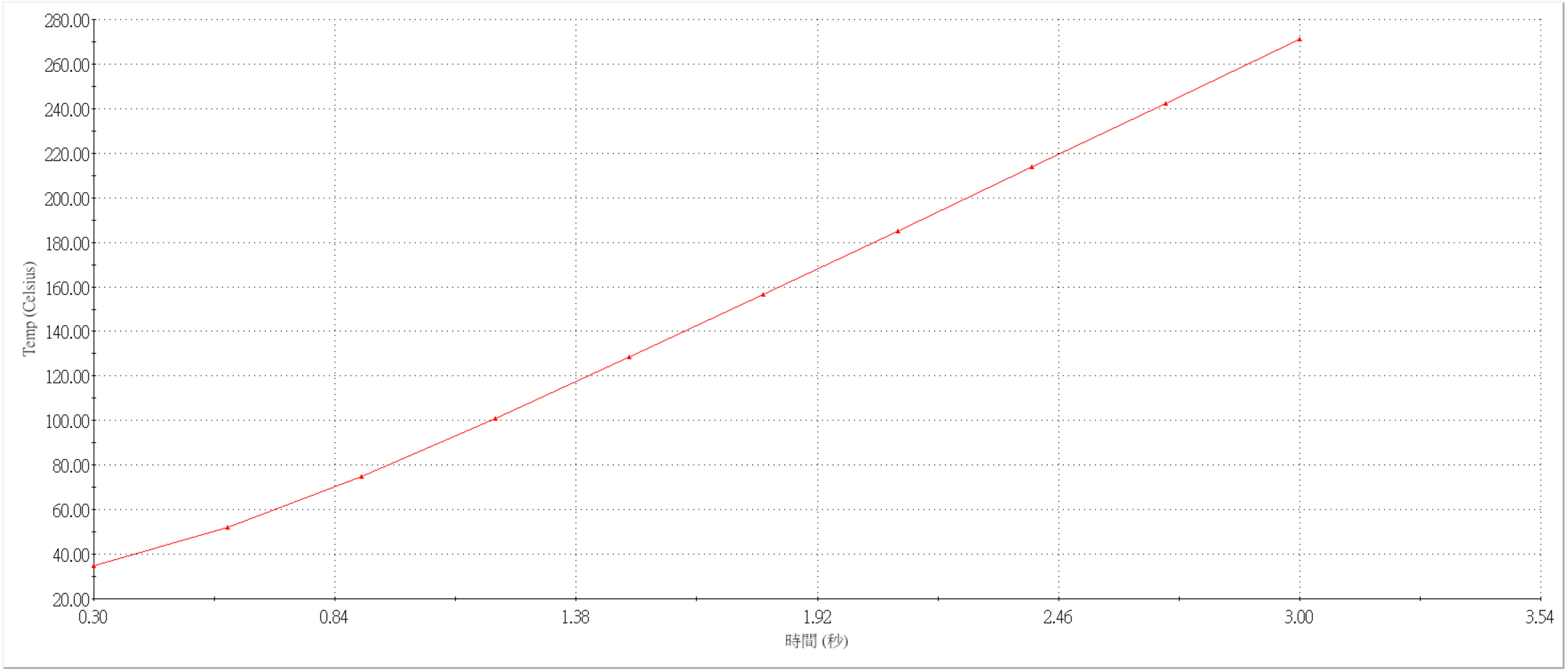


模擬假設

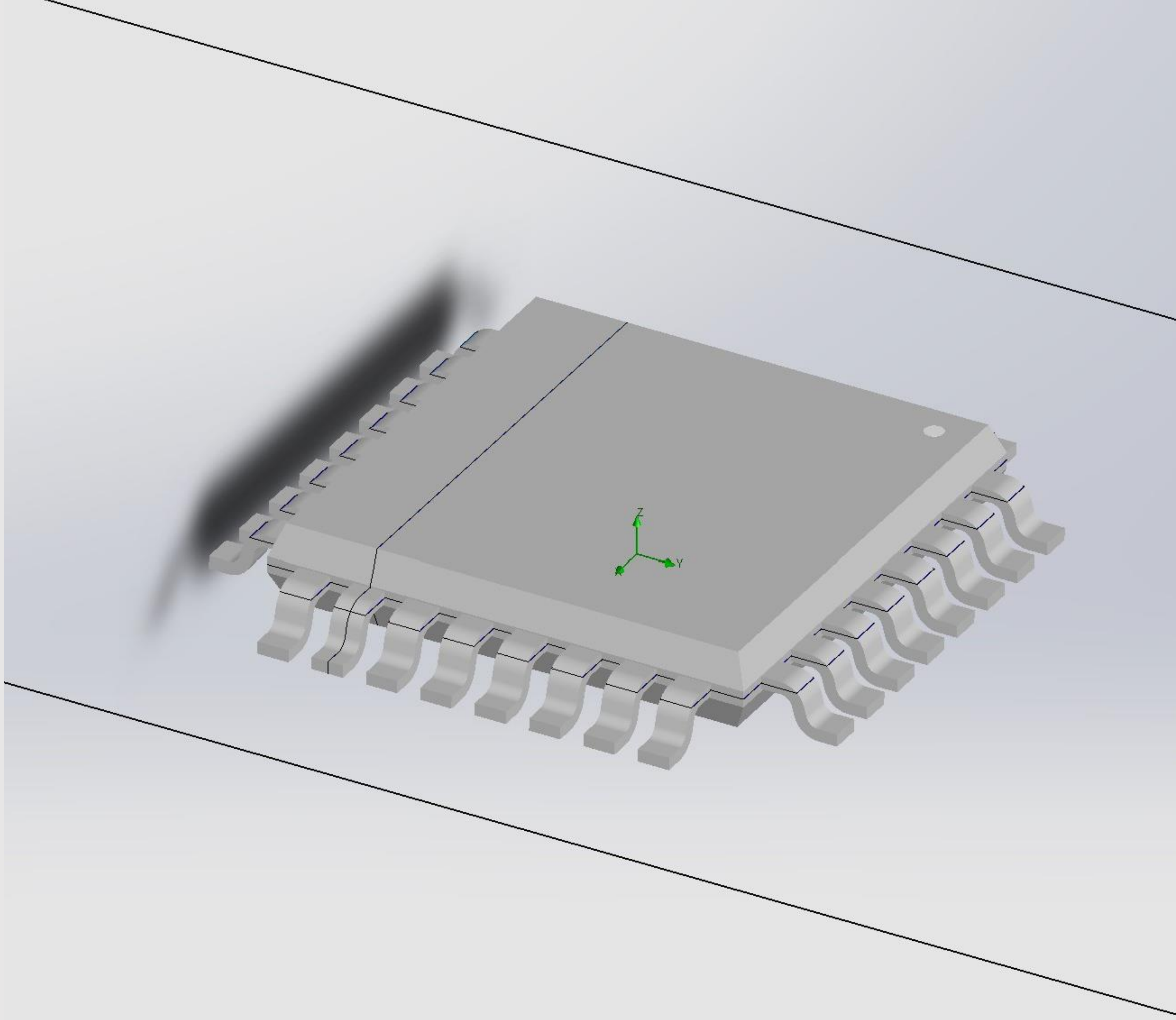
- **暫態分析**
- 材質:紅銅(熱導率k = 386.4 W/(m.K))
- Convection coefficient h = 10 W/(m^2.K)
- 熱功率P = 35 W
- 初始溫度 = 30℃
- 模擬時間 = 3 sec



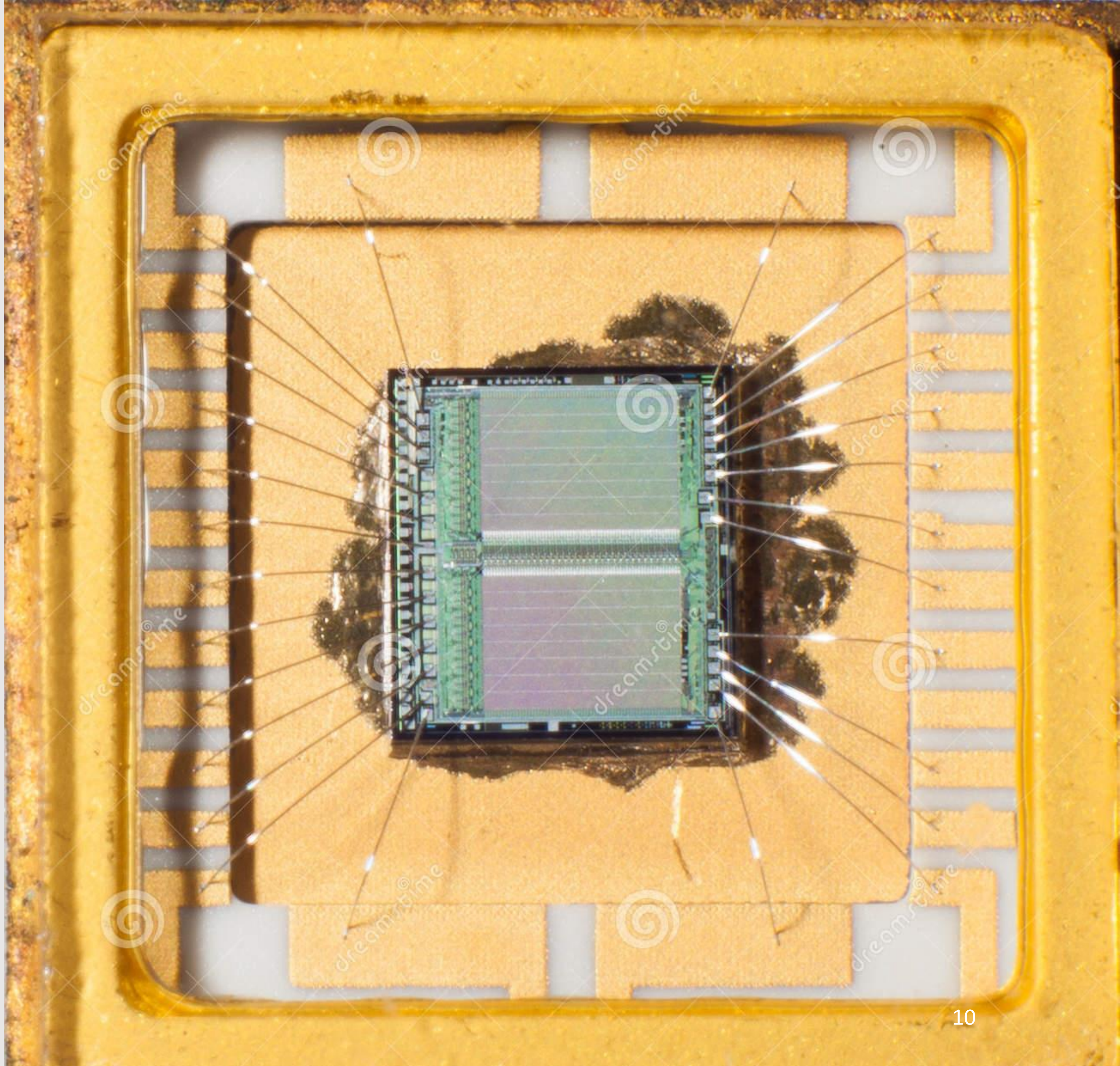
模擬假設


280.00
260.00
240.00
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
Temp (Celsius)
0.30
0.84
1.38
1.92
2.46
3.00
3.54
時間 (秒)

Mod. 2



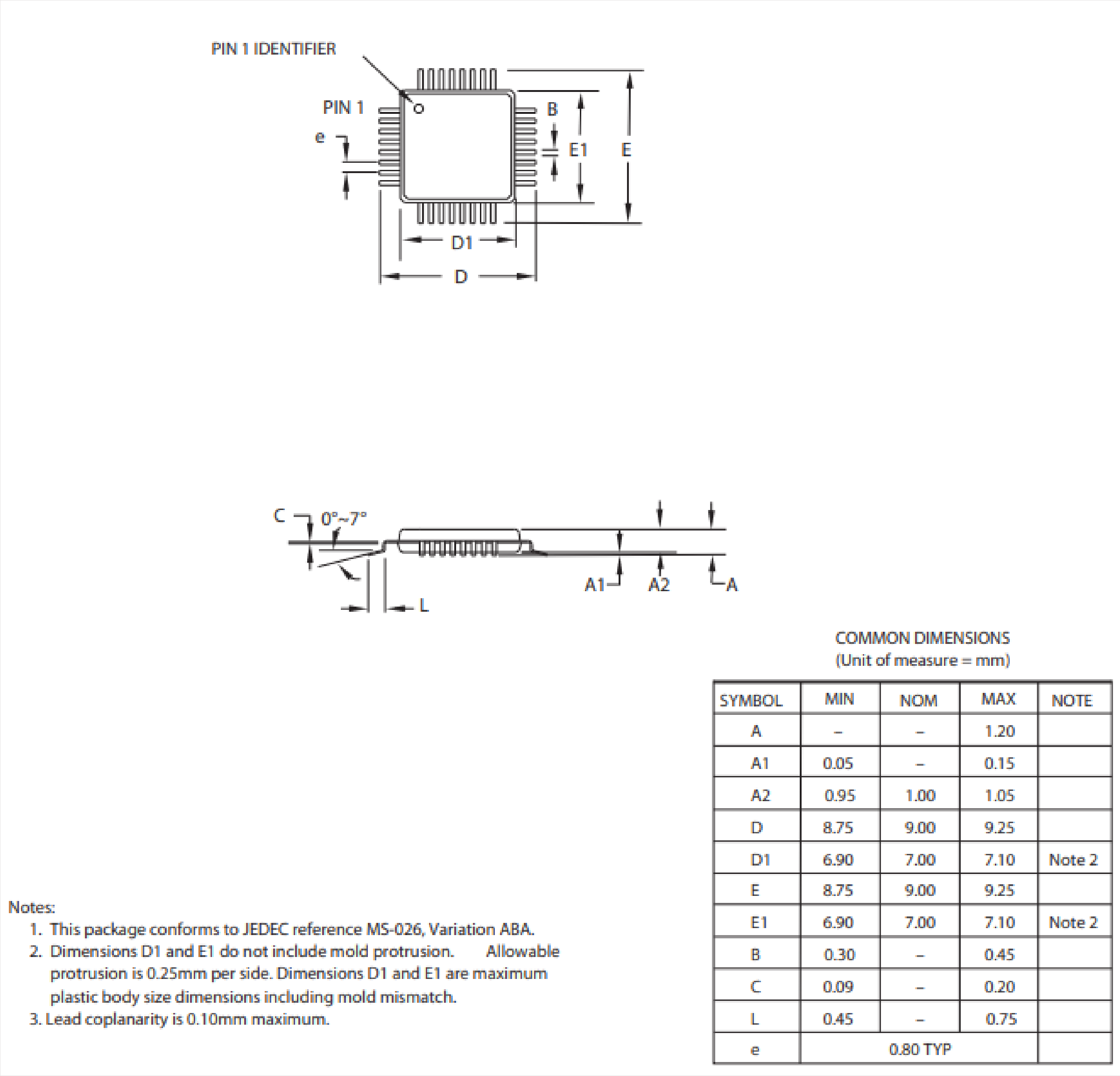
- Inside a microprochip stock image. Image of abstract - 80701633 (dreamstime.com)



材料與方法

ATMEGA328

- Temperature range (operating):
  -40℃~85℃
- Size: body--7*7*1(mm)
  leg—1.3*0.38*0.15(mm)
- 假定其封裝材料皆為TQFP



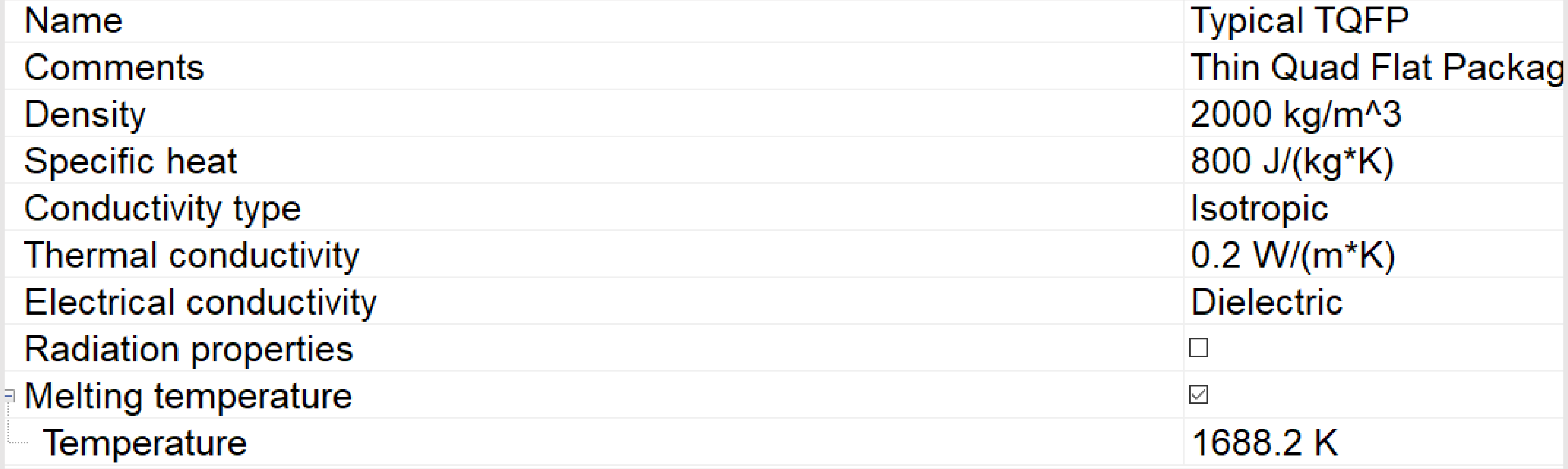
COMMON DIMENSIONS
(Unit of measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	1.20	
A1	0.05	–	0.15	
A2	0.95	1.00	1.05	
D	8.75	9.00	9.25	
D1	6.90	7.00	7.10	Note 2
E	8.75	9.00	9.25	
E1	6.90	7.00	7.10	Note 2
B	0.30	–	0.45	
C	0.09	–	0.20	
L	0.45	–	0.75	
e	0.80 TYP			

Notes:

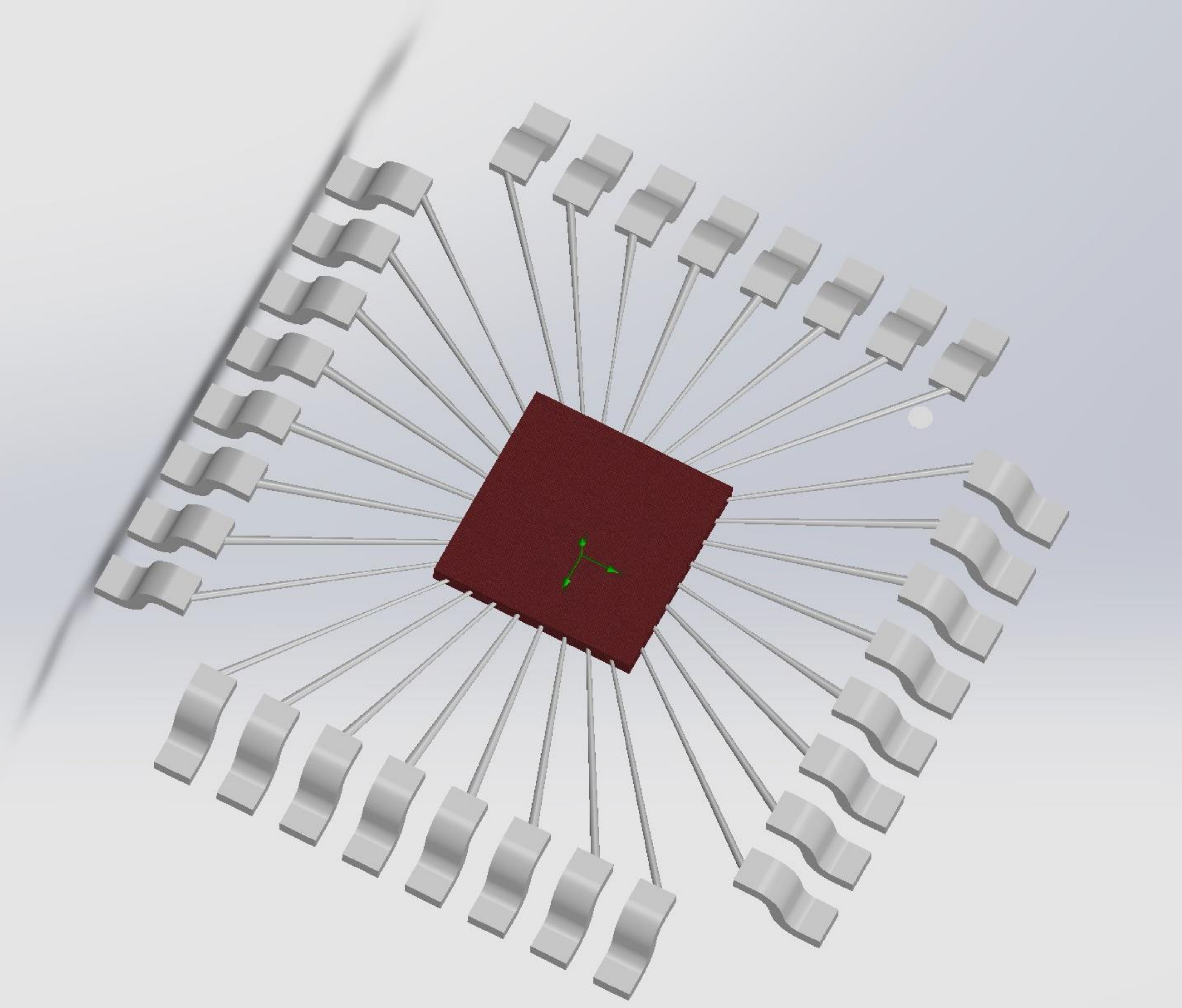
1. This package conforms to JEDEC reference MS-026, Variation ABA.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10mm maximum.

TQFP: thin quad flat package

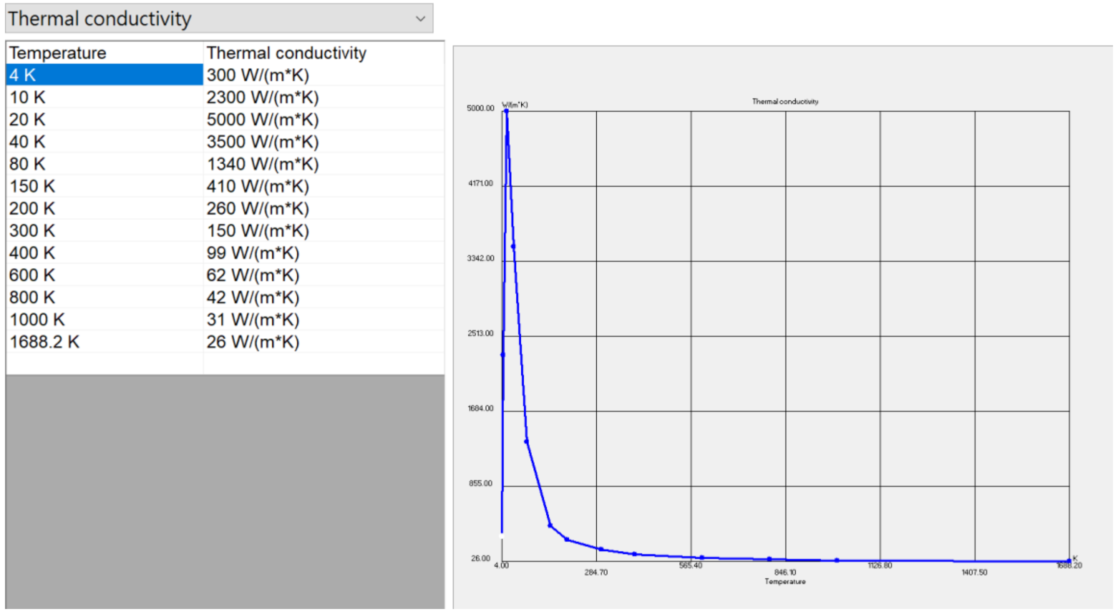


Name	Typical TQFP
Comments	Thin Quad Flat Packag
Density	2000 kg/m^3
Specific heat	800 J/(kg*K)
Conductivity type	Isotropic
Thermal conductivity	0.2 W/(m*K)
Electrical conductivity	Dielectric
Radiation properties	☐
Melting temperature	☑
Temperature	1688.2 K

- Silicon
- Copper
- Connector

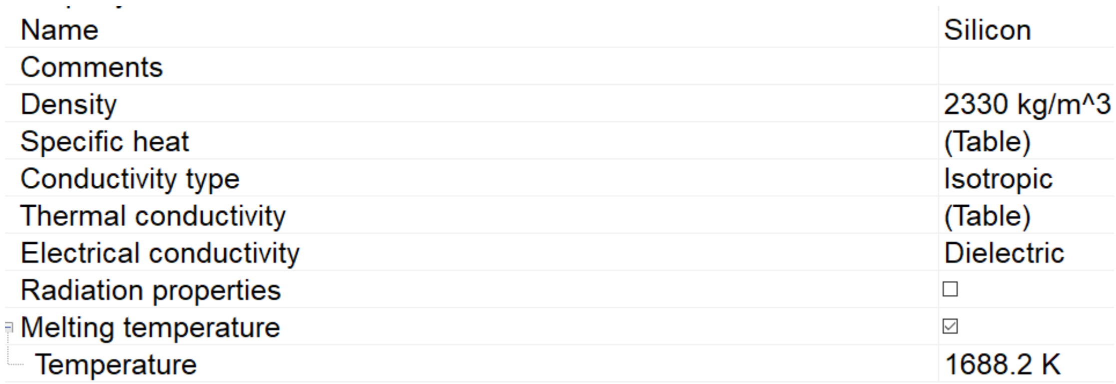


Semiconductor: silicon

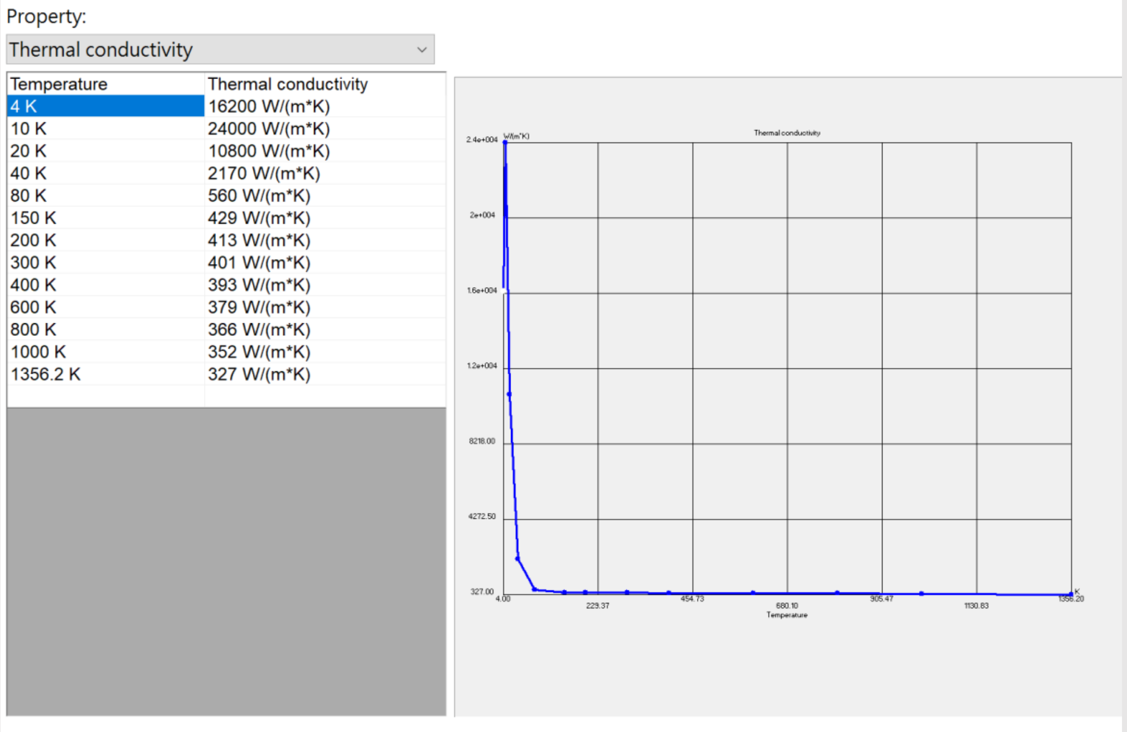


Thermal conductivity

Temperature	Thermal conductivity
4 K	300 W/(m*K)
10 K	2300 W/(m*K)
20 K	5000 W/(m*K)
40 K	3500 W/(m*K)
80 K	1340 W/(m*K)
150 K	410 W/(m*K)
200 K	260 W/(m*K)
300 K	150 W/(m*K)
400 K	99 W/(m*K)
600 K	62 W/(m*K)
800 K	42 W/(m*K)
1000 K	31 W/(m*K)
1688.2 K	26 W/(m*K)



Name	Silicon
Comments	
Density	2330 kg/m^3
Specific heat	(Table)
Conductivity type	Isotropic
Thermal conductivity	(Table)
Electrical conductivity	Dielectric
Radiation properties	☐
Melting temperature	☑
Temperature	1688.2 K



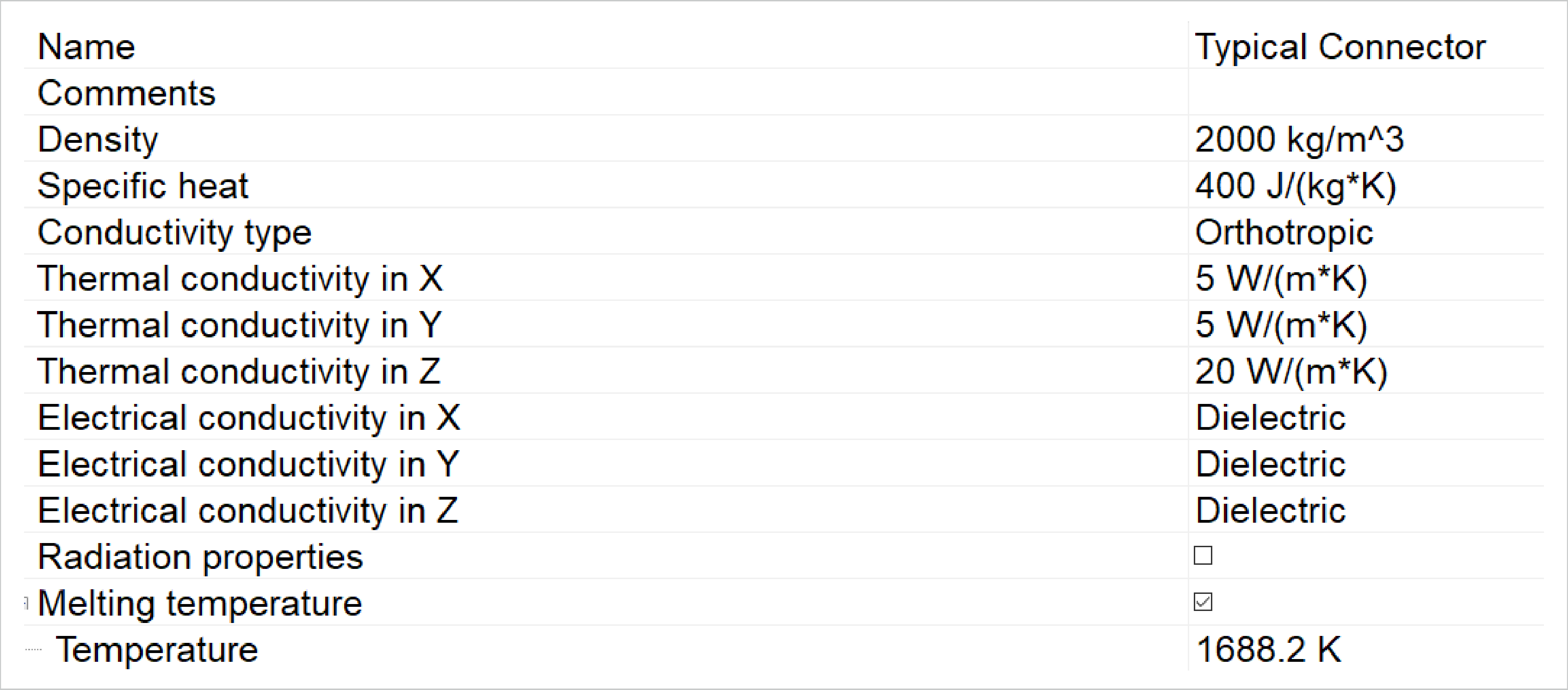
Property:

Thermal conductivity

Temperature	Thermal conductivity
4 K	16200 W/(m*K)
10 K	24000 W/(m*K)
20 K	10800 W/(m*K)
40 K	2170 W/(m*K)
80 K	560 W/(m*K)
150 K	429 W/(m*K)
200 K	413 W/(m*K)
300 K	401 W/(m*K)
400 K	393 W/(m*K)
600 K	379 W/(m*K)
800 K	366 W/(m*K)
1000 K	352 W/(m*K)
1356.2 K	327 W/(m*K)

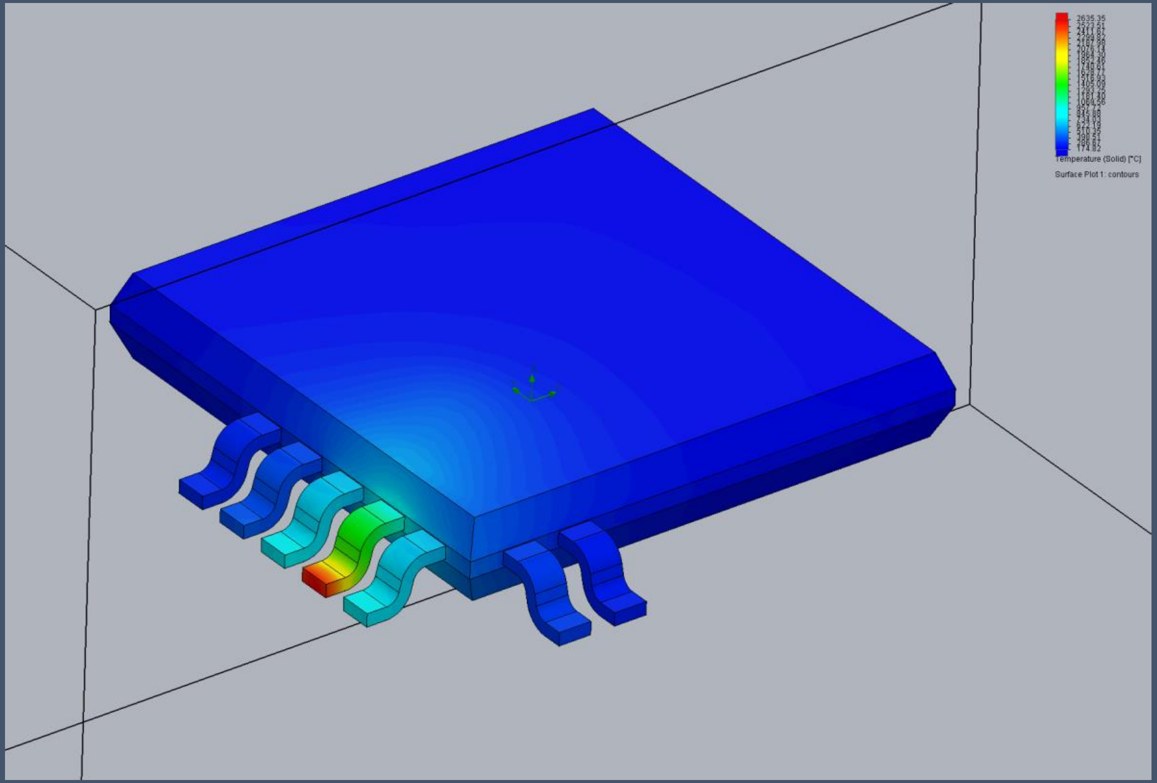
Name	Copper
Comments	
Density	8960 kg/m^3
Specific heat	(Table)
Conductivity type	Isotropic
Thermal conductivity	(Table)
Electrical conductivity	Conductor
Resistivity	(Table)
Radiation properties	☐
Melting temperature	☑
Temperature	1356.2 K

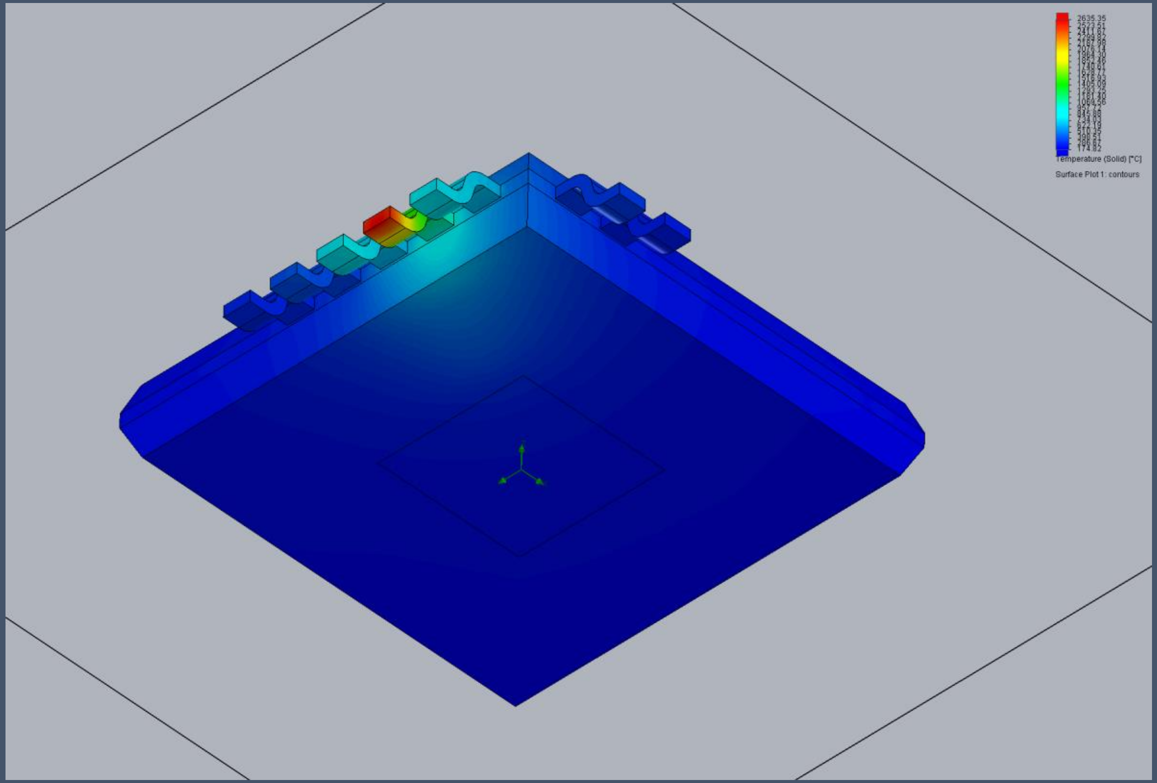
copper



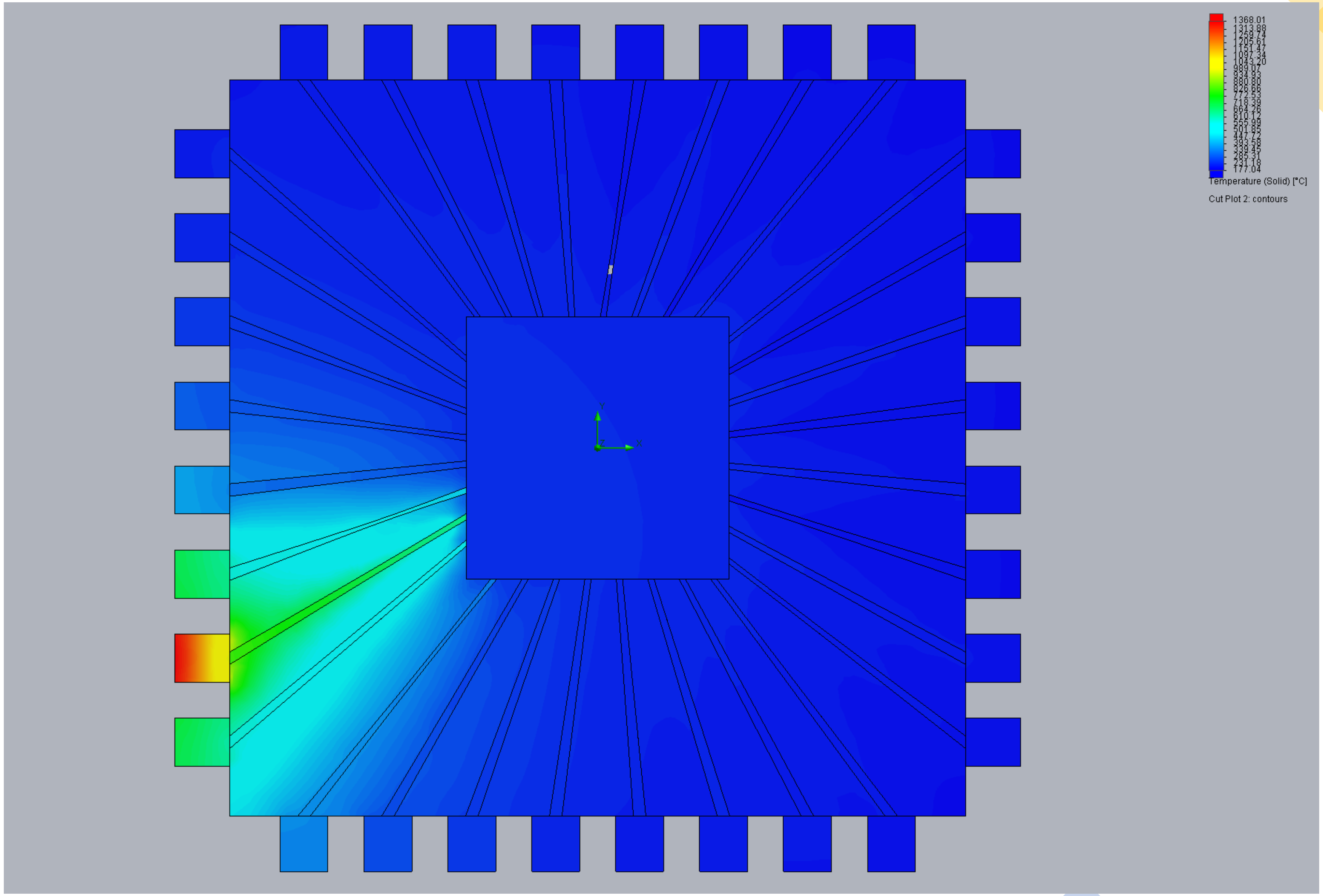
Name	Typical Connector
Comments	
Density	2000 kg/m^3
Specific heat	400 J/(kg*K)
Conductivity type	Orthotropic
Thermal conductivity in X	5 W/(m*K)
Thermal conductivity in Y	5 W/(m*K)
Thermal conductivity in Z	20 W/(m*K)
Electrical conductivity in X	Dielectric
Electrical conductivity in Y	Dielectric
Electrical conductivity in Z	Dielectric
Radiation properties	☐
Melting temperature	☑
Temperature	1688.2 K

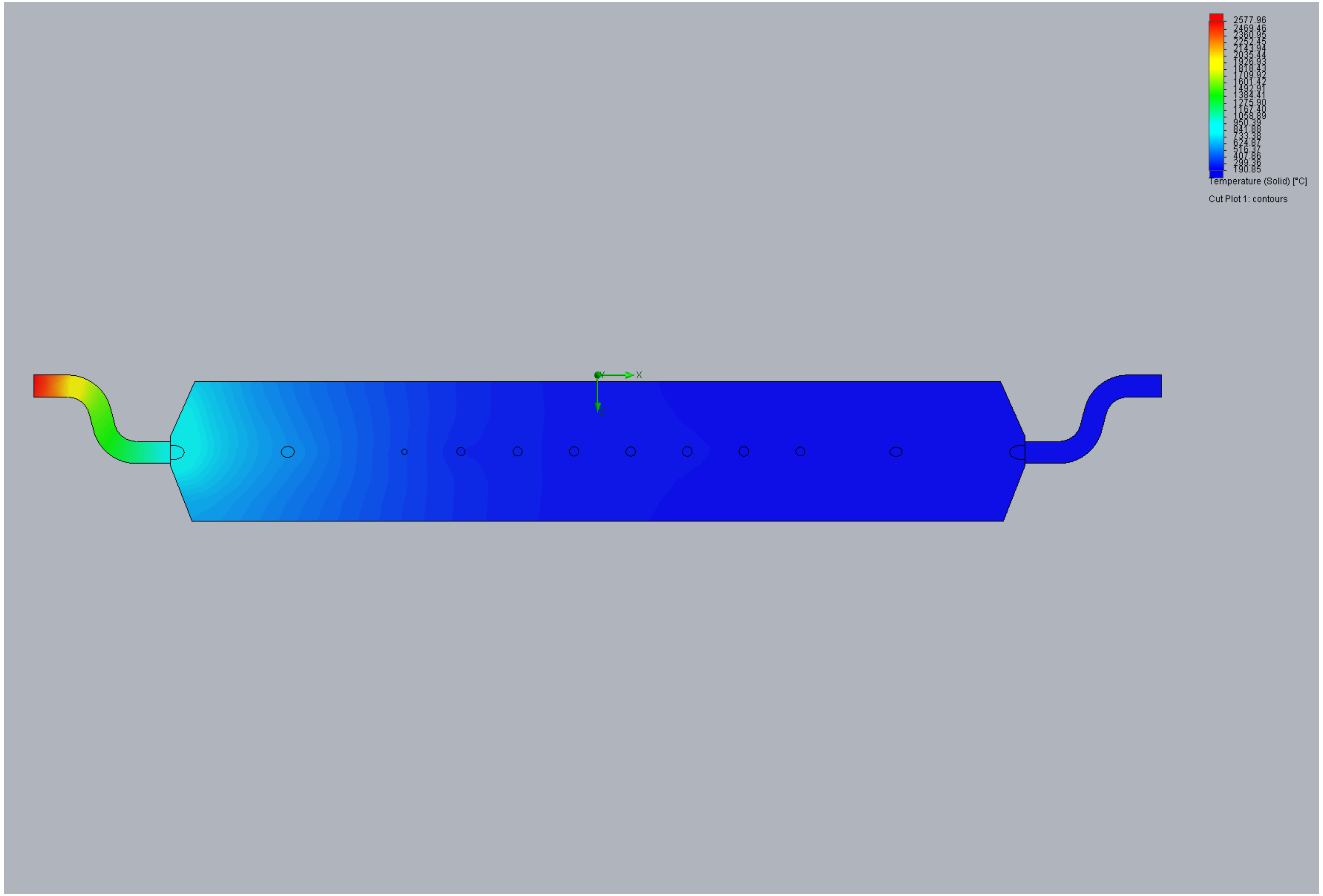
Connector

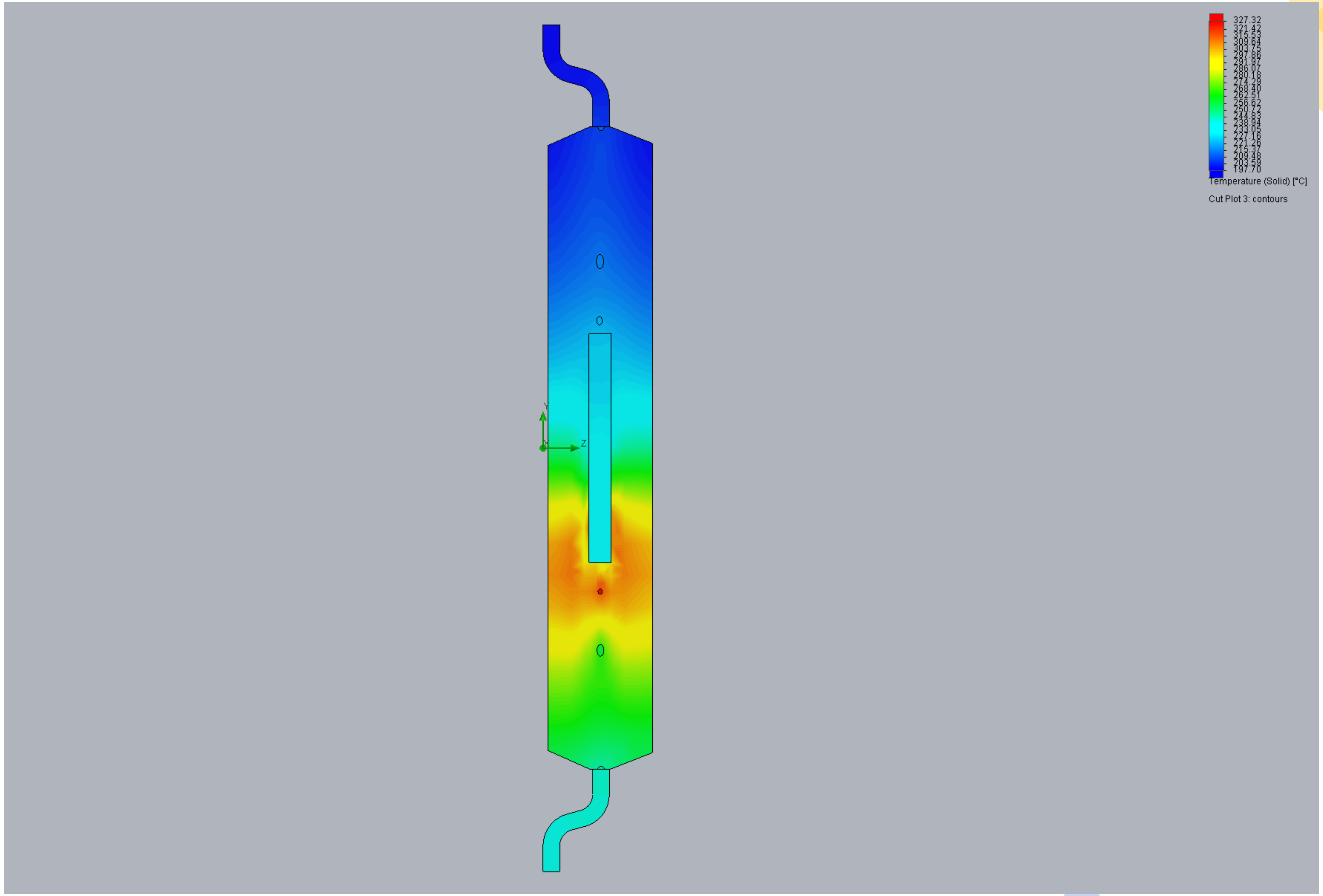

2635.35
174.82
Temperature (Solid) [°C]
Surface Plot 1: contours

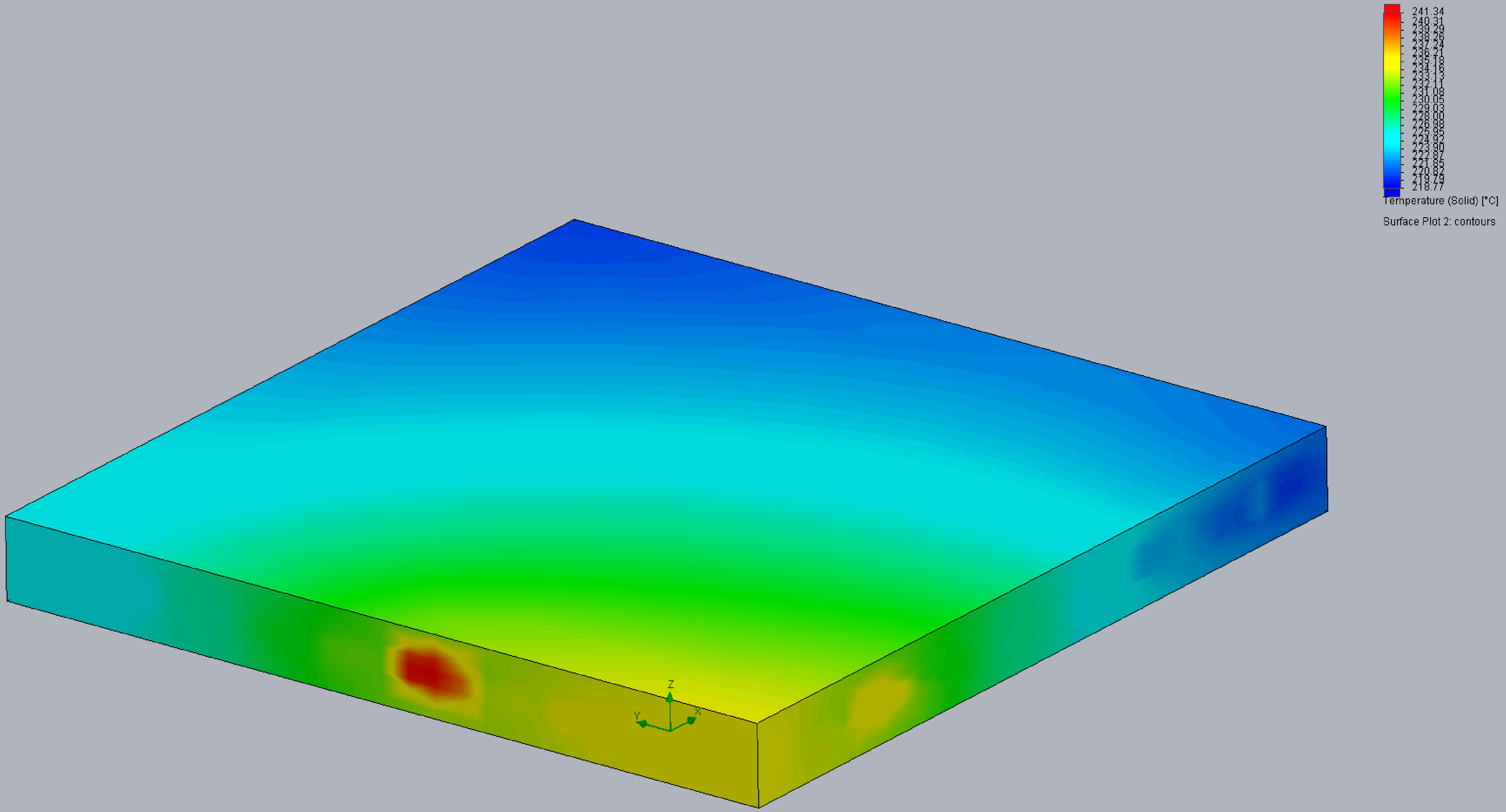

2635.35
174.82
Temperature (Solid) [°C]
Surface Plot 1: contours

表面 t=892s


1368.01
1313.88
1259.74
1205.61
1151.47
1097.34
1043.20
989.07
934.93
880.80
826.66
772.53
718.39
664.26
610.12
555.99
501.85
447.72
393.58
339.45
285.31
231.18
177.04
Temperature (Solid) [°C]
Cut Plot 2: contours

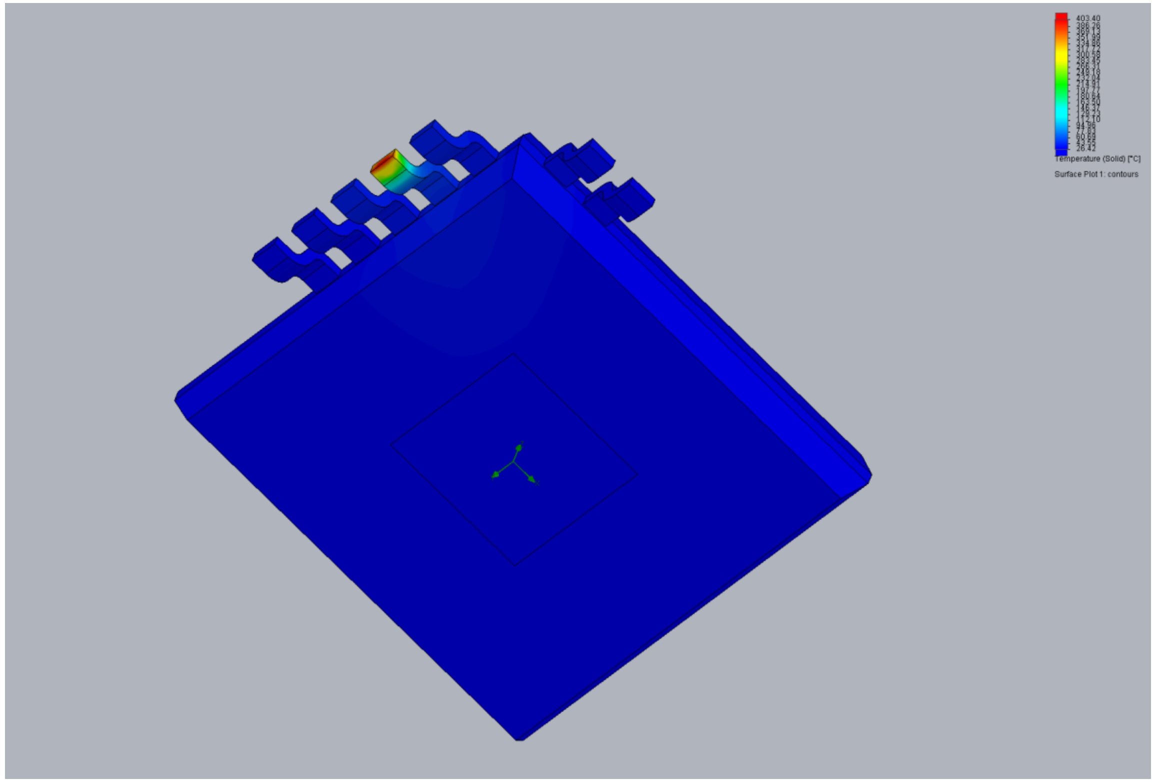

2577.96
2469.46
2360.95
2252.45
2143.94
2035.44
1926.93
1818.43
1709.92
1601.42
1492.91
1384.41
1275.90
1167.40
1058.89
950.39
841.88
733.38
624.87
516.37
407.86
299.36
190.85
Temperature (Solid) [°C]
Cut Plot 1: contours
X
Y
Z

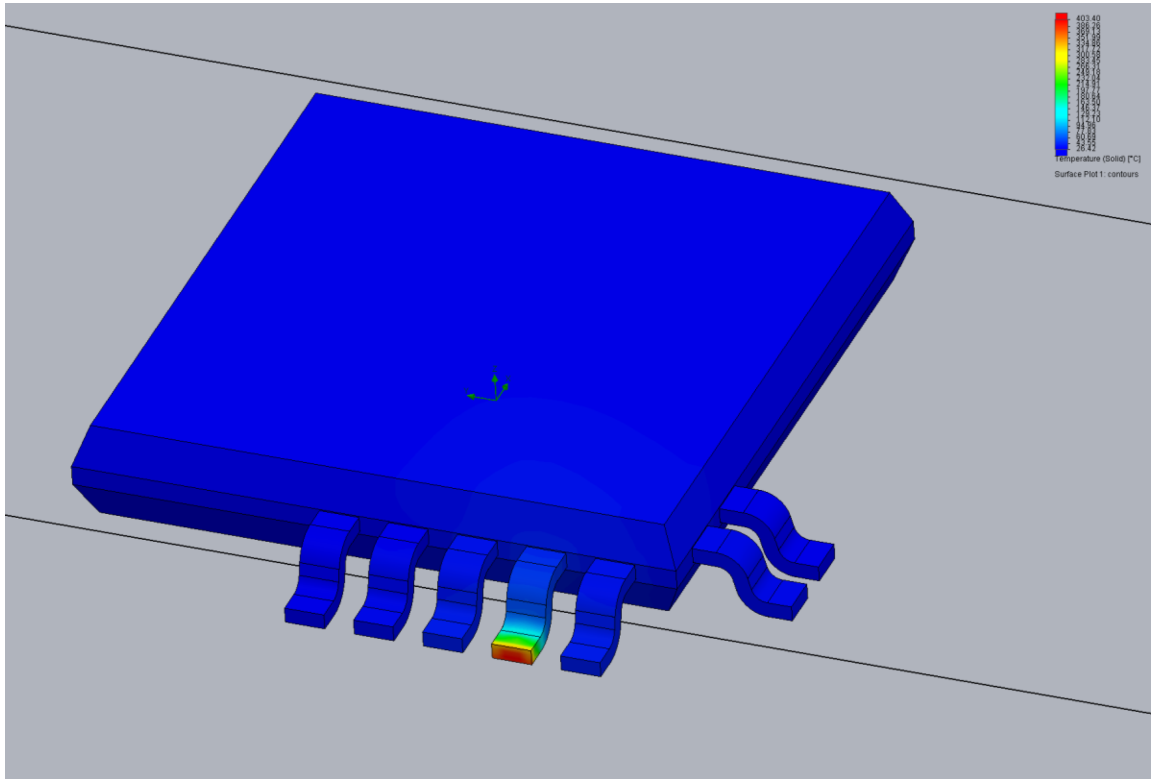

327.32
321.42
315.53
309.64
303.75
297.86
291.97
286.07
280.18
274.29
268.40
262.51
256.62
250.72
244.83
238.94
233.05
227.16
221.26
215.37
209.48
203.59
197.70
Temperature (Solid) [°C]
Cut Plot 3: contours
Y
Z

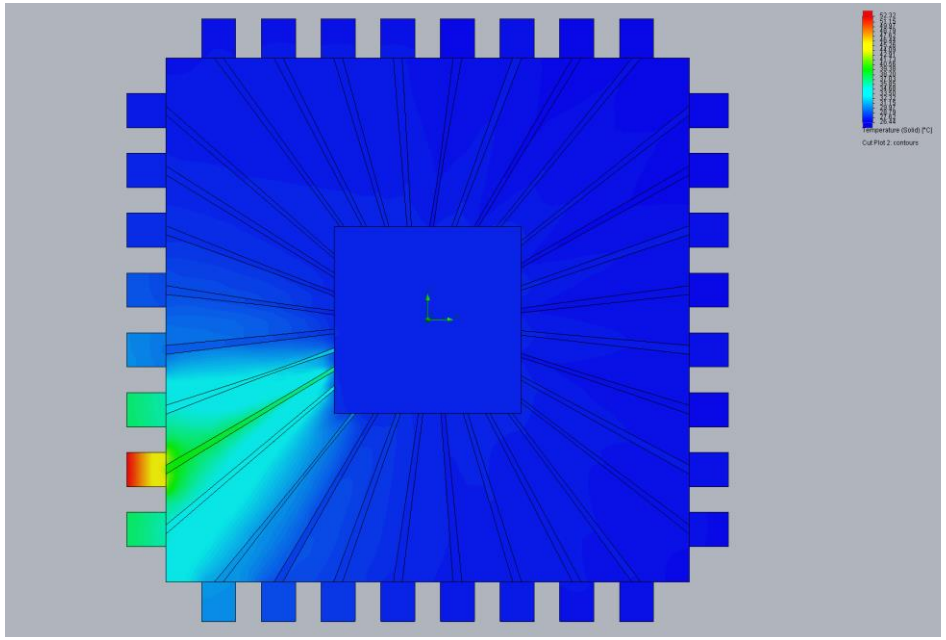

241.34
240.31
239.29
238.26
237.24
236.21
235.18
234.16
233.13
232.11
231.08
230.05
229.03
228.00
226.98
225.95
224.92
223.90
222.87
221.85
220.82
219.79
218.77
Temperature (Solid) [°C]
Surface Plot 2: contours
Z
Y
X

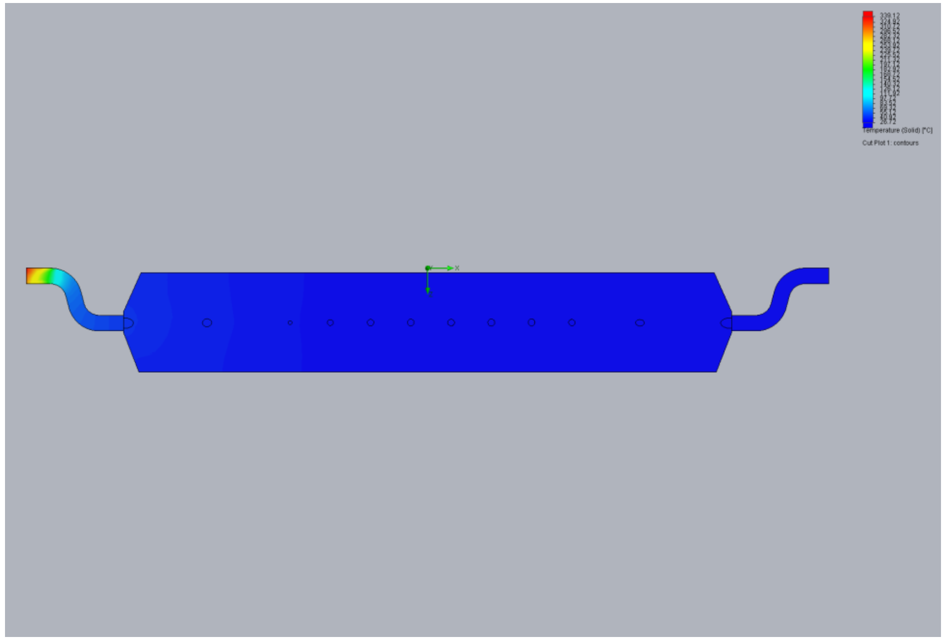
transient

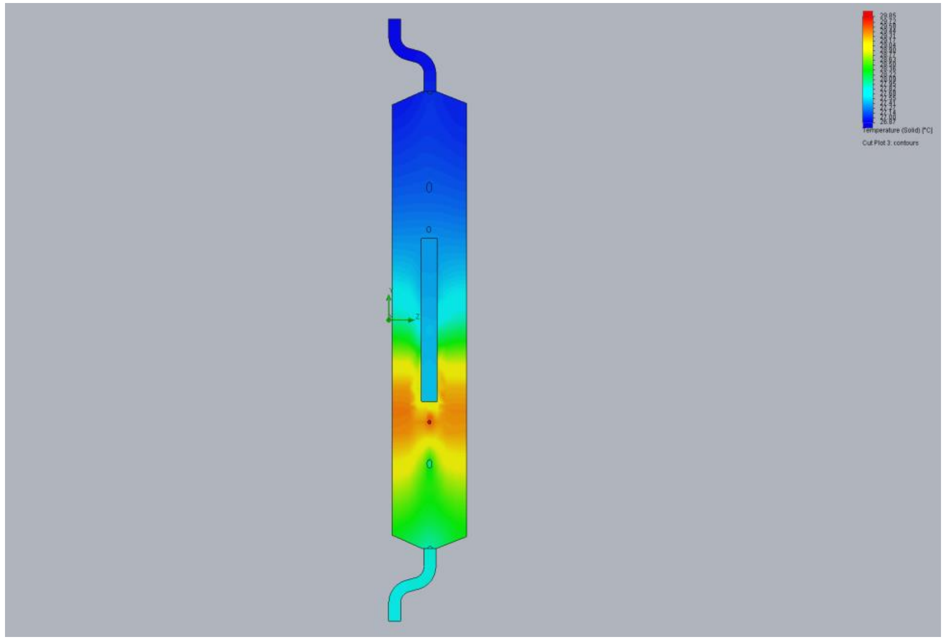
t = 60s to reach around 350c at pin

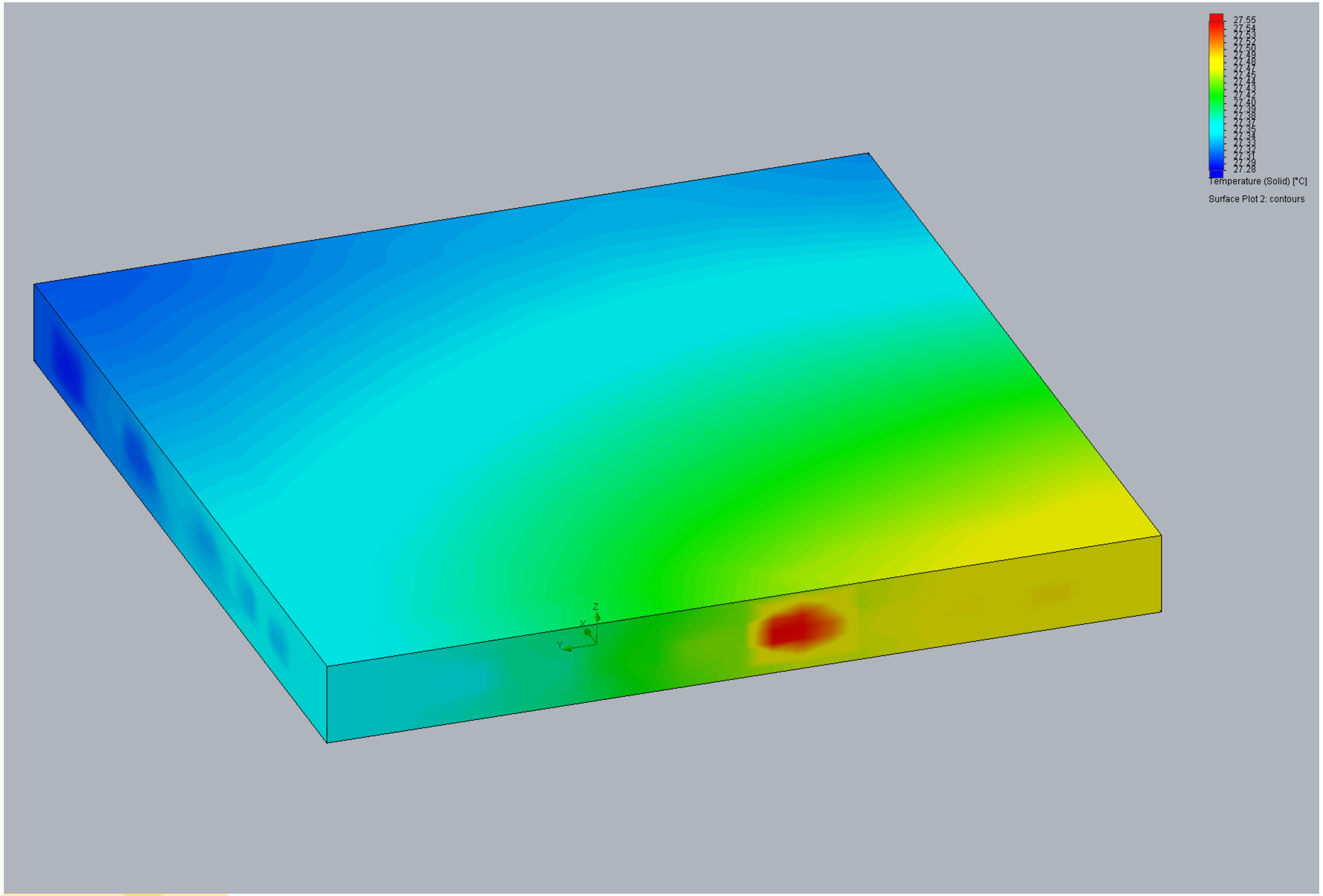





52.32
26.44
Temperature (Solid) [°C]
Cut Plot 2: contours


339.12
324.92
310.72
40.92
26.72
Temperature (Solid) [°C]
Cut Plot 1: contours


29.85
26.87
Temperature (Solid) [°C]
Cut Plot 3: contours

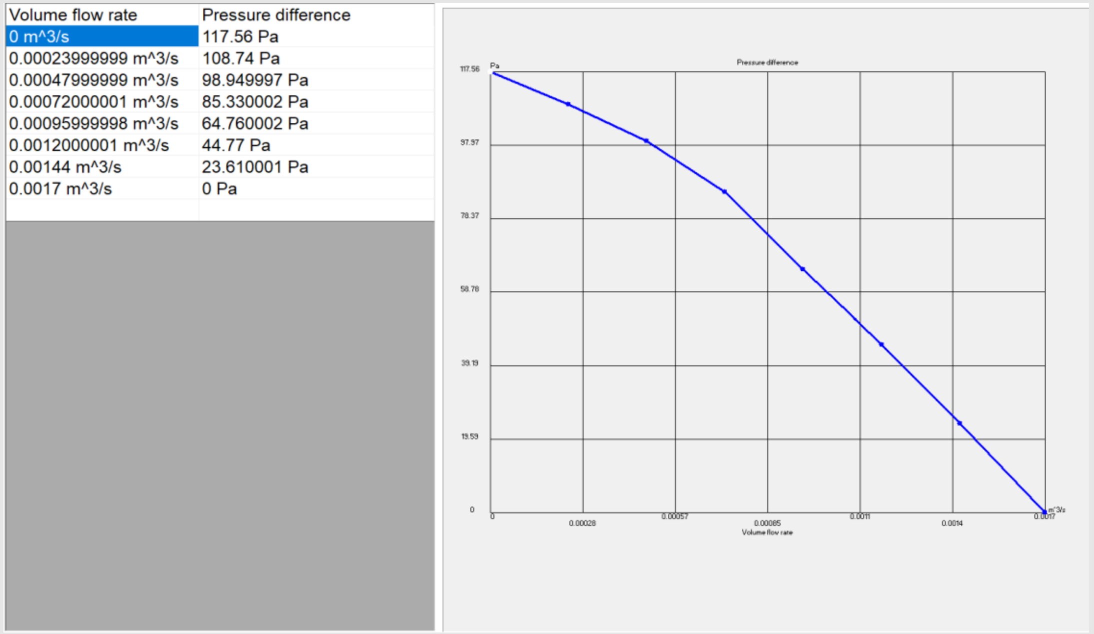

27.55
27.54
27.53
27.52
27.50
27.49
27.48
27.47
27.45
27.44
27.43
27.42
27.40
27.39
27.38
27.37
27.35
27.34
27.33
27.32
27.31
27.29
27.28
Temperature (Solid) [°C]
Surface Plot 2: contours
Z
X
Y

材料與方法

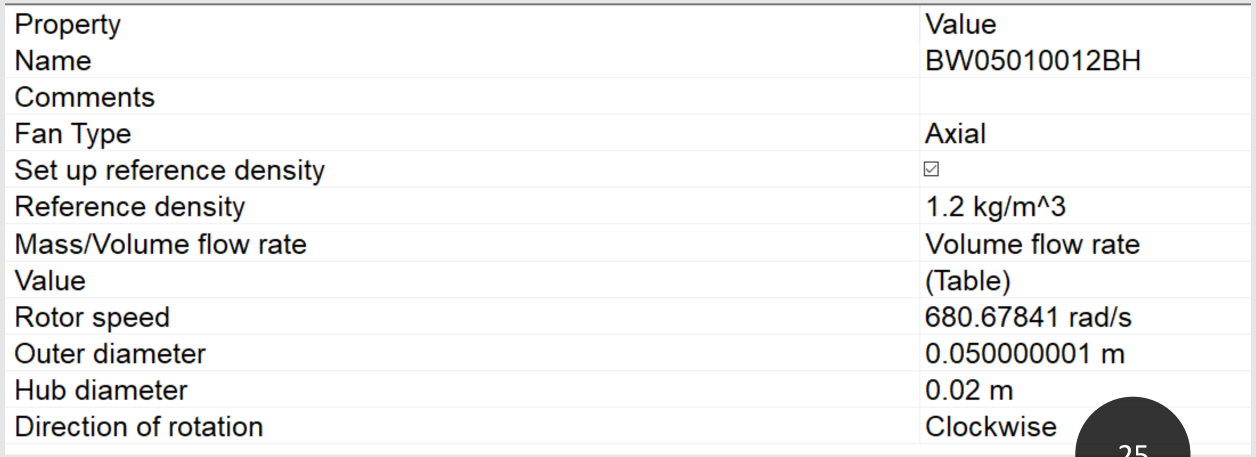
熱風槍

Env temp: 350 C

Fan: d=5 cm

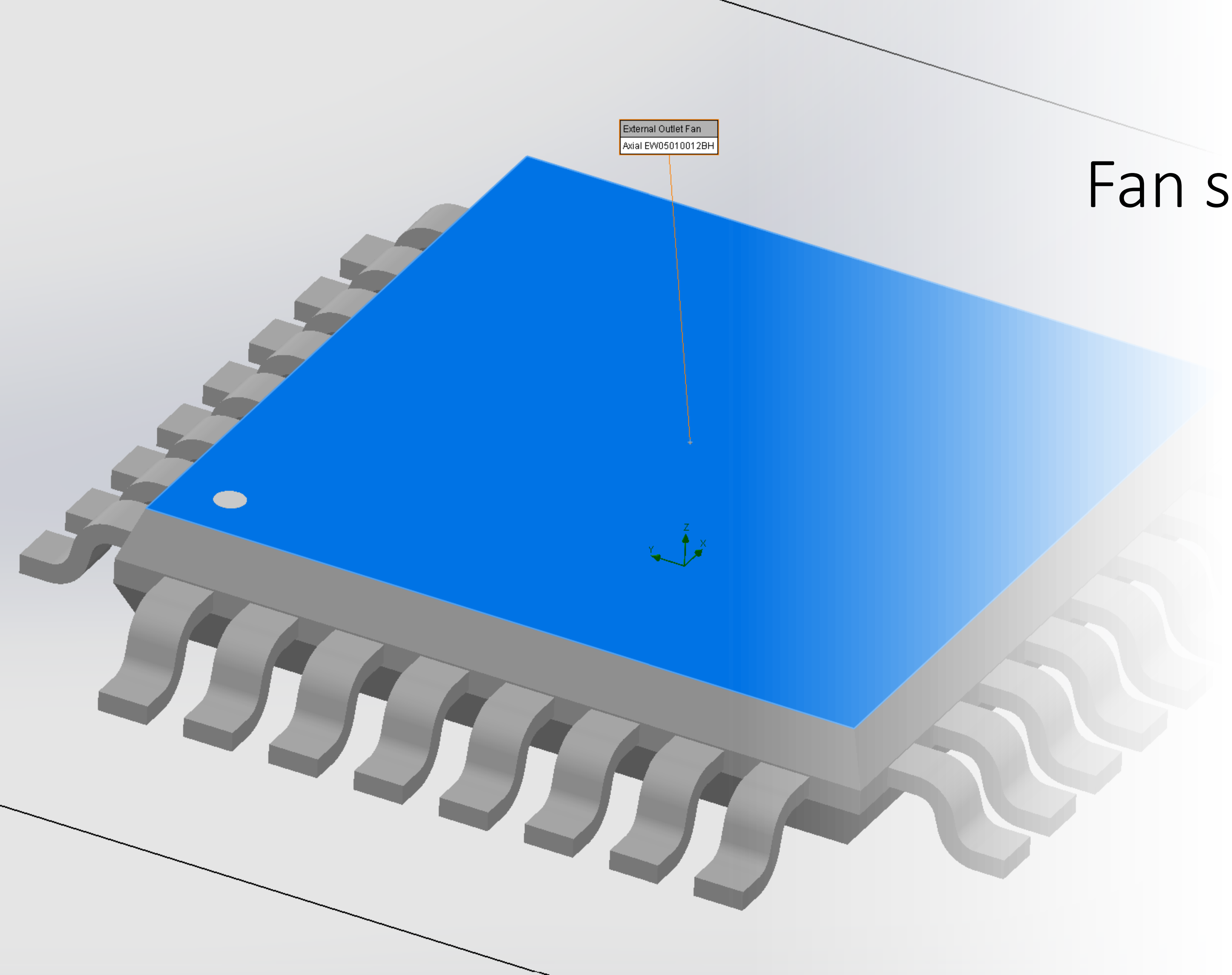


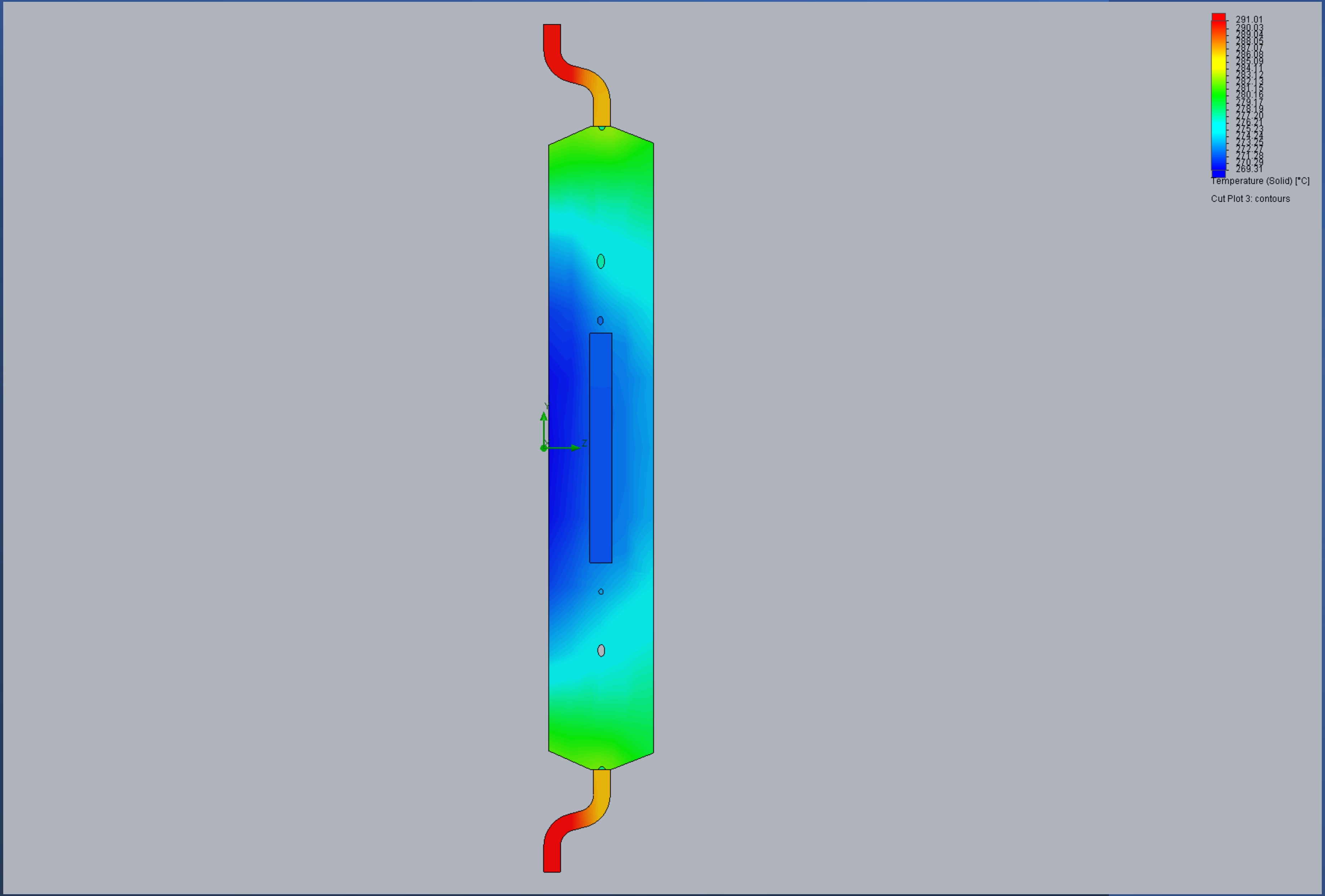
Volume flow rate	Pressure difference
0 m^3/s	117.56 Pa
0.00023999999 m^3/s	108.74 Pa
0.00047999999 m^3/s	98.949997 Pa
0.00072000001 m^3/s	85.330002 Pa
0.00095999998 m^3/s	64.760002 Pa
0.0012000001 m^3/s	44.77 Pa
0.00144 m^3/s	23.610001 Pa
0.0017 m^3/s	0 Pa

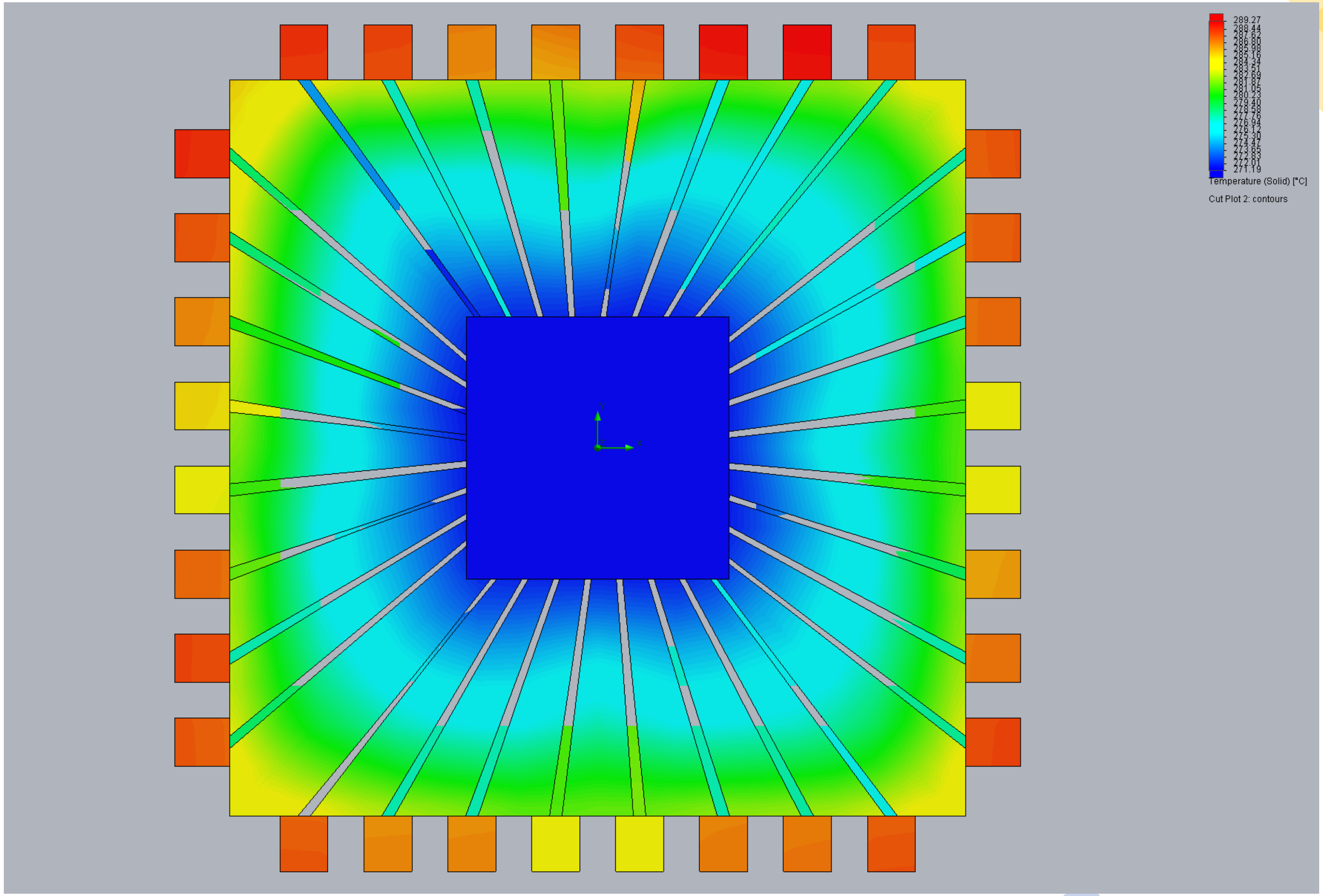


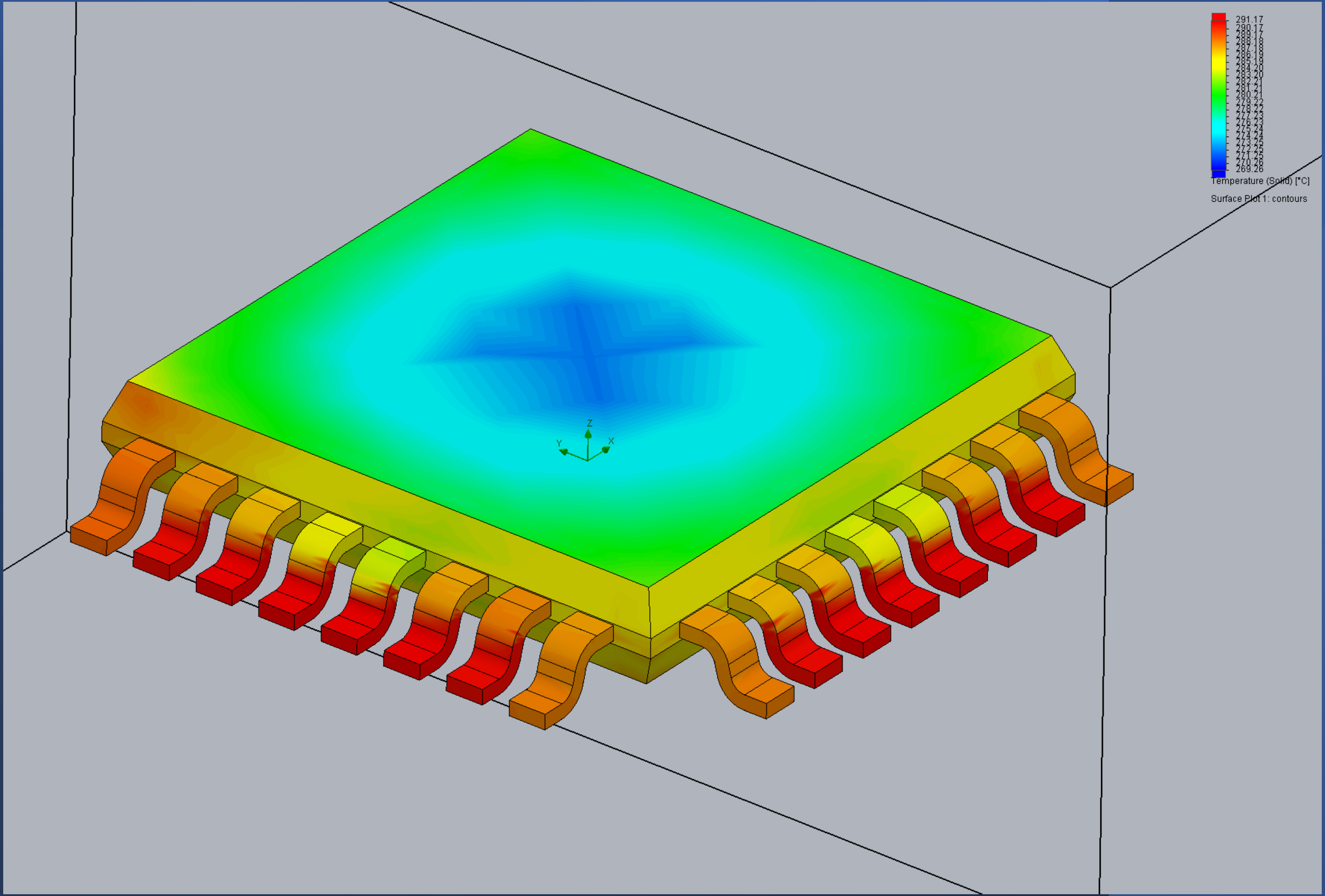
Property	Value
Name	BW05010012BH
Comments	
Fan Type	Axial
Set up reference density	☑
Reference density	1.2 kg/m^3
Mass/Volume flow rate	Volume flow rate
Value	(Table)
Rotor speed	680.67841 rad/s
Outer diameter	0.050000001 m
Hub diameter	0.02 m
Direction of rotation	Clockwise

Fan surface




291.01
290.03
289.04
288.05
287.07
286.08
285.09
284.11
283.12
282.13
281.15
280.16
279.17
278.19
277.20
276.21
275.23
274.24
273.25
272.27
271.28
270.29
269.31
Temperature (Solid) [°C]
Cut Plot 3: contours
Y
Z


289.27
288.44
287.62
286.80
285.98
285.16
284.34
283.51
282.69
281.87
281.05
280.23
279.40
278.58
277.76
276.94
276.12
275.30
274.47
273.65
272.83
272.01
271.19
Temperature (Solid) [°C]
Cut Plot 2: contours


291.17
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288.18
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284.20
283.20
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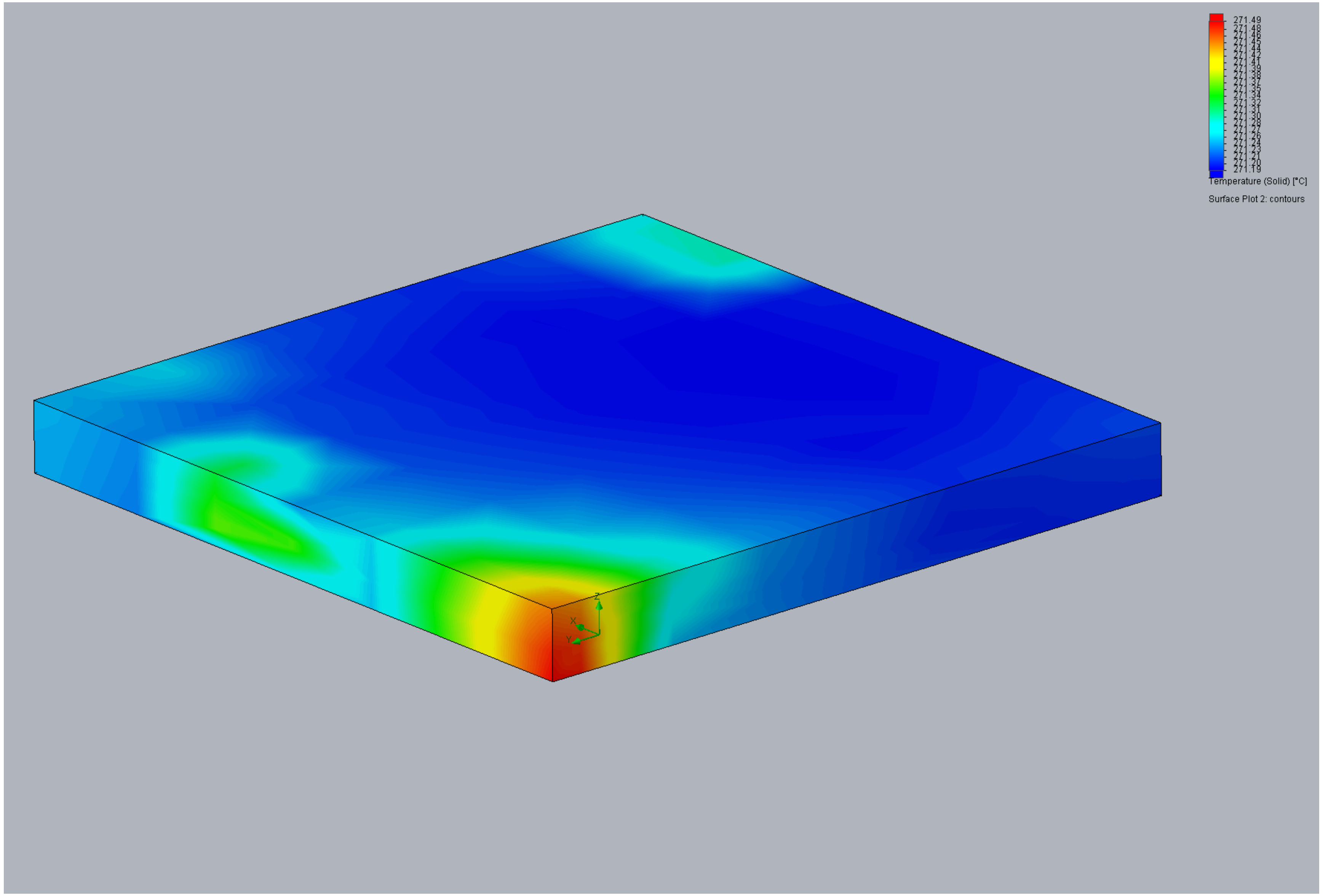
281.21
280.21
279.22
278.22
277.23
276.23
275.24
274.24
273.25
272.25
271.25
270.26
269.26
Temperature (Solid) [°C]
Surface Plot 1: contours
Z
Y
X


271.49
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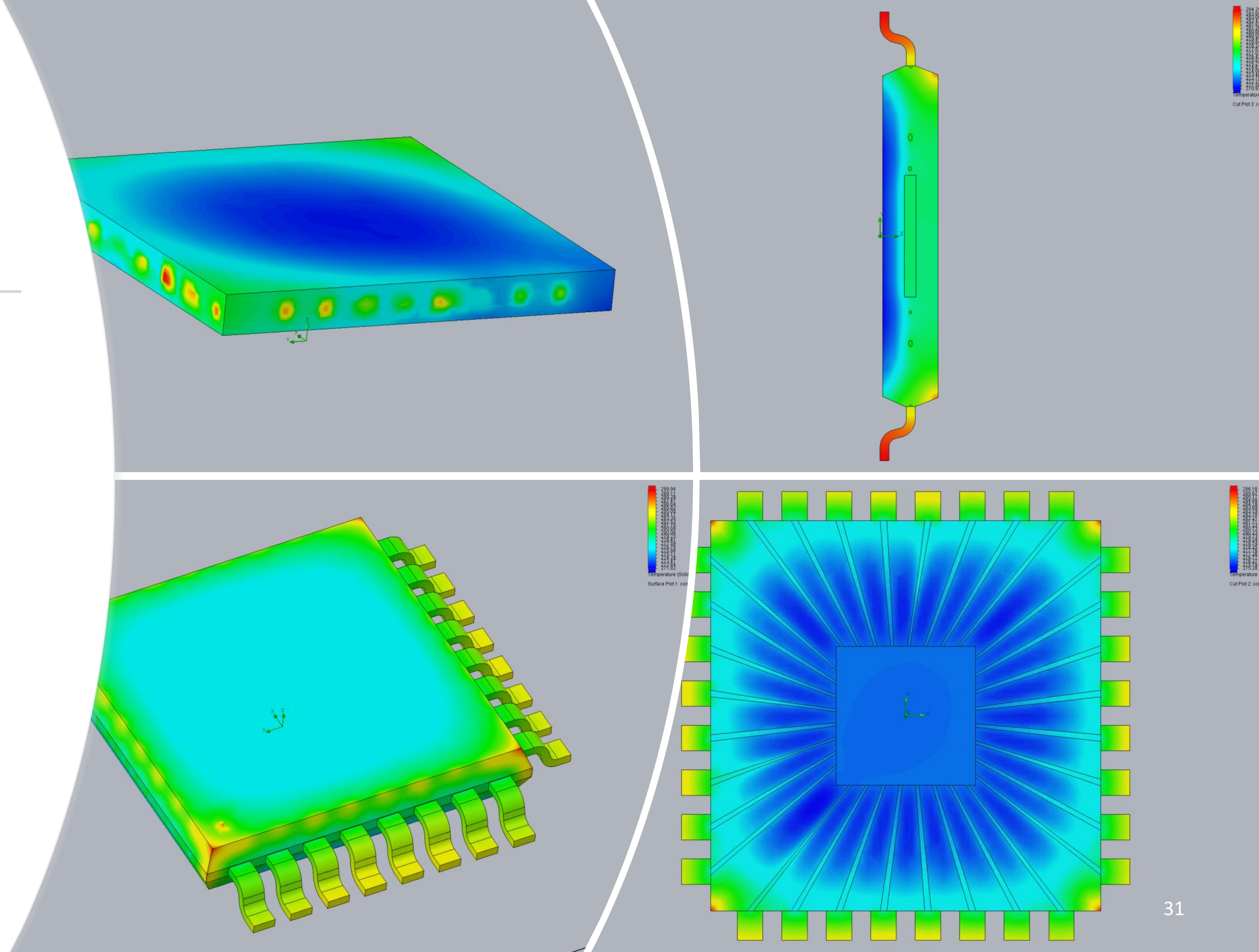
271.35
271.34
271.32
271.31
271.30
271.28
271.27
271.26
271.24
271.23
271.21
271.20
271.19
Temperature (Solid) [°C]
Surface Plot 2: contours
Z
X
Y

Transient t = 809s

- With minimum mesh size =0.03



Discussion

- Transient and stable
- Material matters a lot
- Surface rate are too high

Results

Silicon chip can stay under appropriate temperature.

Internal temperature seems close in both cases.

Considering the transient simulation, it seems hard to really damage the chip.

參考文獻

- https://www.eetimes.com/soldering-practices-are-insane/
- https://reurl.cc/Nr4Zlx