Thermal Analysis Simulation about mini Port Card with ANSYS

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Parameters

Temperature (degree C)

· Air = 5

· Coolant = -15

Heat transfer coefficient : h (W/m^2 k)

· Air = 3

· Coolant = 700

Thermal conductivity : k (W/m k)

·Silicon(chip) = 148

·Glass = 1.0

·Gold = 317

·Copper = 401

·BeO = 248

·Glue = 0.1

·Carbon Fiber = 372(0 deg.) / 1(90 deg.)

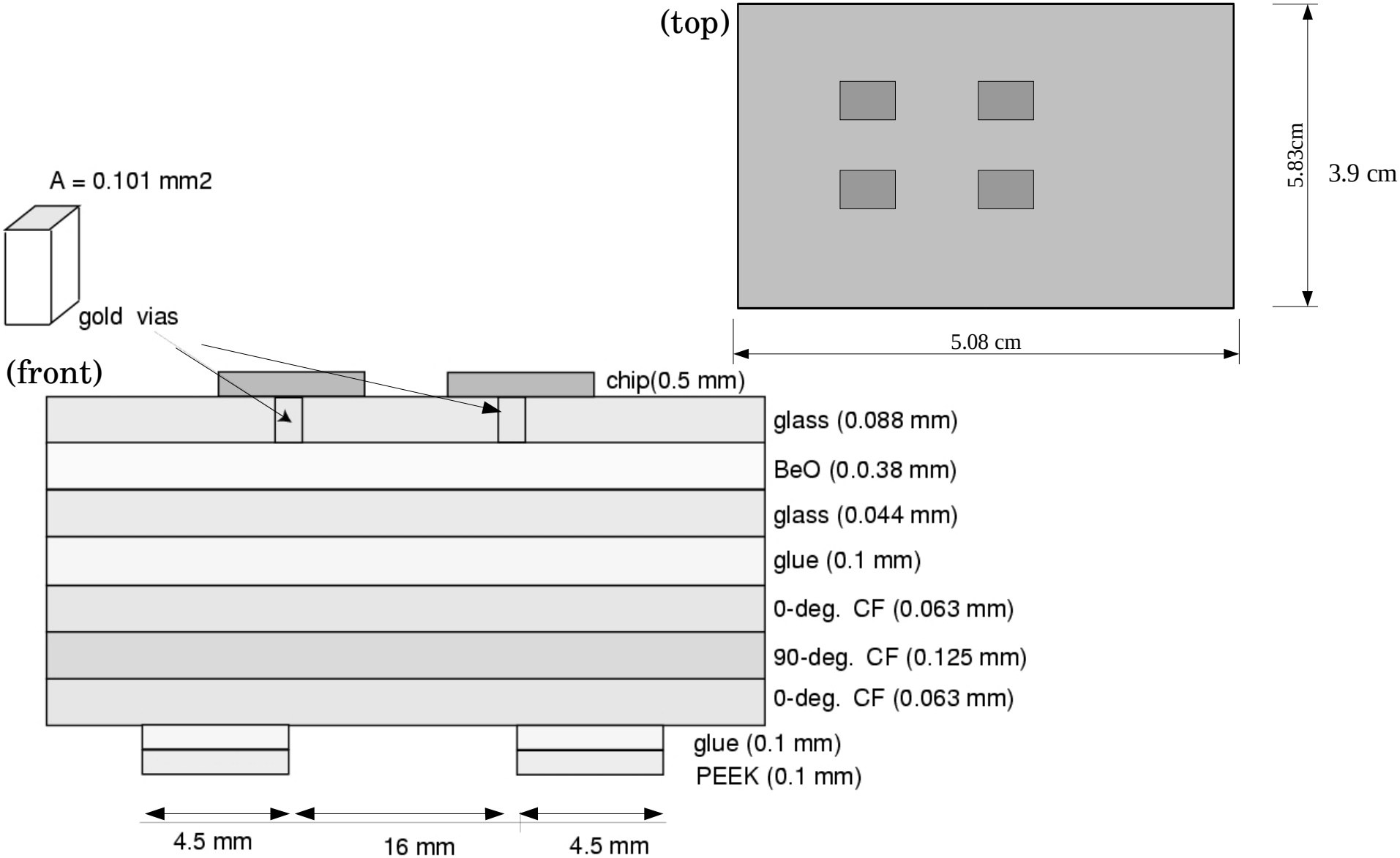
·PEEK = 0.25

·Polyimide = 0.12

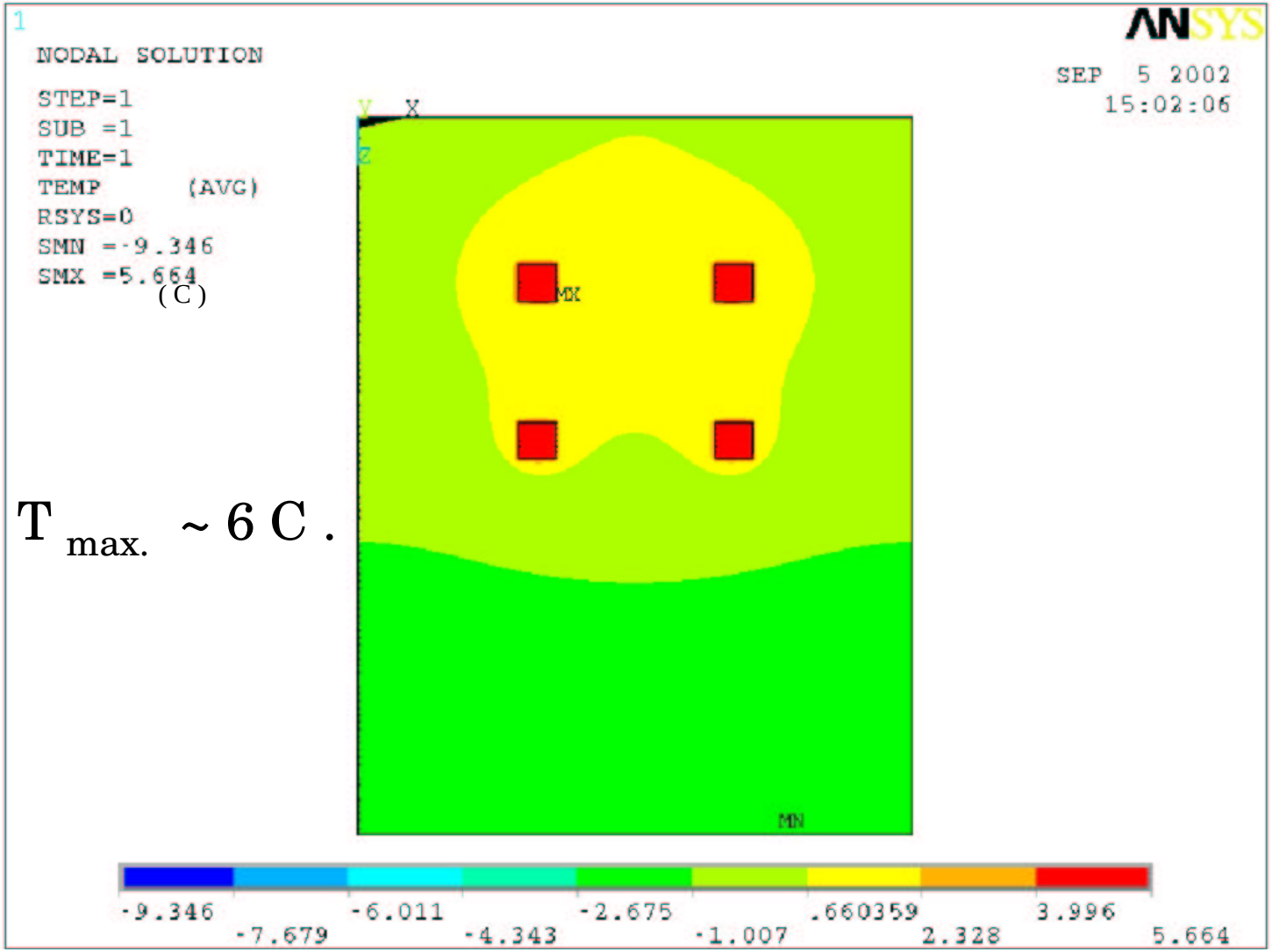
Heat rate

0.5 W/chip

Geometry of BeO miniPC used in this simulation

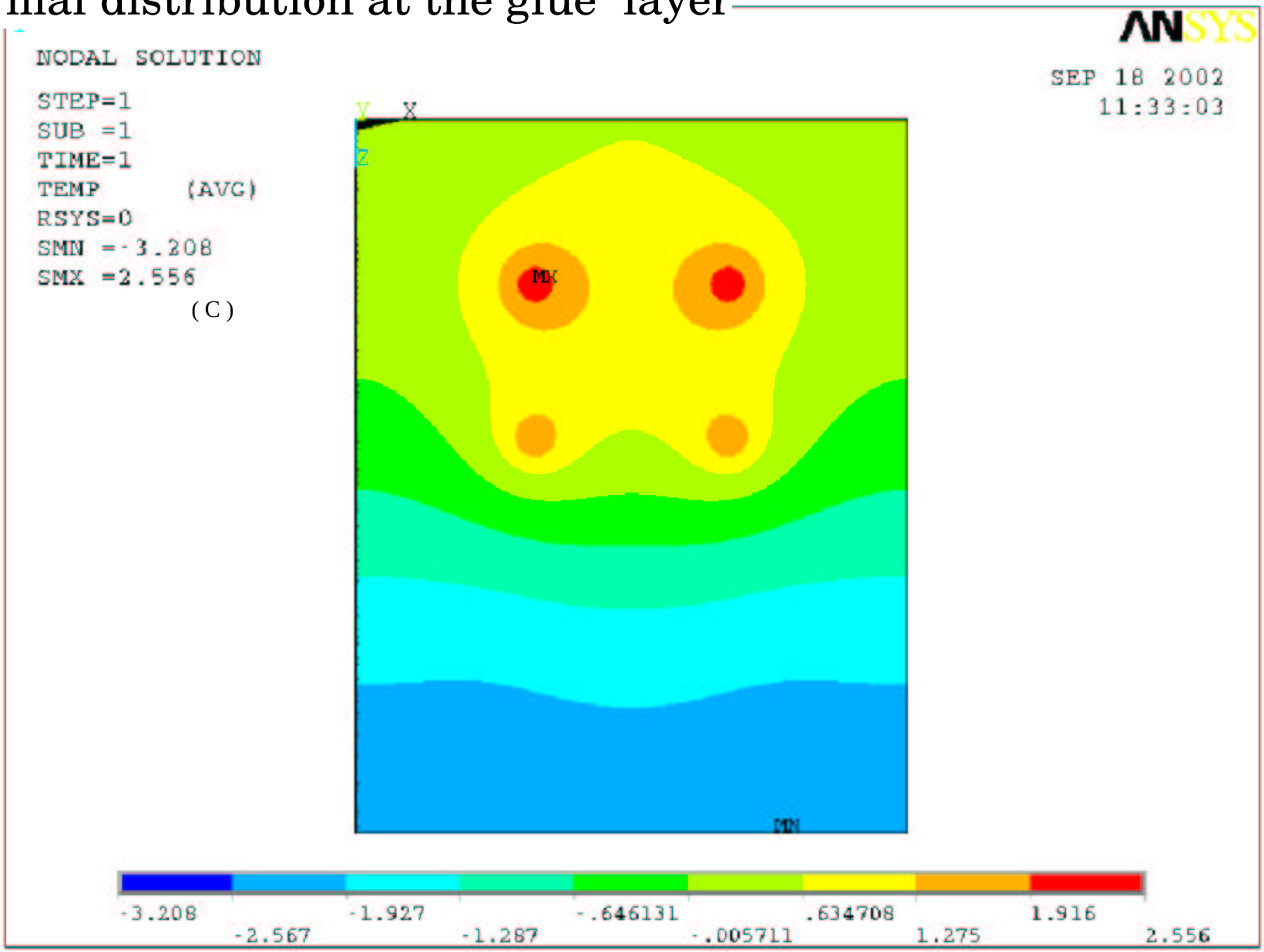


Thermal distribution of BeO miniPC



$T_{max.} \sim 6\ C$.

Thermal distribution at the glue layer



Modifying the thermal conductivity of gold vias

Measured thermal conductivity is usually less than the pure metal conductivity.

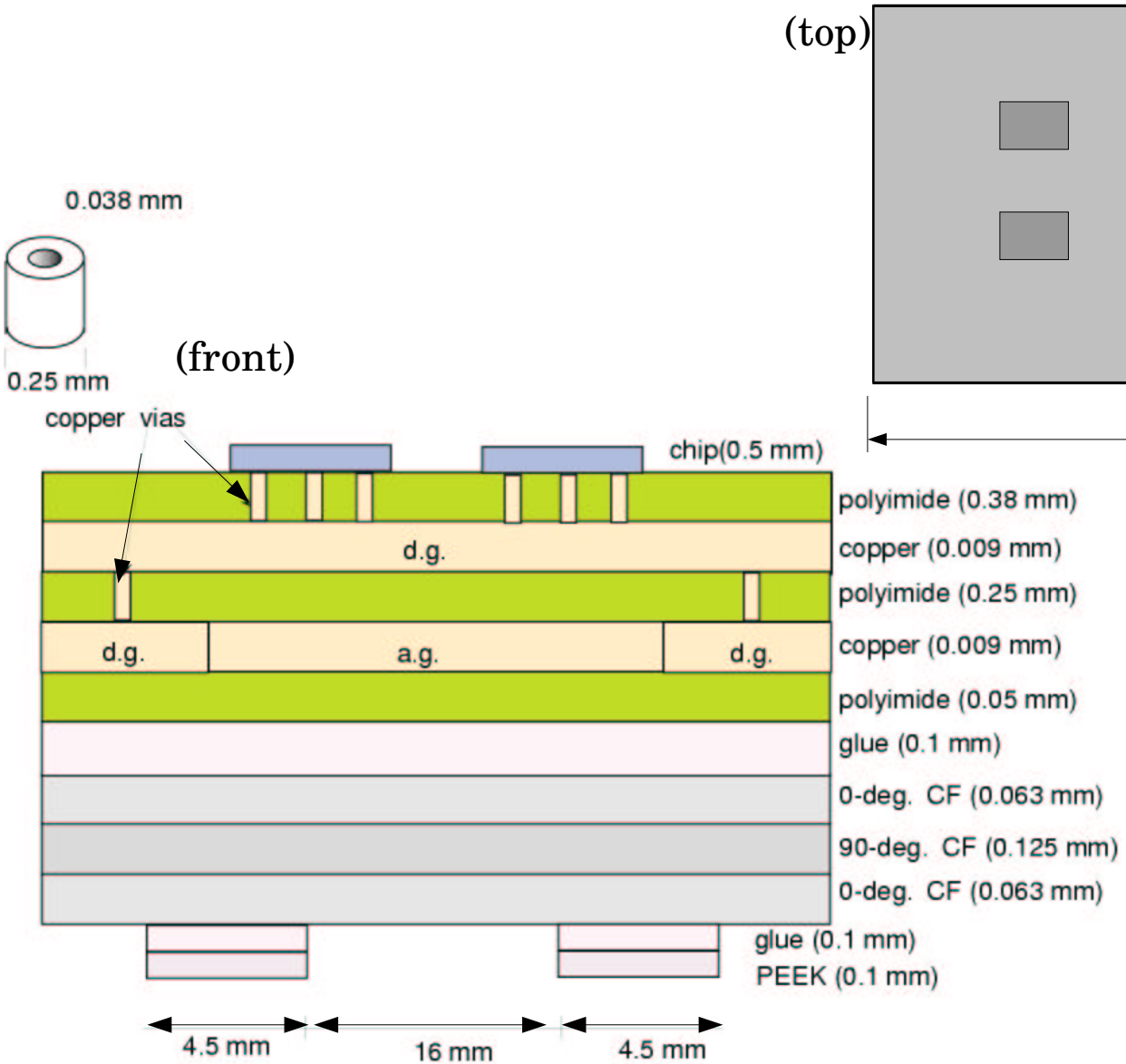
Modified k_gold = (k_gold_pure) * (275 / k_silver_pure)
= 203 (W/m k)

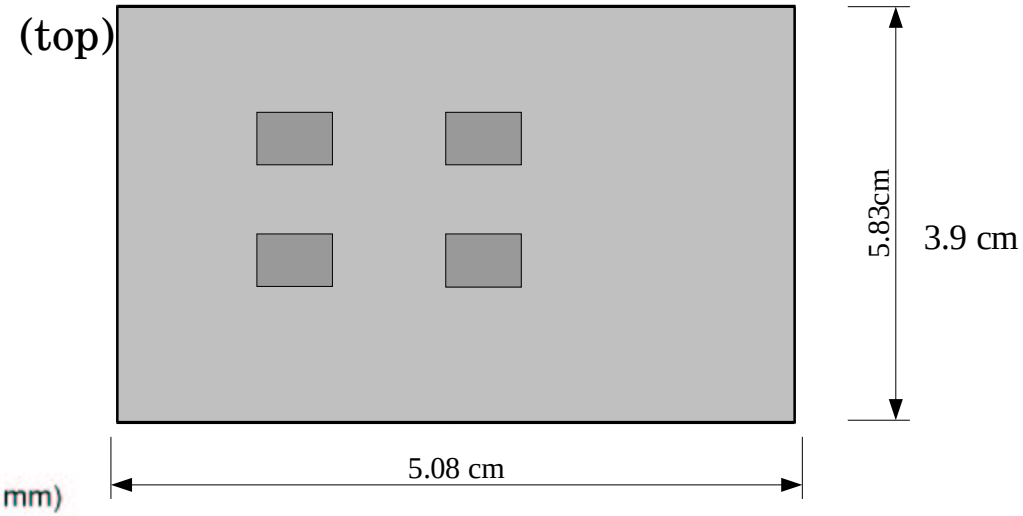
Results

	k_gold (W/m k)	Max. Temp.(C)
Pure	317	5.66
Modified	203	5.83

This effect is small.

Geometry of polyimide miniPC used in this simulation





Maximum temperature of polyimide miniPC, for different number of vias .

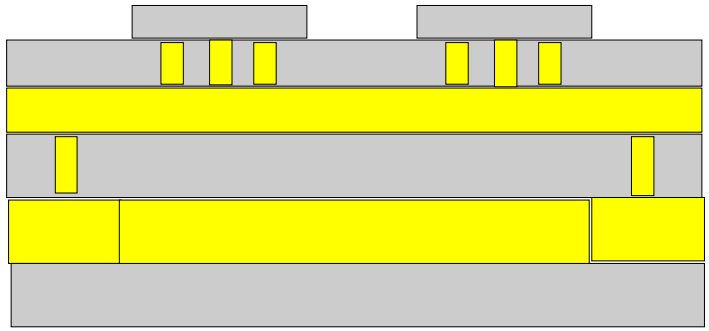
of vias

Under each chips	Between the copper GNDs	Max.Temp.(C)
4	10	40.59
4	20	40.15
9	10	32.41
9	20	32.36

The number of vias under the chips contributes the temperature, but between the GNDs doesn't.

Changing thickness of the copper GNDs

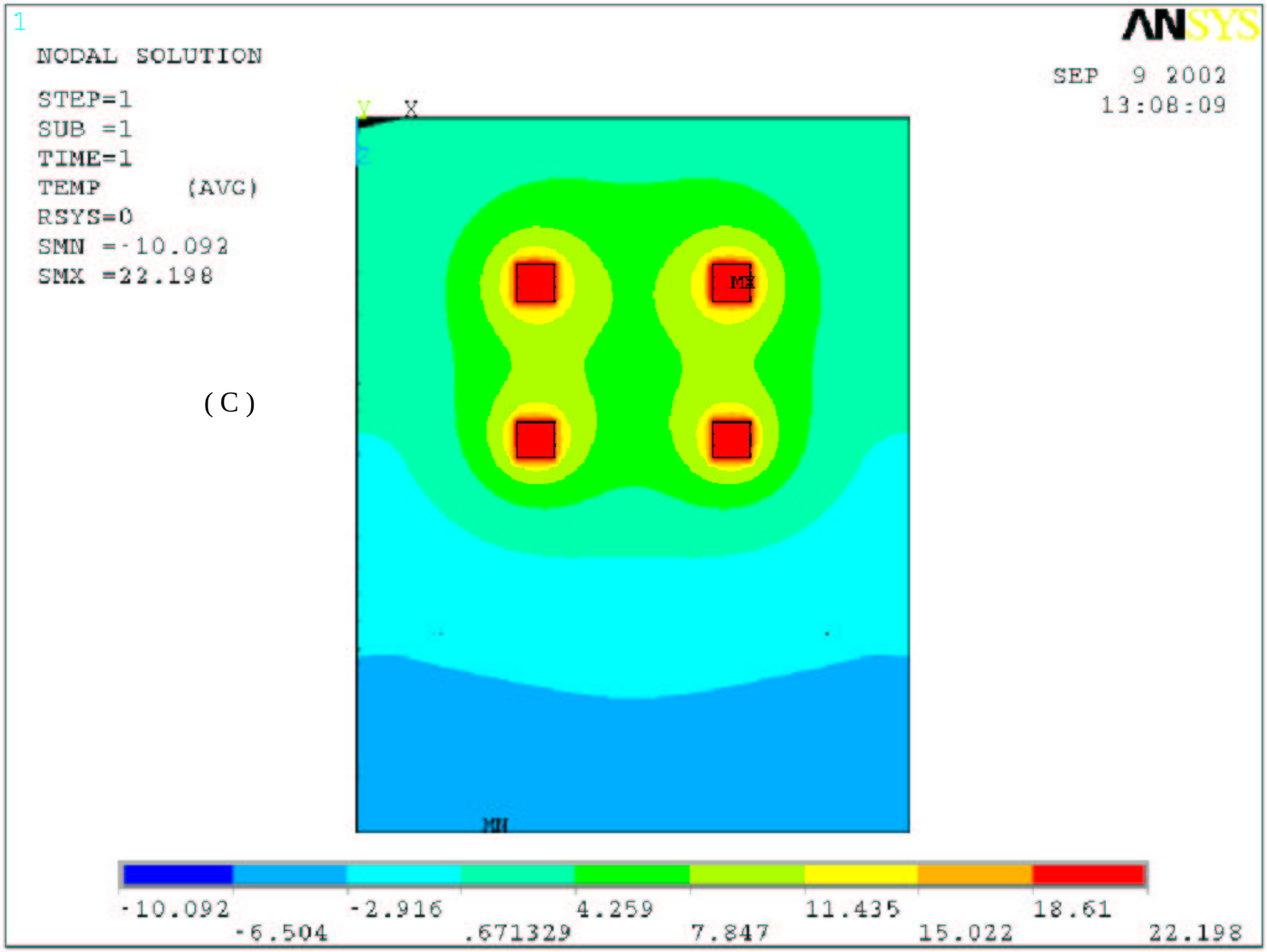
(for polyimide MPC with 9 vias under the chips and 20 between the GNDs.)



	9 um	9 um	18 um	18 um	27 um	36 um
	9 um	18 um	9 um	18 um	9 um	9 um
	(1)	(2)	(3)	(4)	(5)	(6)
Max. Temp.(C)	32.36	31.63	22.57	22.2	18.24	15.74

Up-side GND helps cooling down,
but down-side doesn't .

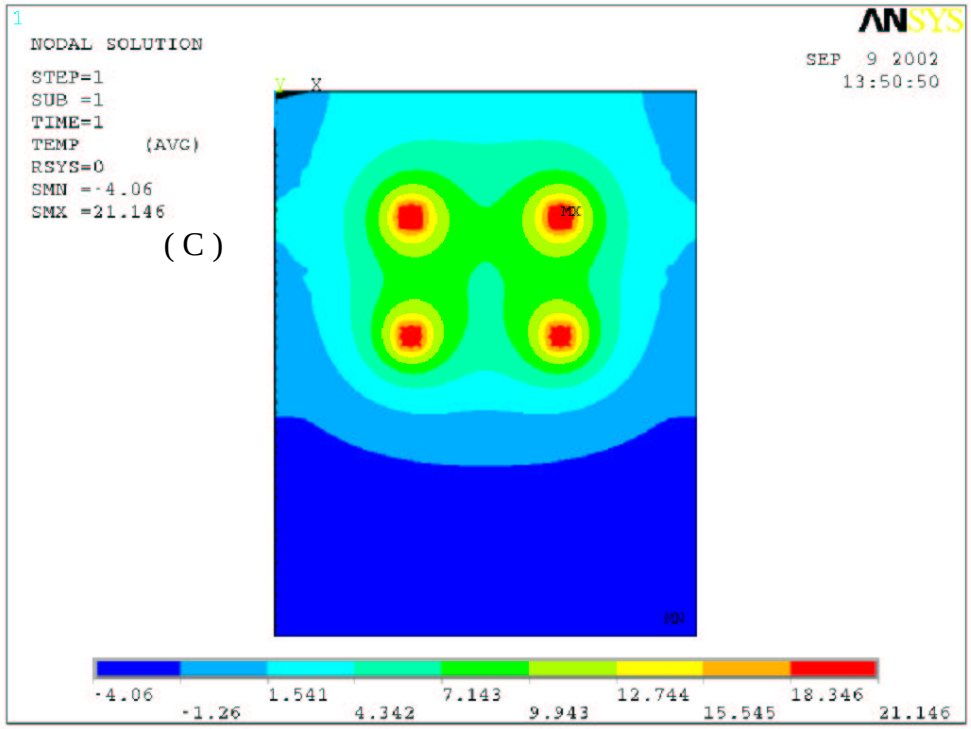
Thermal distribution for the case (4)



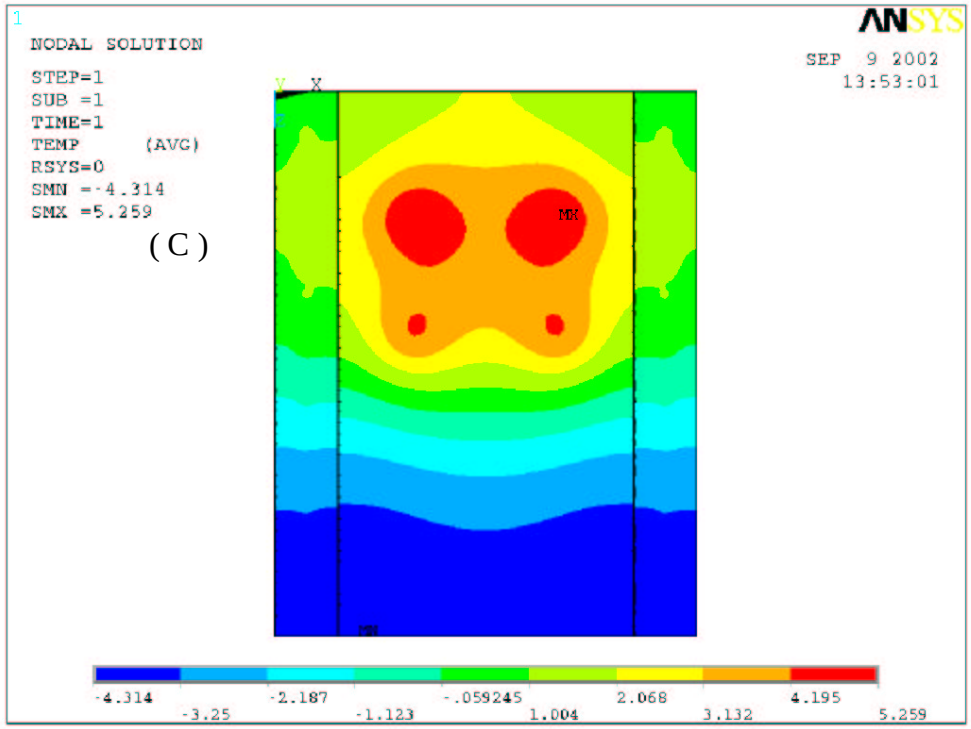
(C)

Thermal distribution at the GND layers for the case (4)

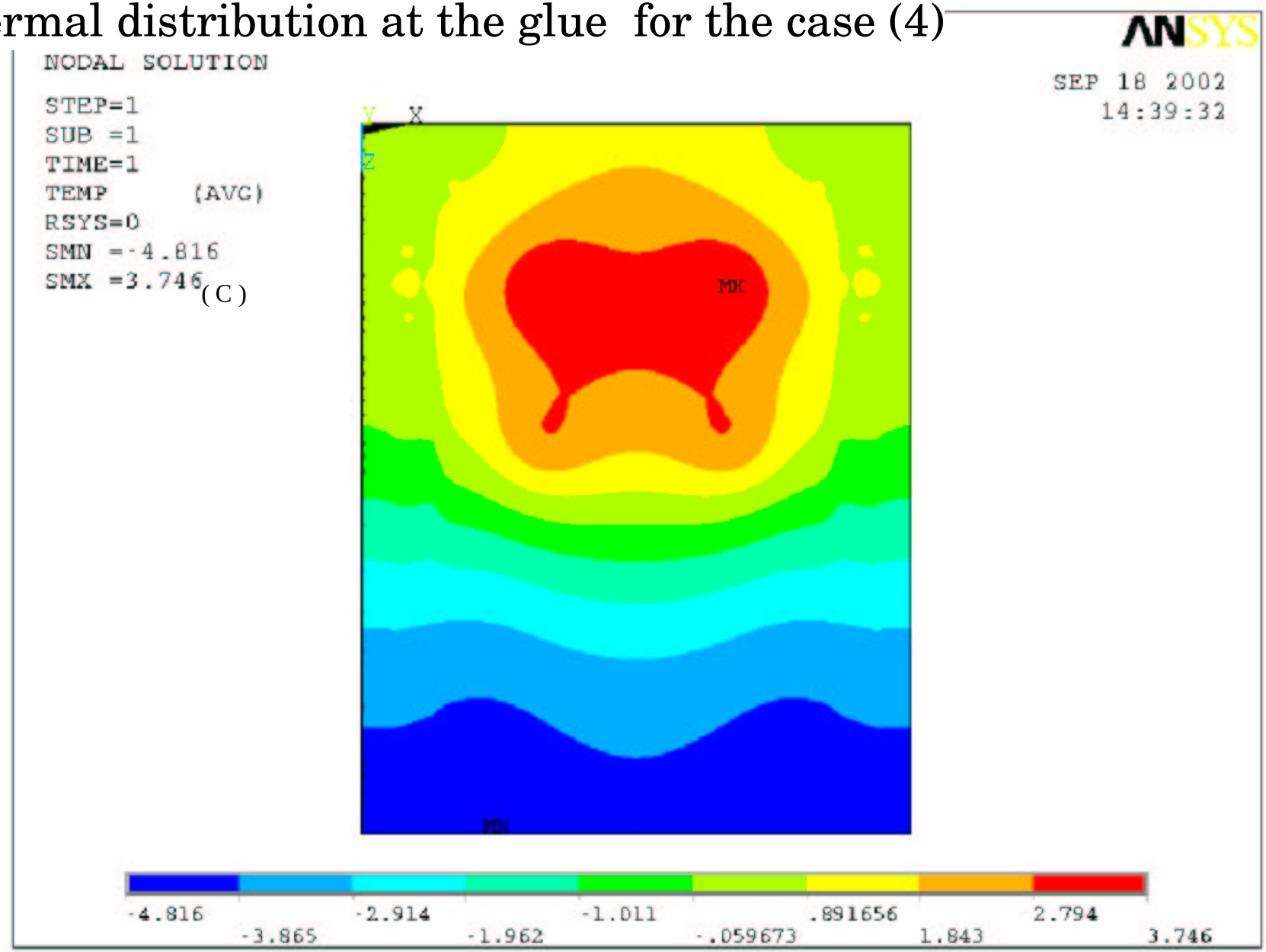
up-side



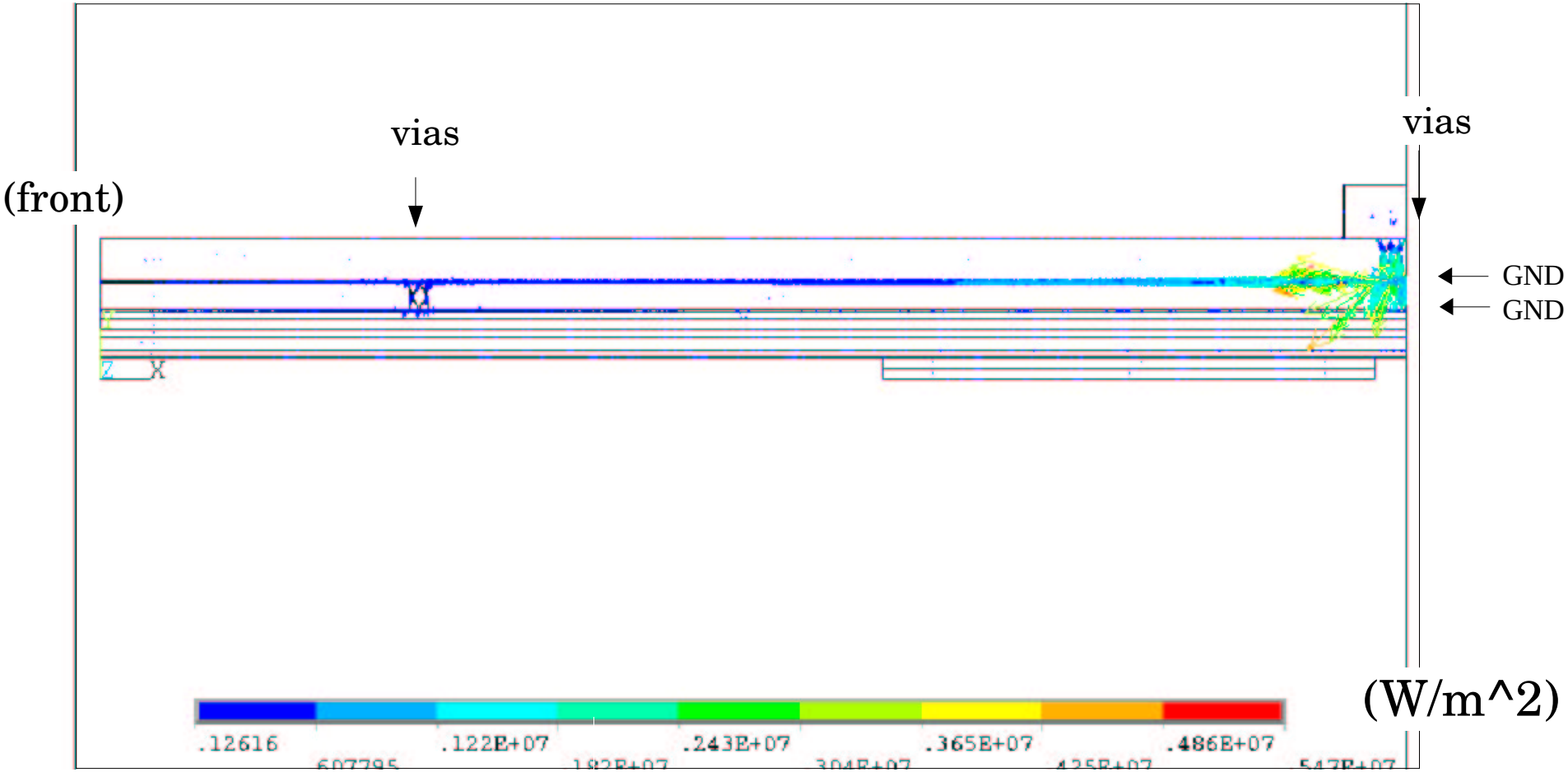
down-side



Thermal distribution at the glue for the case (4)

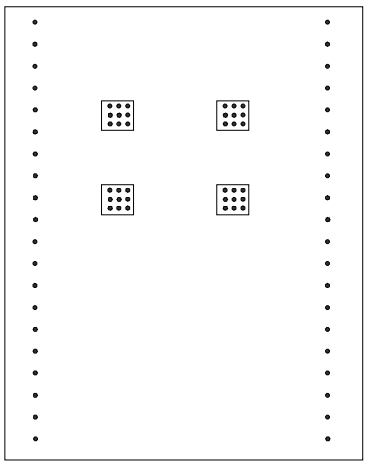


Thermal Flux for the case (4)

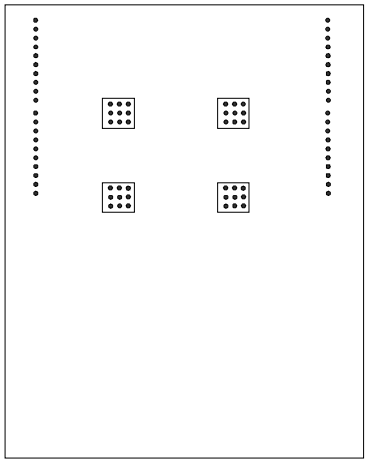


Heat flows mainly through the vias under the chips and then spreads out through the up-side copper GND.

Comparing the temperature of miniPC which have different vias positions (for case (6))



A

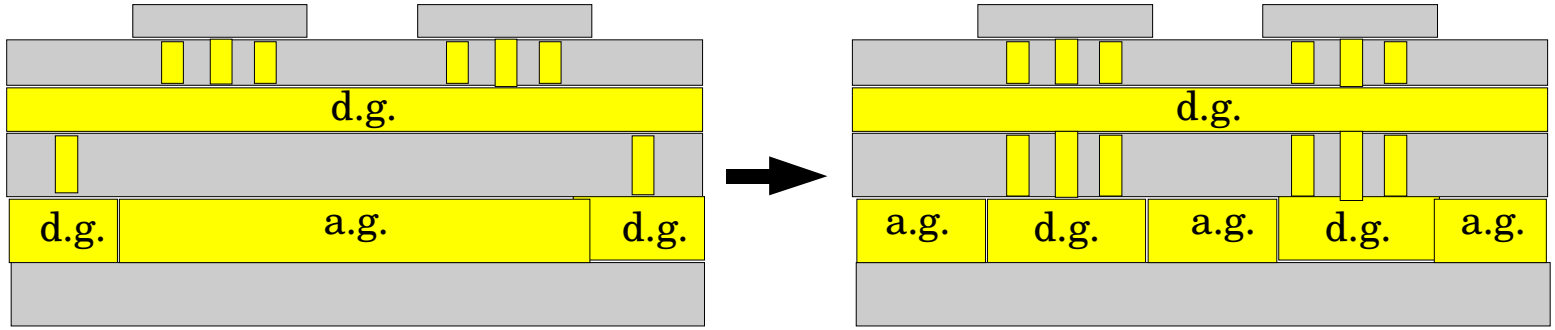


B

	Max. Temp. (C)
A	15.735
B	15.726

Positions of the vias between the GNDs give little contribution to the temperature .

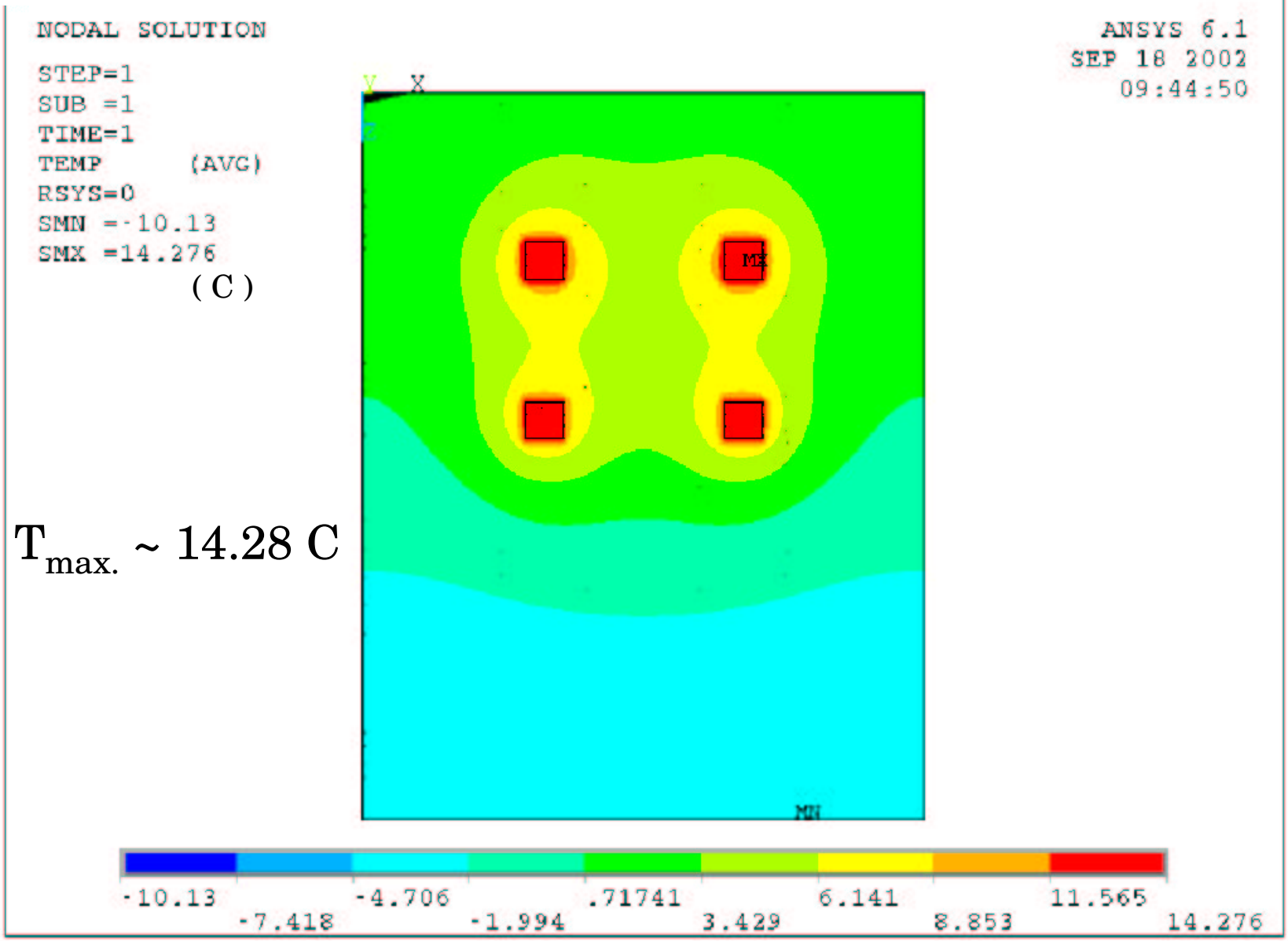
Extending the vias to the "down-side" ground



Not using the side vias, extend the vias under the chips to the "down-side" ground and move the down-side digital ground there.

(<u>thickness of GND = 18 μm</u>)

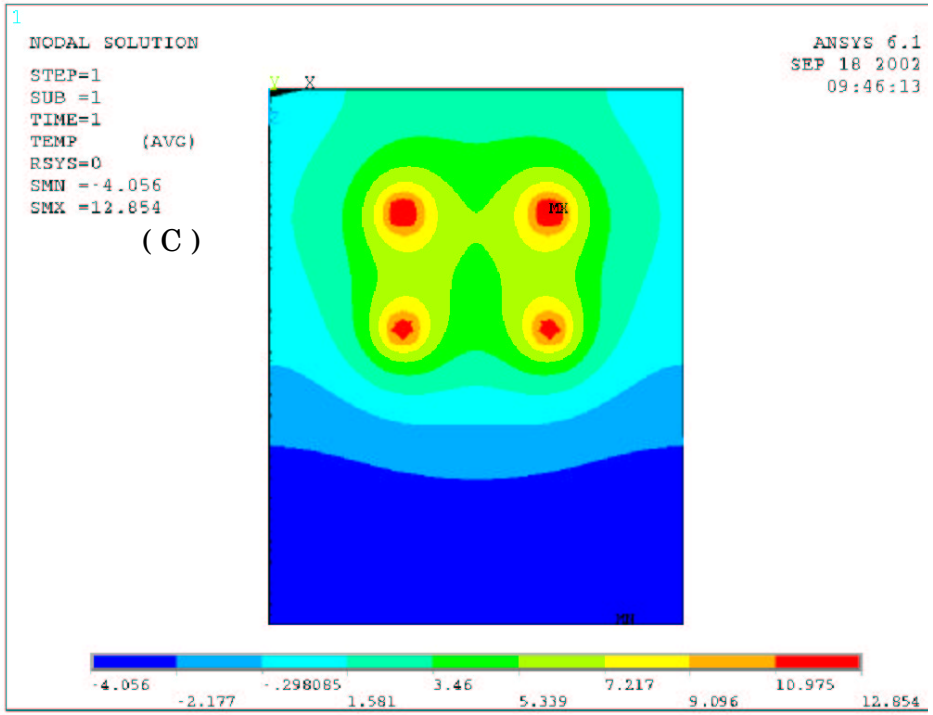
Thermal distribution for 9 vias MPC



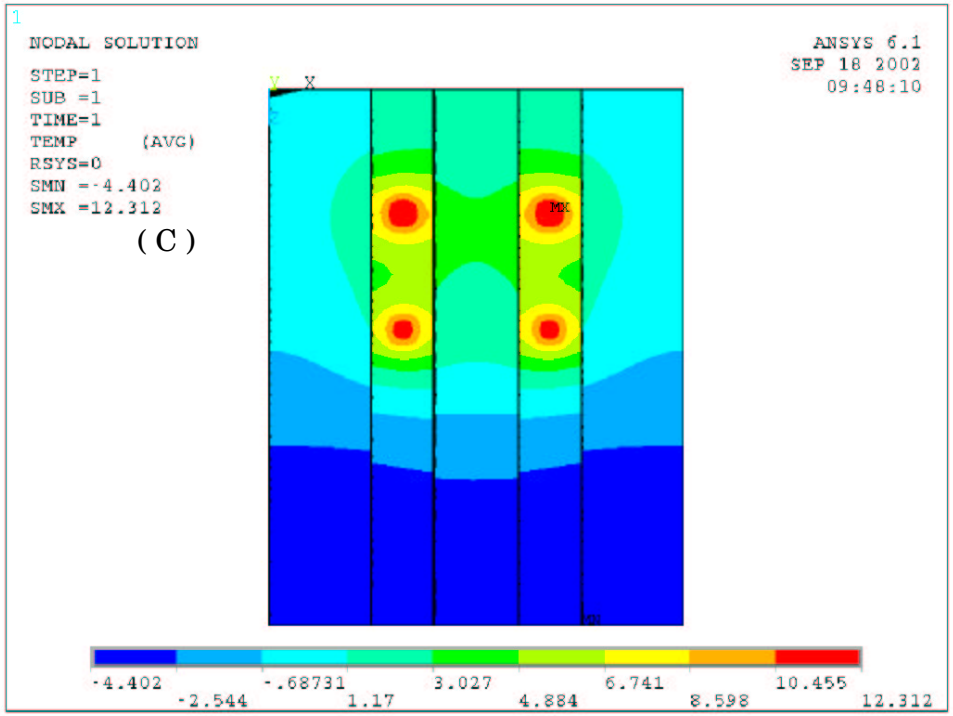
$T_{max.} \sim 14.28$ C

Thermal distribution at the GND layers for 9 vias MPC

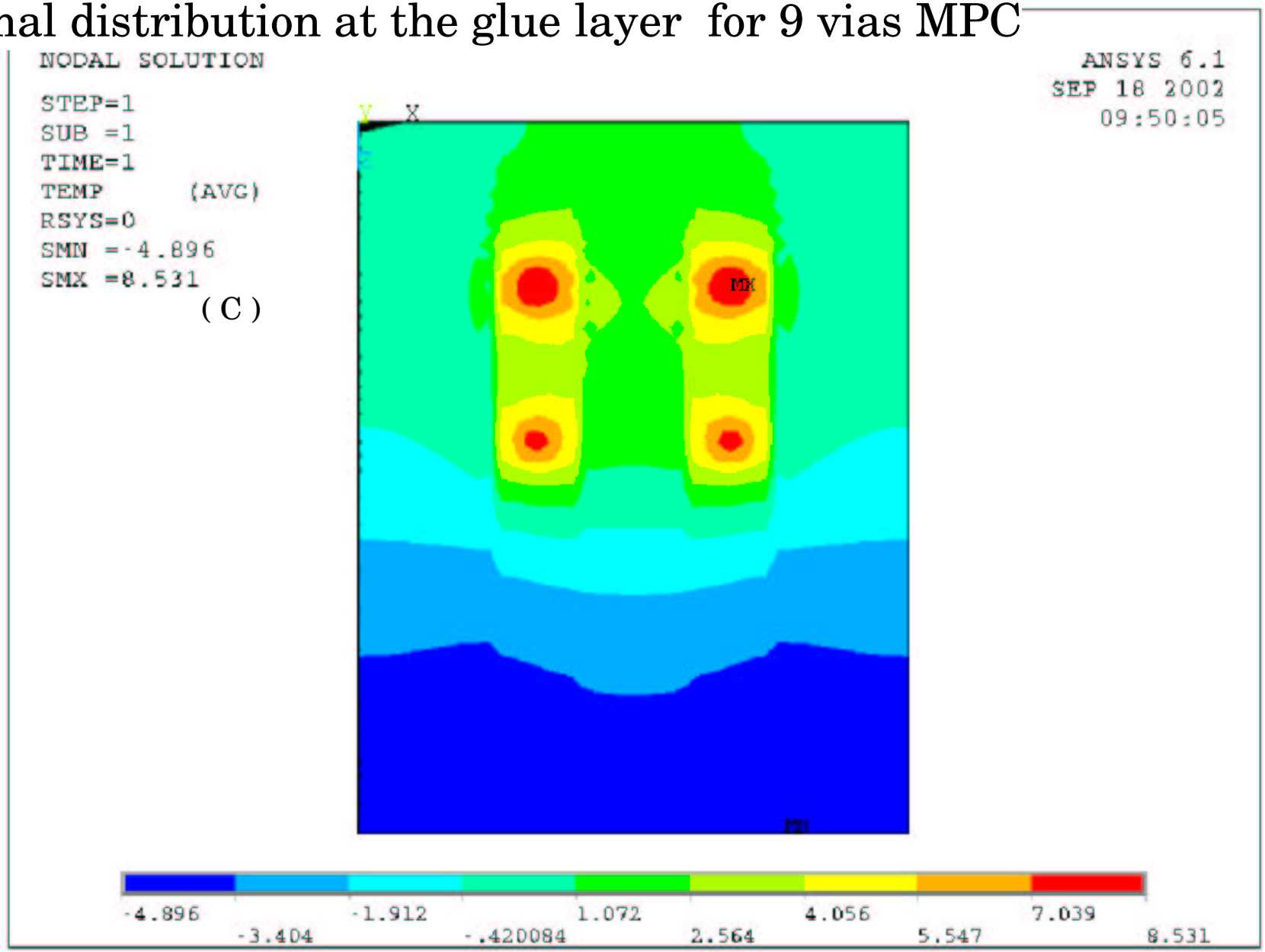
up-side



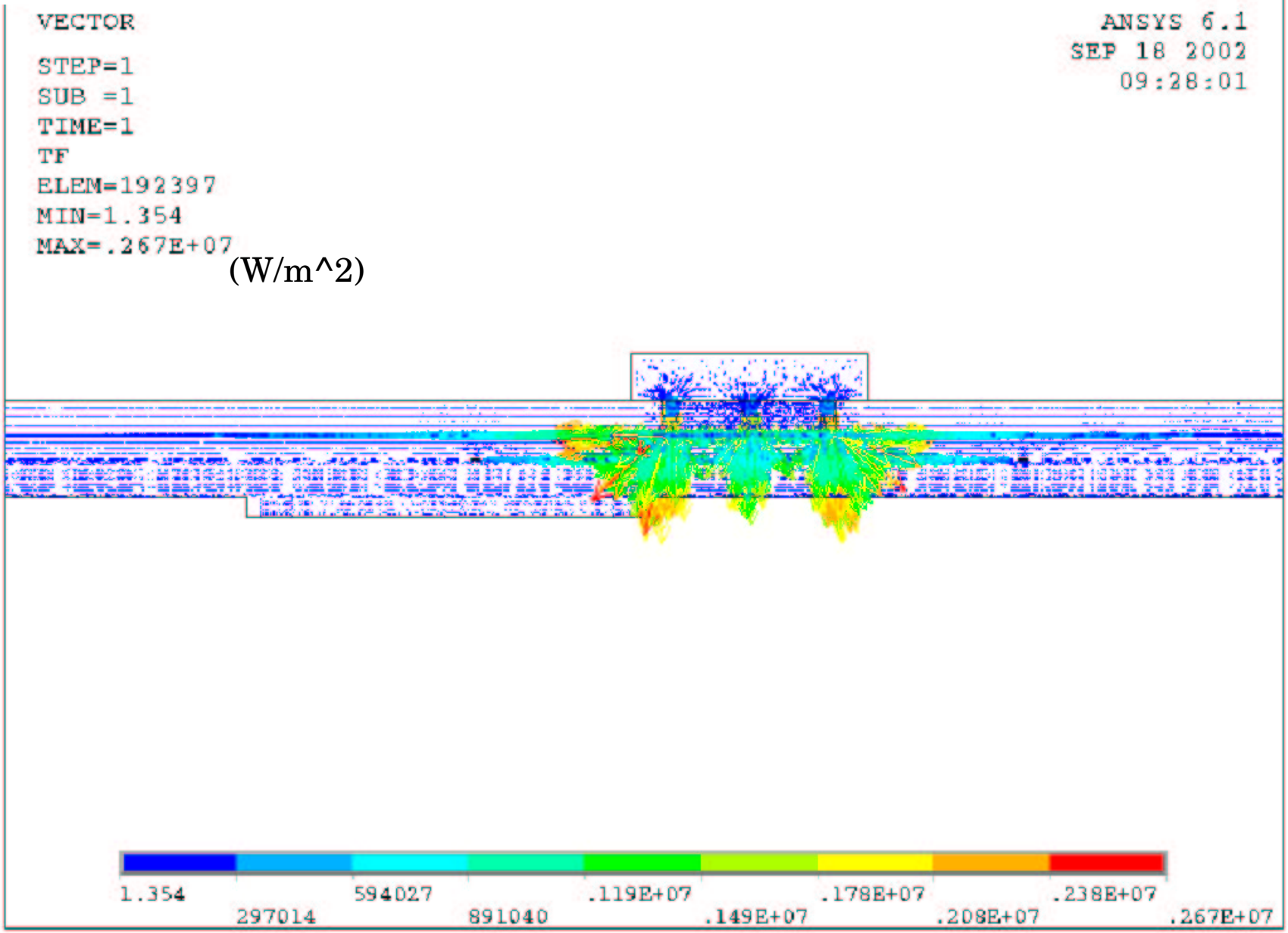
down-side



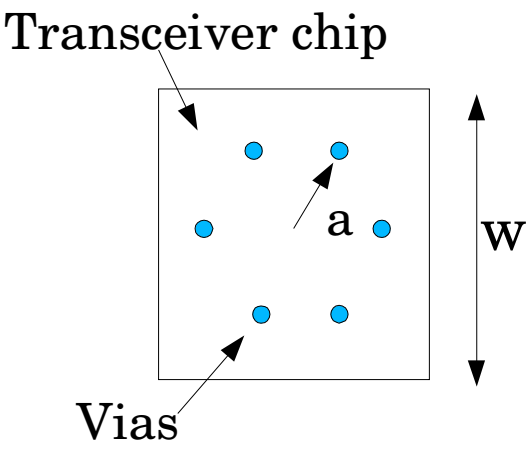
Thermal distribution at the glue layer for 9 vias MPC



Thermal flux for 9 vias MPC



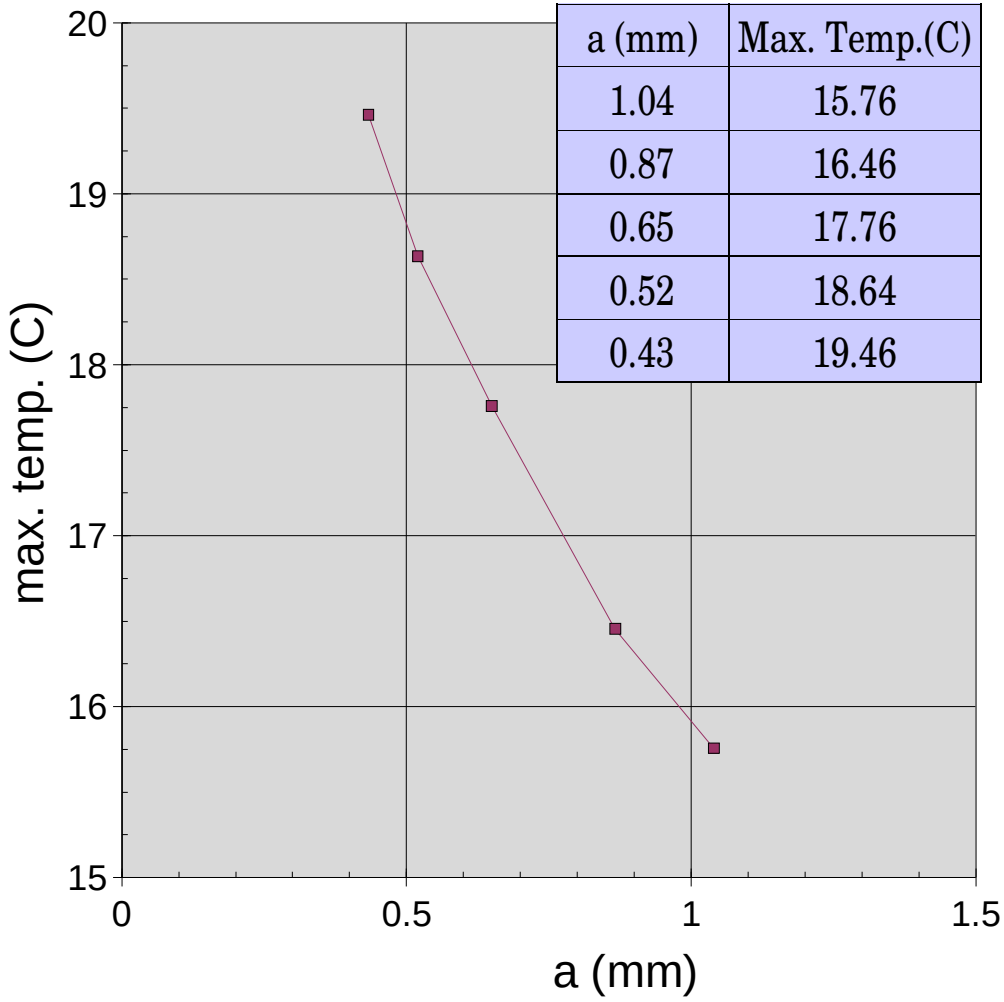
6 vias MPC (Change the number of vias (9 -> 6).)



Positions of the vias

a = w/2.5 , w/3 , w/4 , w/5 , w/6
= 1.04 , 0.87, 0.65, 0.52, 0.43 (mm)

Max. temp. (C)

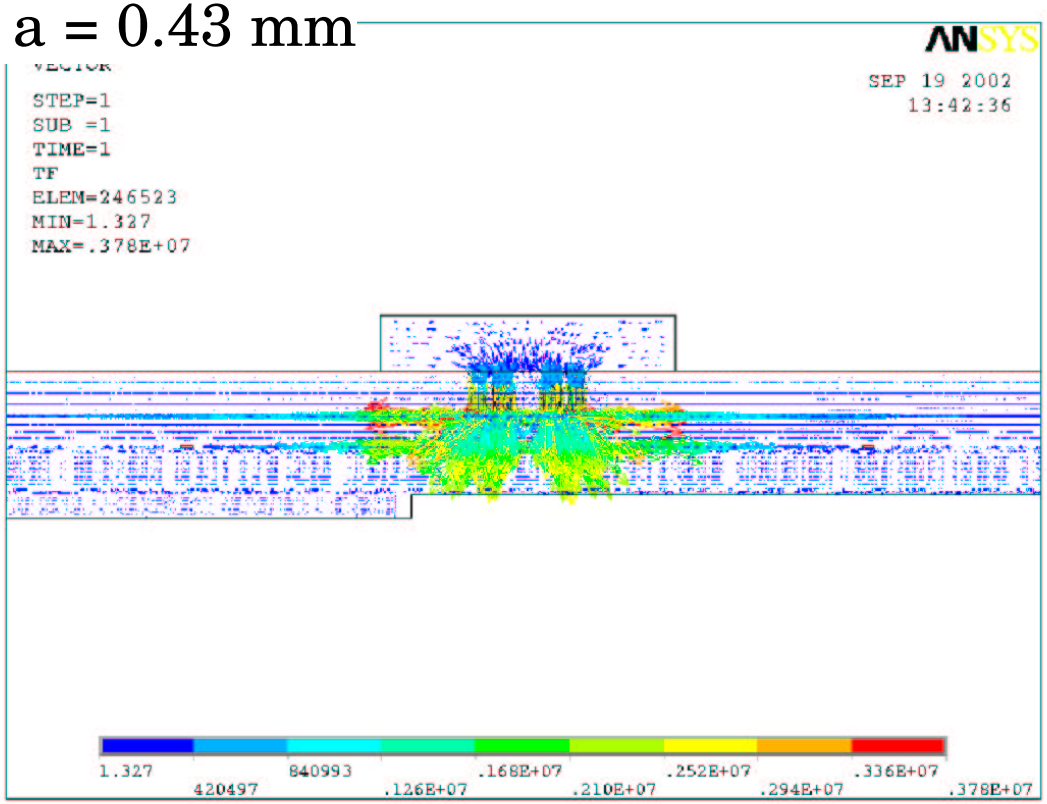


a (mm)	Max. Temp.(C)
1.04	15.76
0.87	16.46
0.65	17.76
0.52	18.64
0.43	19.46

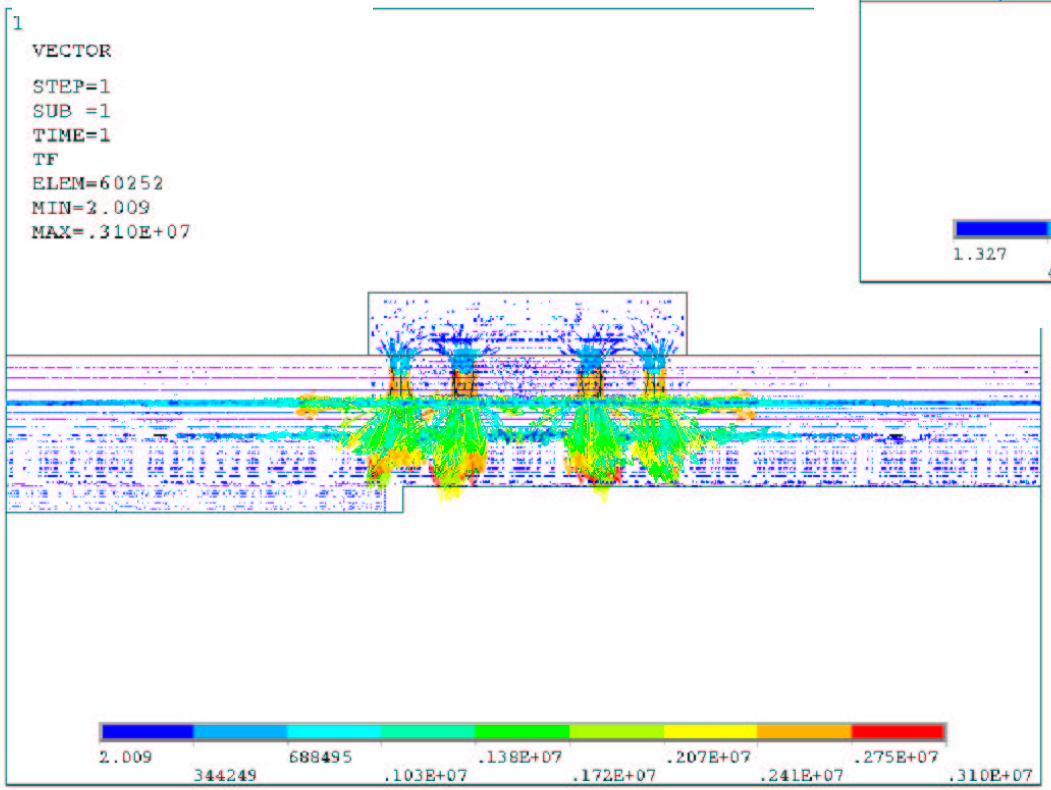
Wide distance between the vias is better.

Thermal flux for 6 vias MPC

a = 0.43 mm

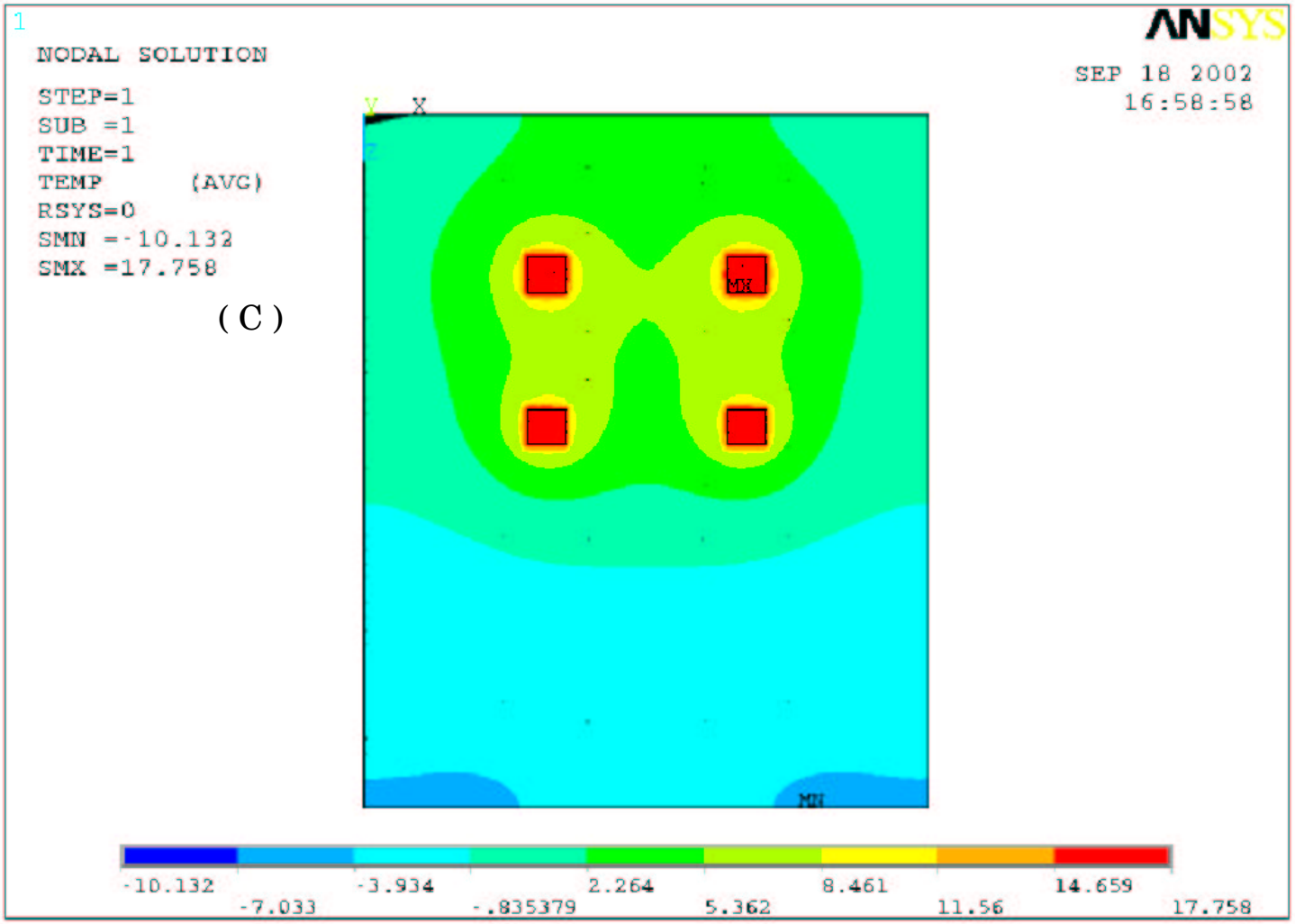


a = 1.04 mm



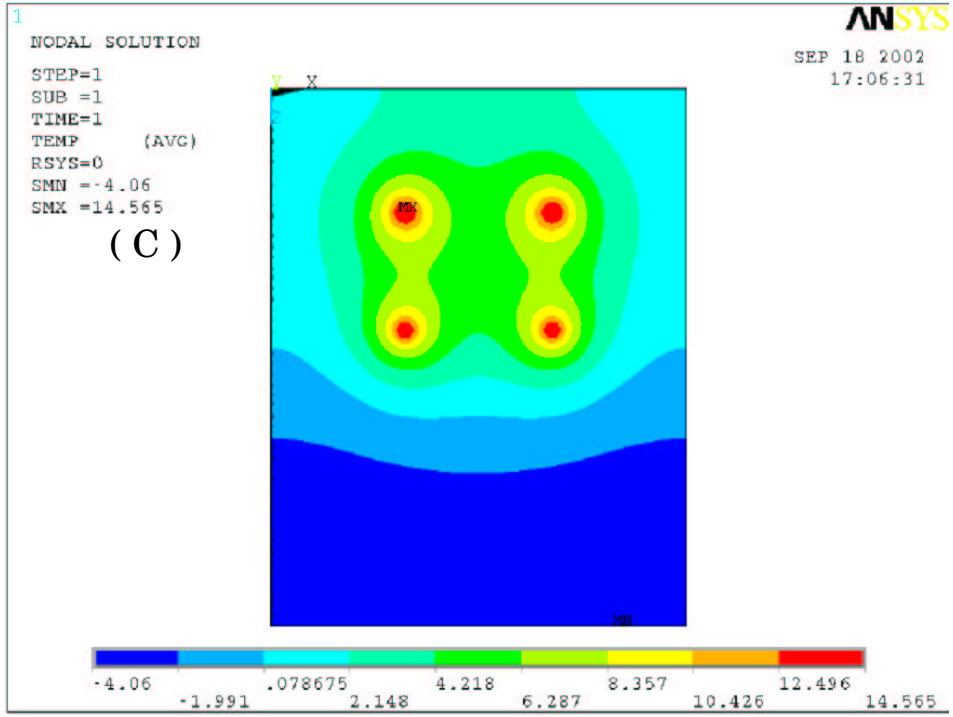
(W/m^2)

Thermal distribution (for 6 vias MPC : a=0.65mm)

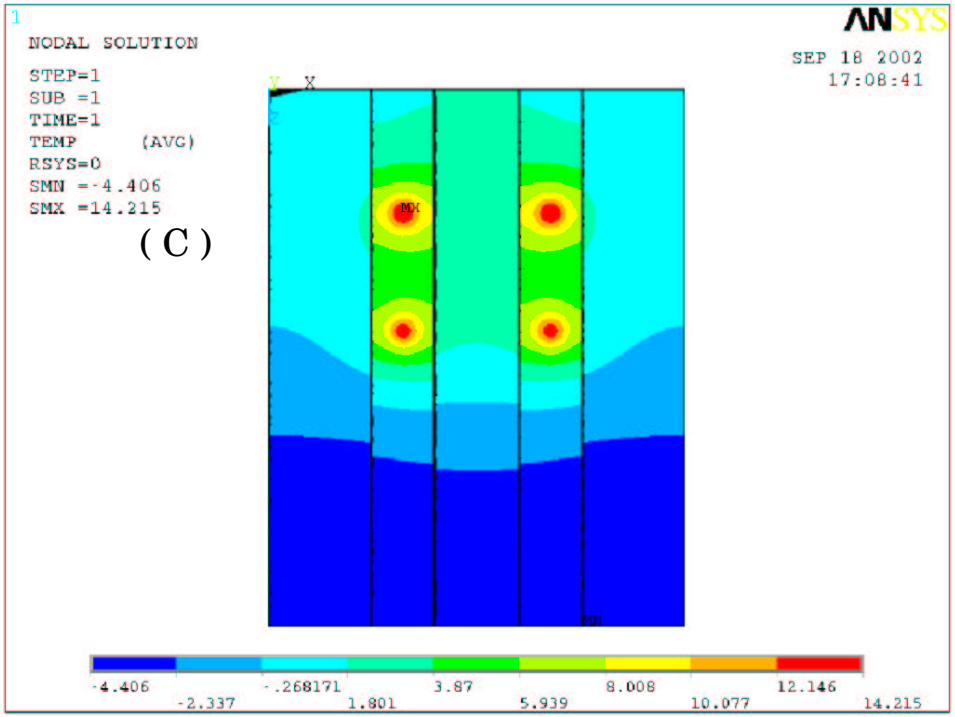


Thermal distribution at the GNDs (for 6 vias MPC : a=0.65 mm)

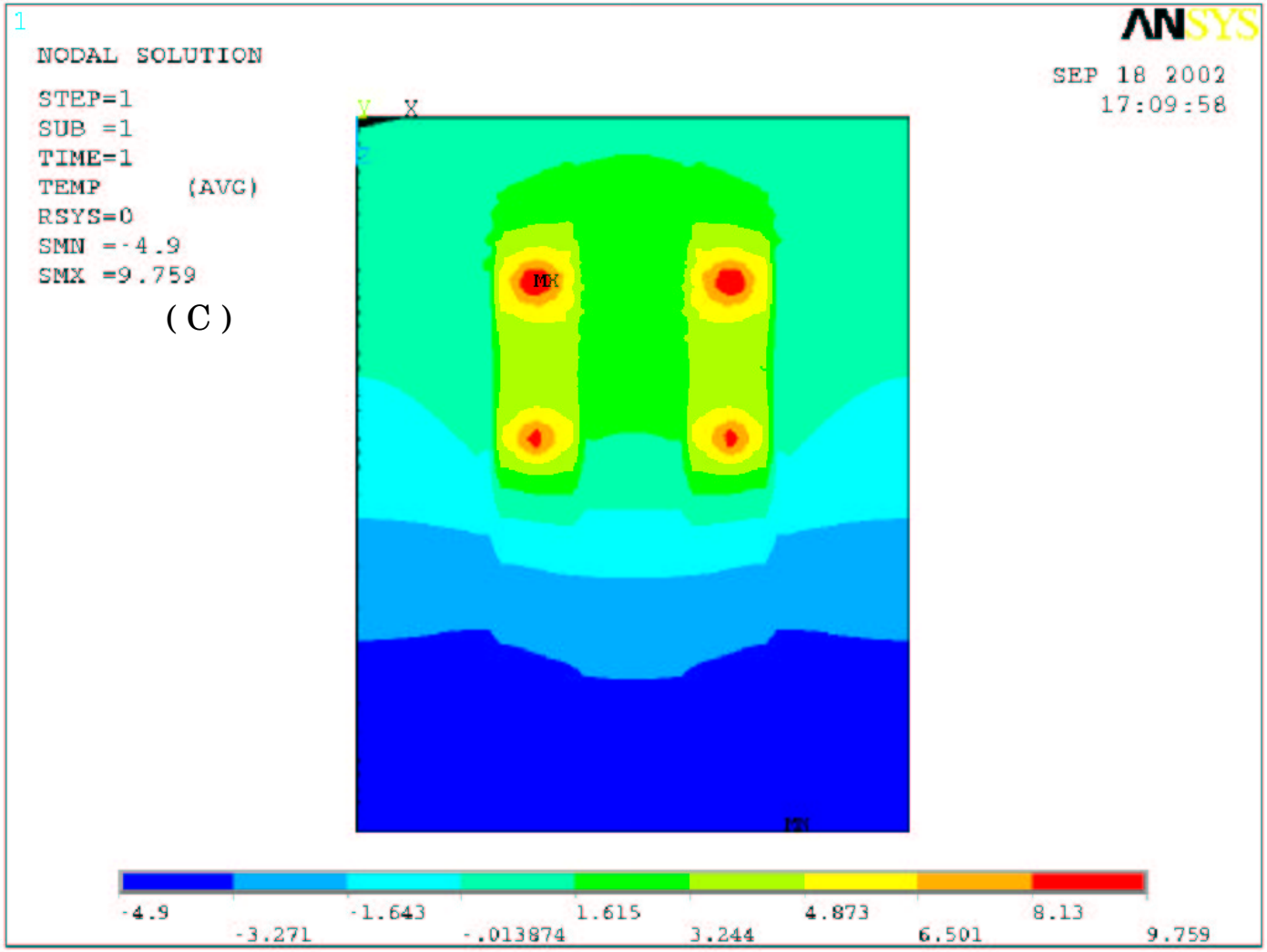
up-side



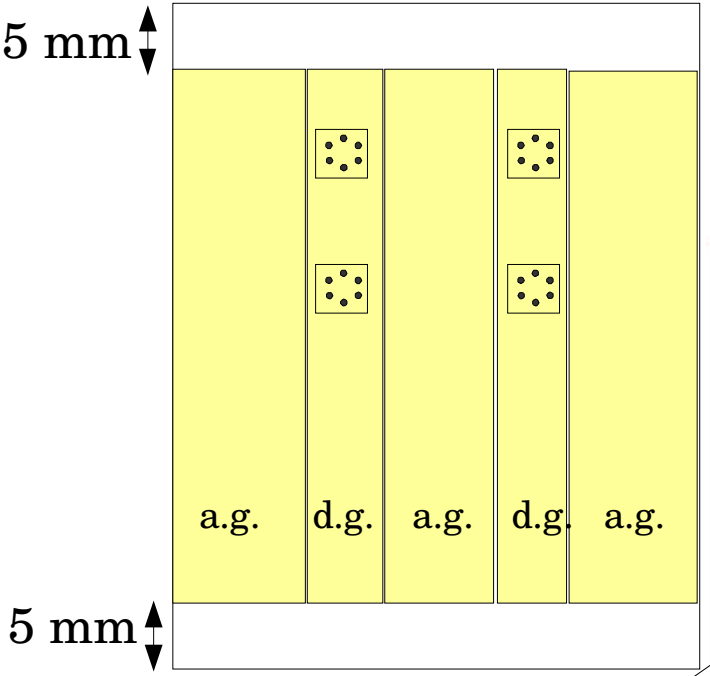
down-side

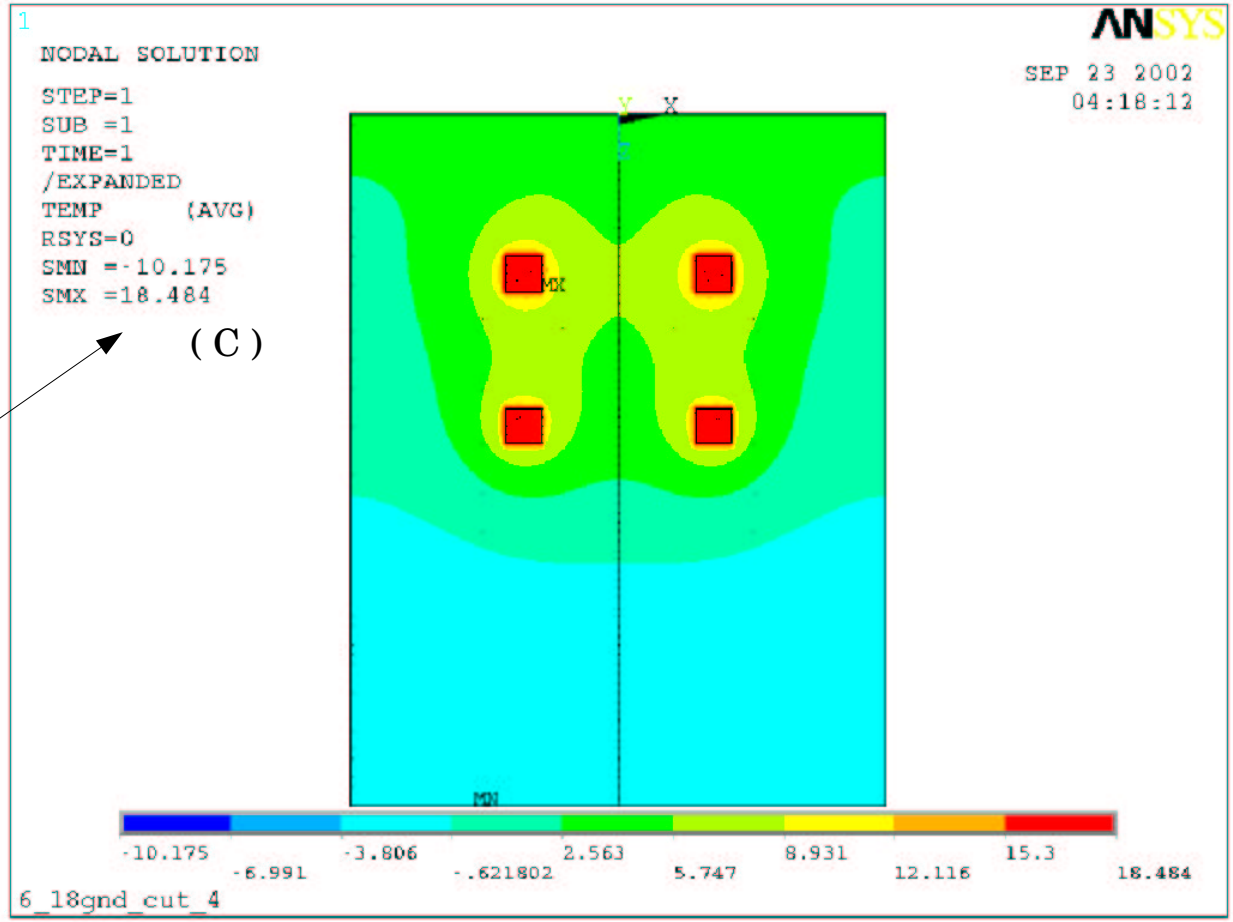


Thermal distribution at the glue layer (for 6 vias MPC : a=0.65 mm)



Cutting the edge of the down-side GNDs (for 6 vias MPC : a=0.65 mm)



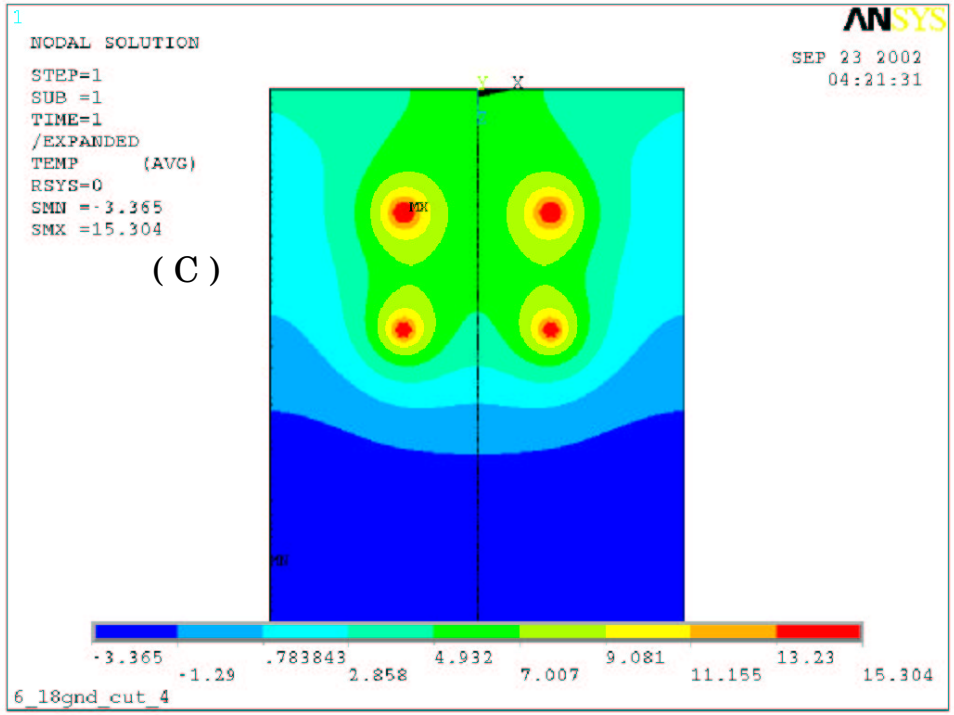


cut : ~18.48 C

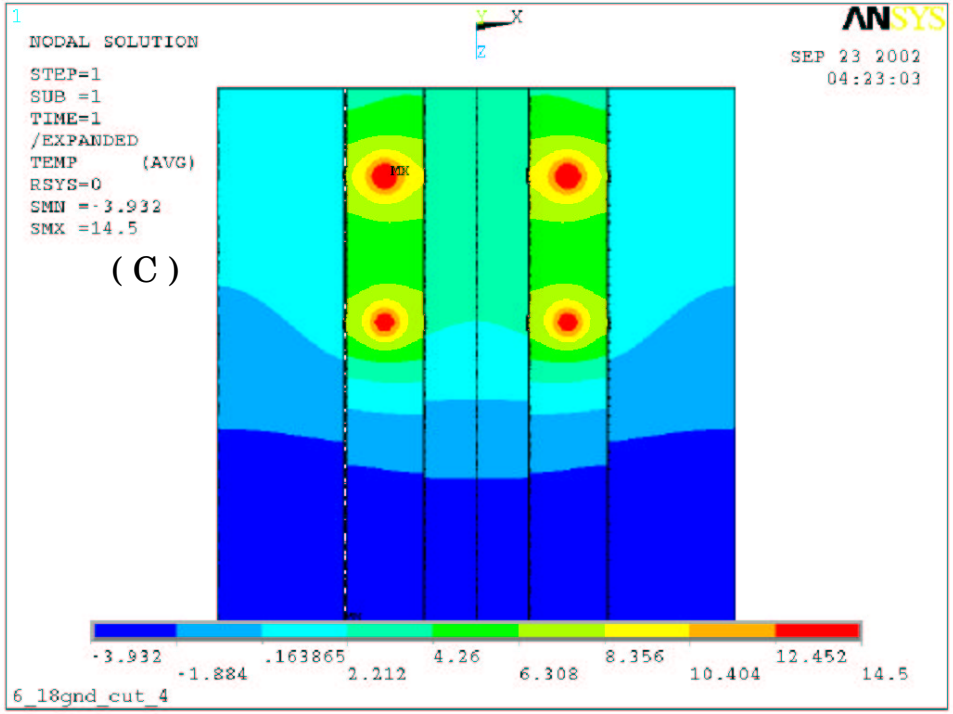
cf) no-cut :~17.76 C

Thermal distribution at the GNDs (for 6 vias MPC : a=0.65 mm)

up-side

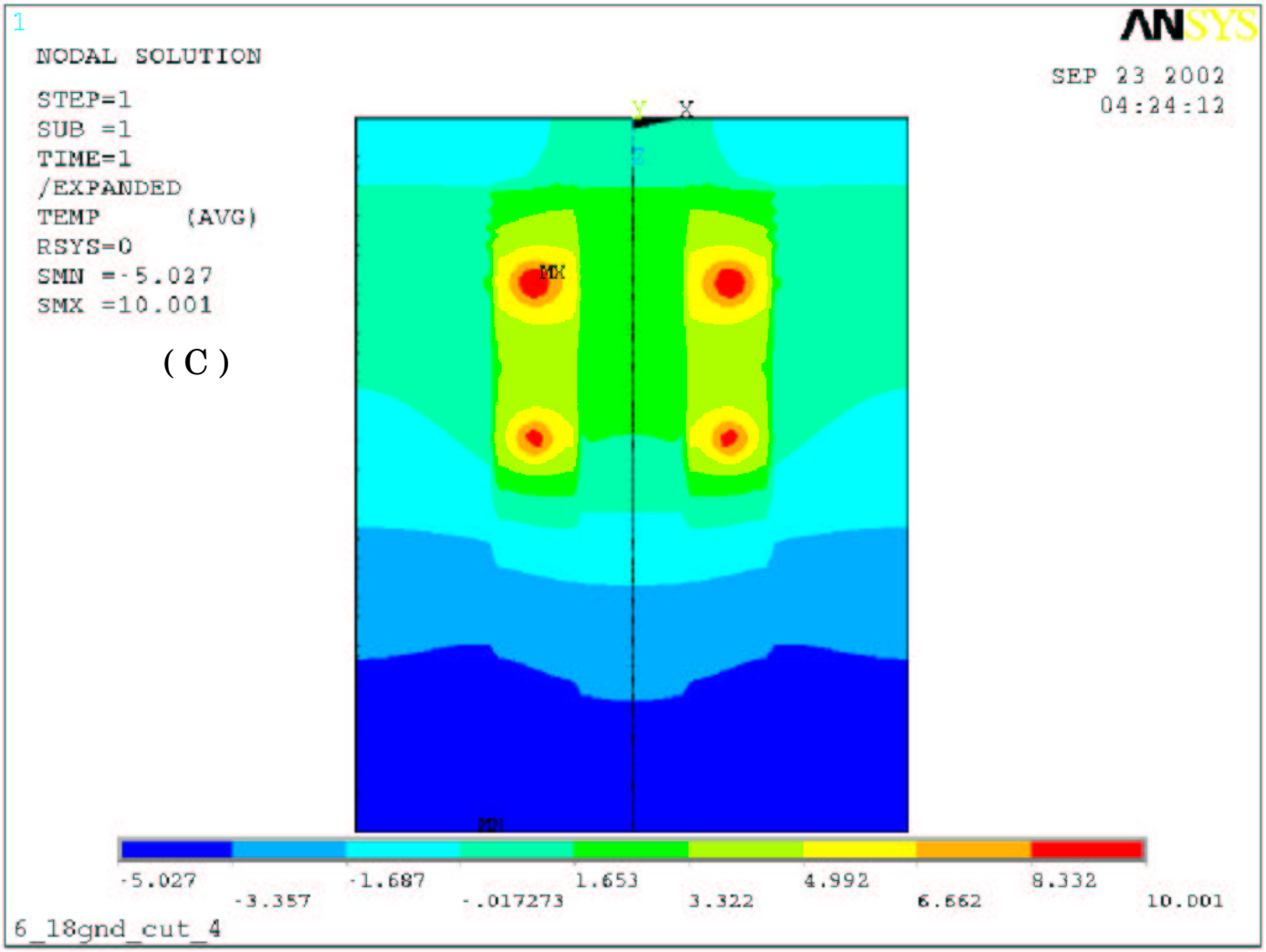


down-side

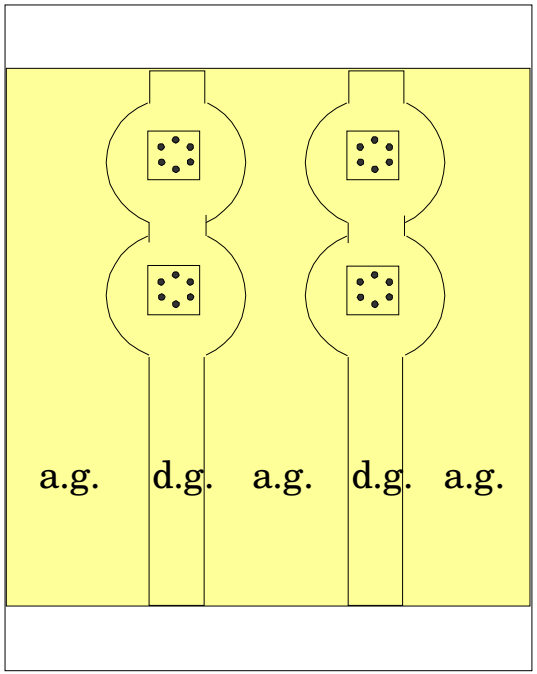


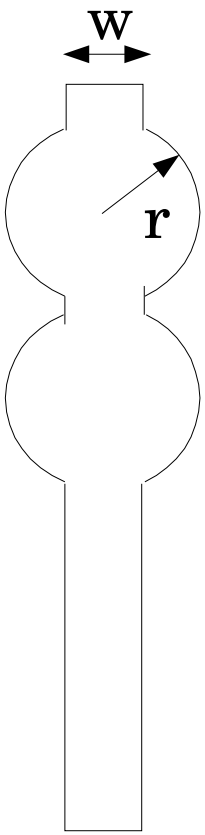
Thermal distribution at the glue layer

(for 6 vias MPC : a=0.65 mm)



Modifying the "down-side" GNDs. (for 6 vias MPC : a=0.65 mm)





Maximum temperature (C)

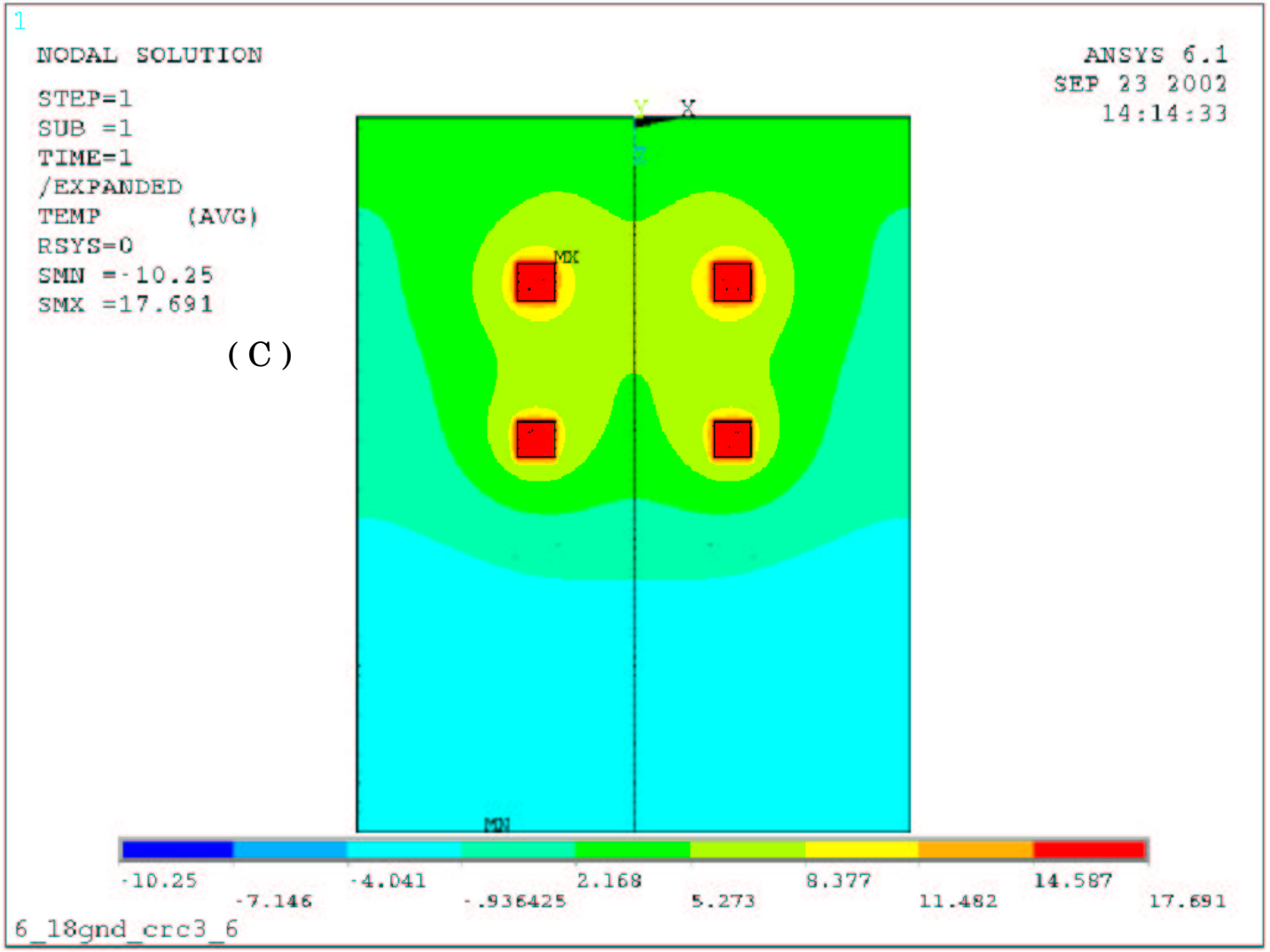
(mm)

w\r	3	4	5	6
3	19.23	18.57	18.07	17.69
4	19.00	18.40	18.02	17.71
5	18.71	18.32	18.01	17.71
6	18.37	18.23	17.96	17.71

cf) not modified : ~18.48 C

Thermal distribution

(for 6 vias MPC : a=0.65 mm : w\r = 3mm\6mm)

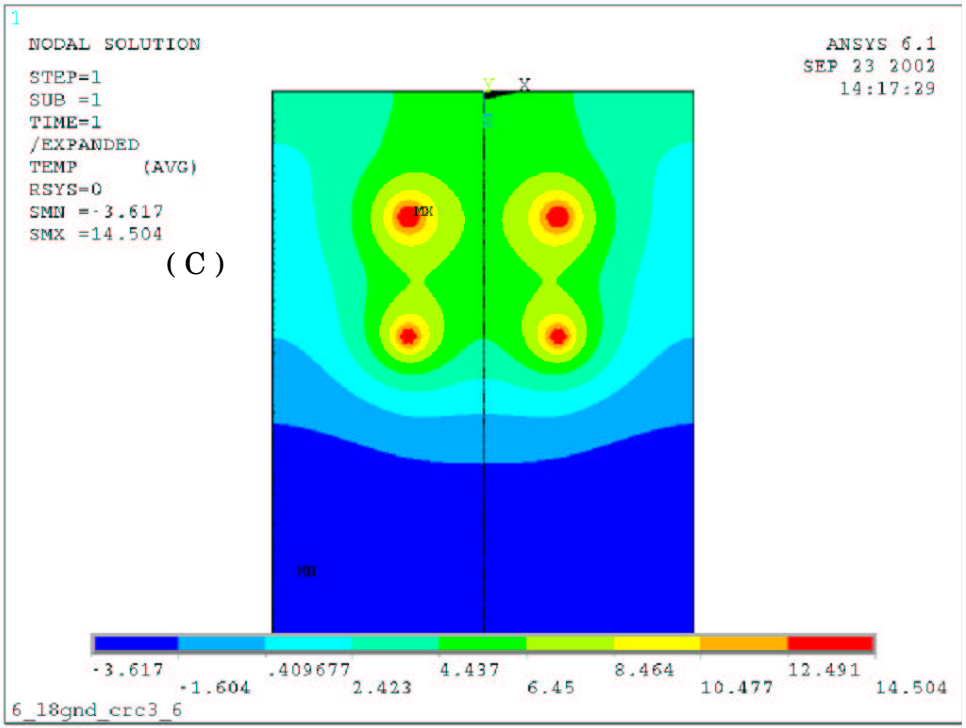


(C)

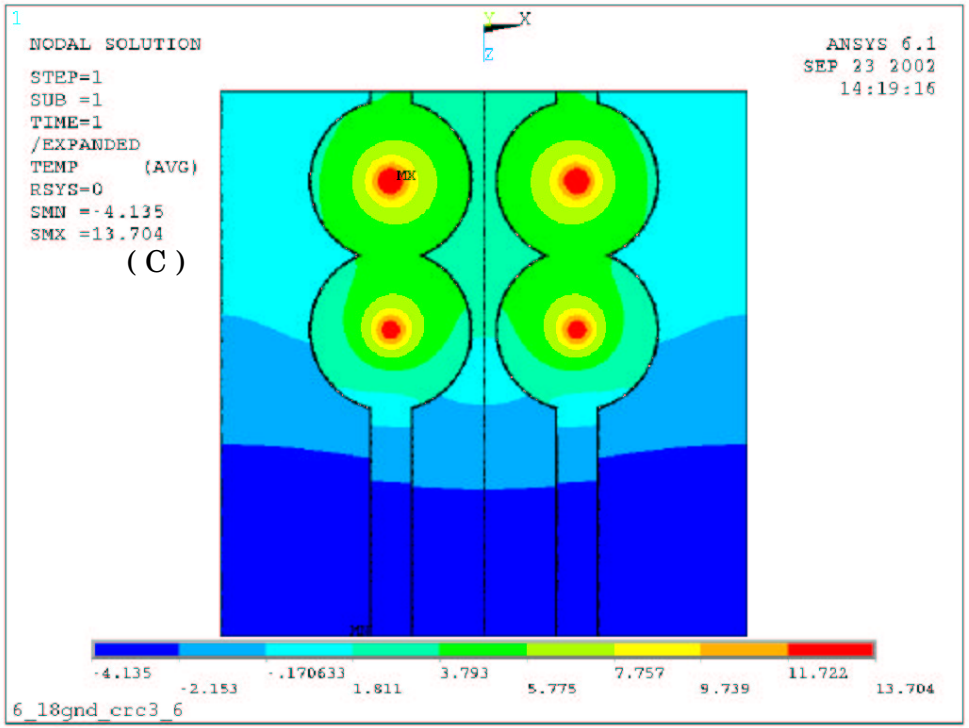
Thermal distribution at the GND layers

(for 6 vias MPC : a=0.65 mm : w\r = 3mm\6mm)

up-side

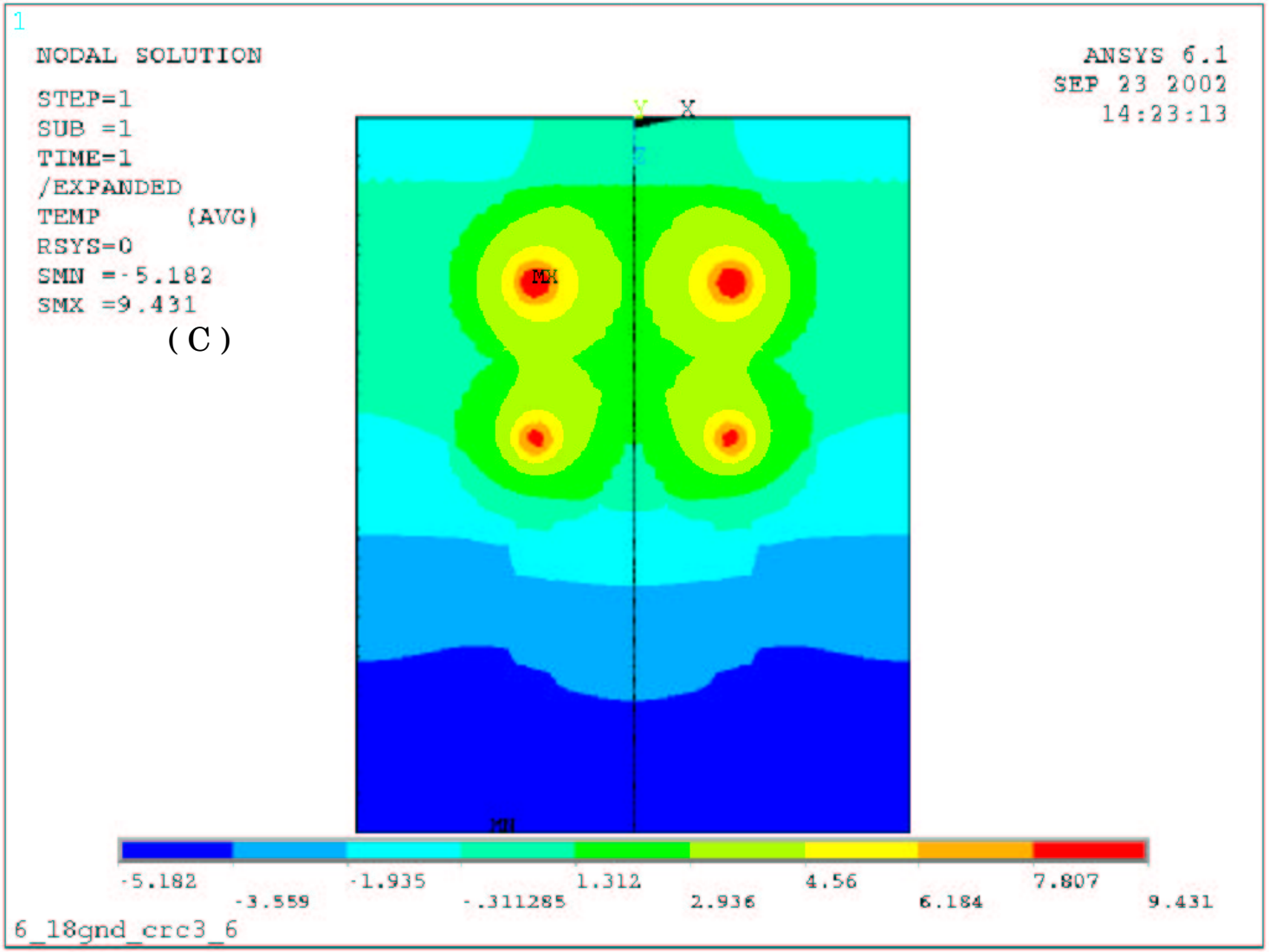


down-side



Thermal distribution at the glue layer

(for 6 vias MPC : a=0.65 mm : w\r = 3mm\6mm)



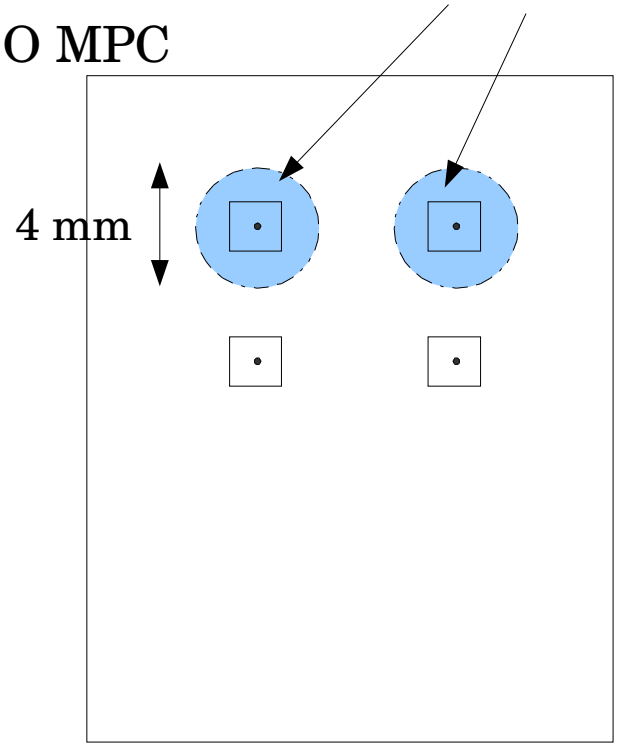
Air in the glue

for BeO and polyimide MPC(w/r=3/6)

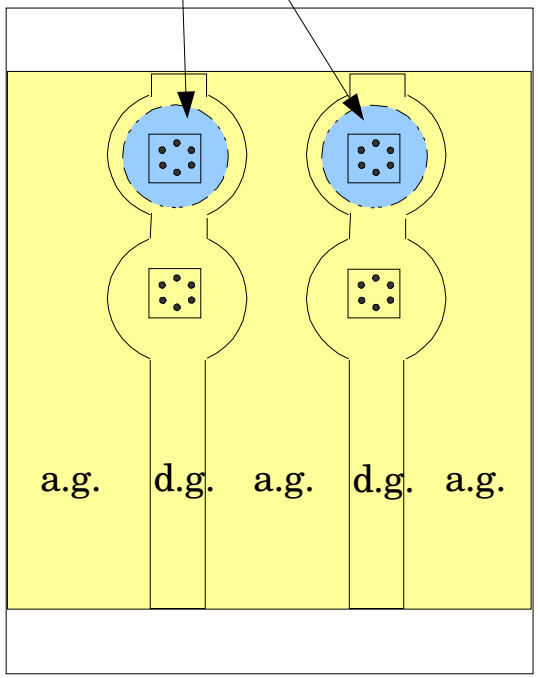
Remove the epoxy in this area and replace it with air

(k_{air} = 0.023 W/m-K)

BeO MPC



Polyimide MPC



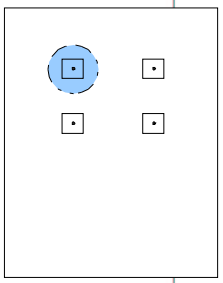
Result

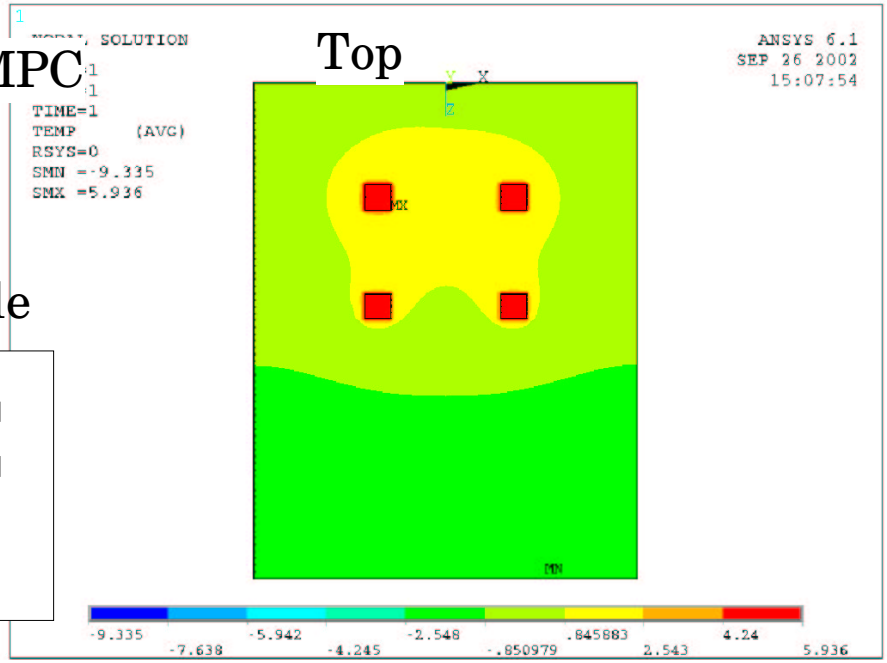
	BeO	Polyimide
normal	5.66	17.69
1 hole	5.94	19.71
2 holes	5.99	19.87

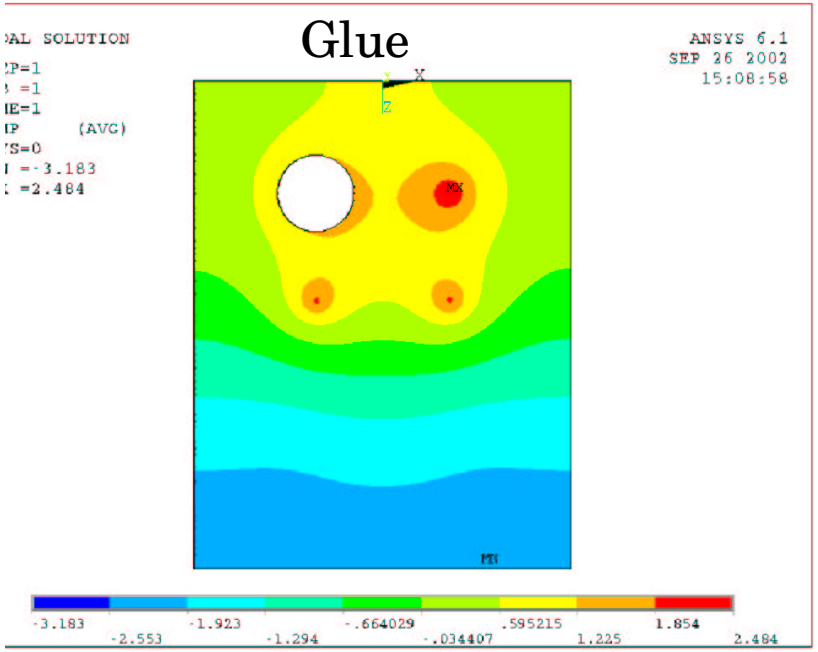
(C)

BeO MPC

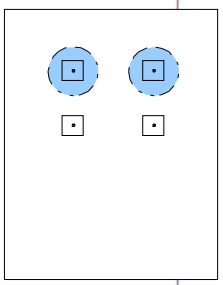
1 hole

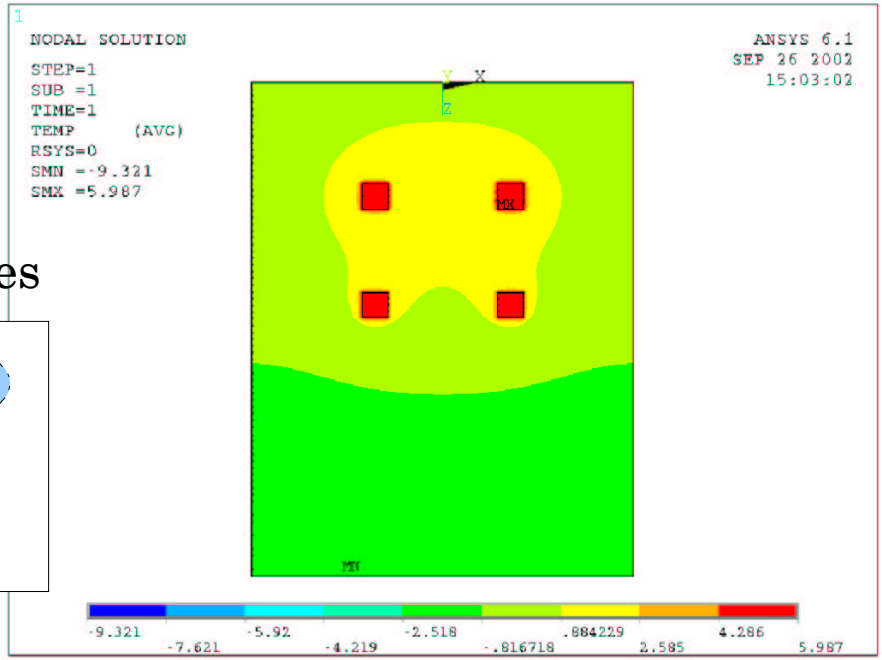


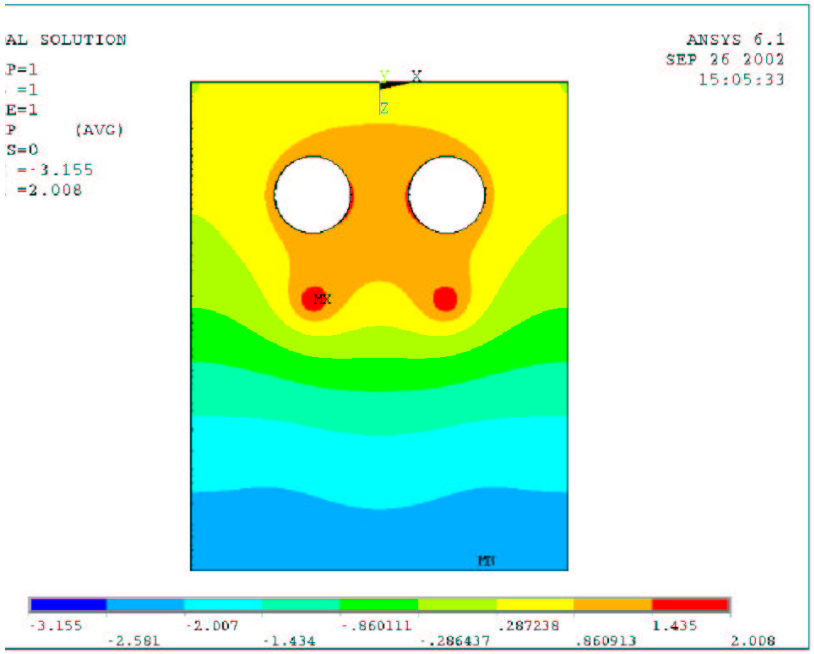




2 holes

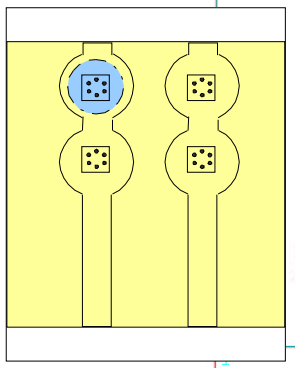




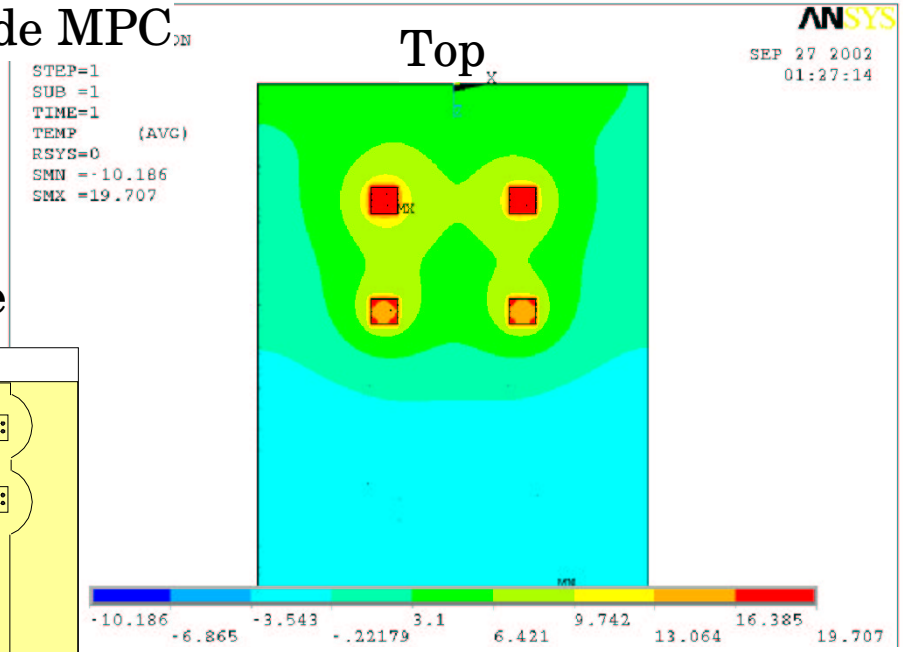


Polyimide MPC

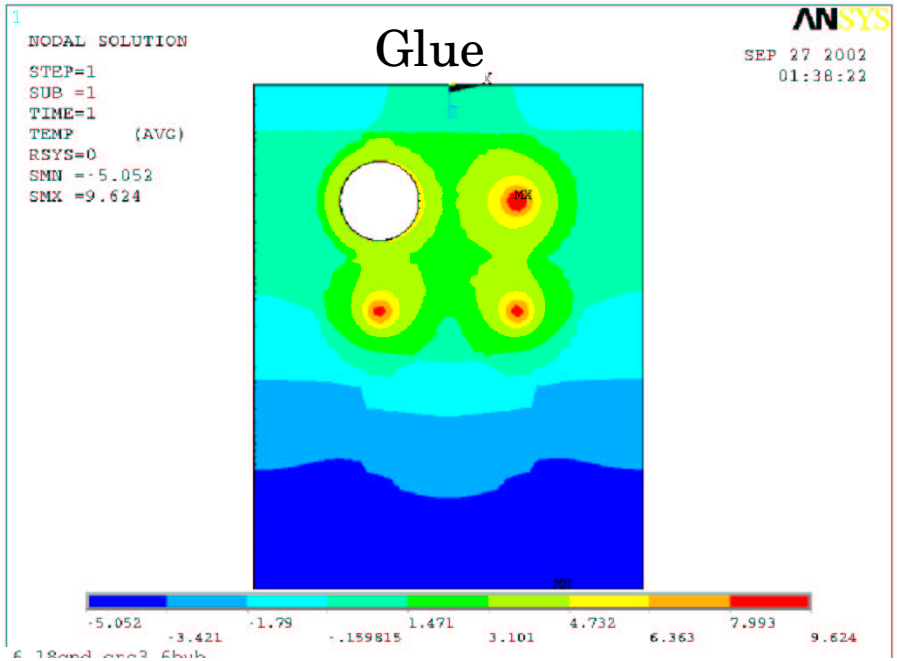
1 hole



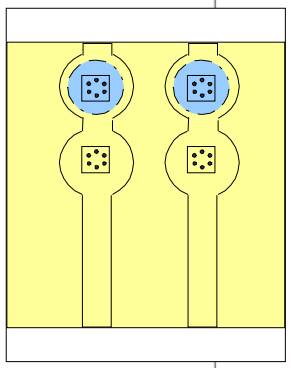
Top

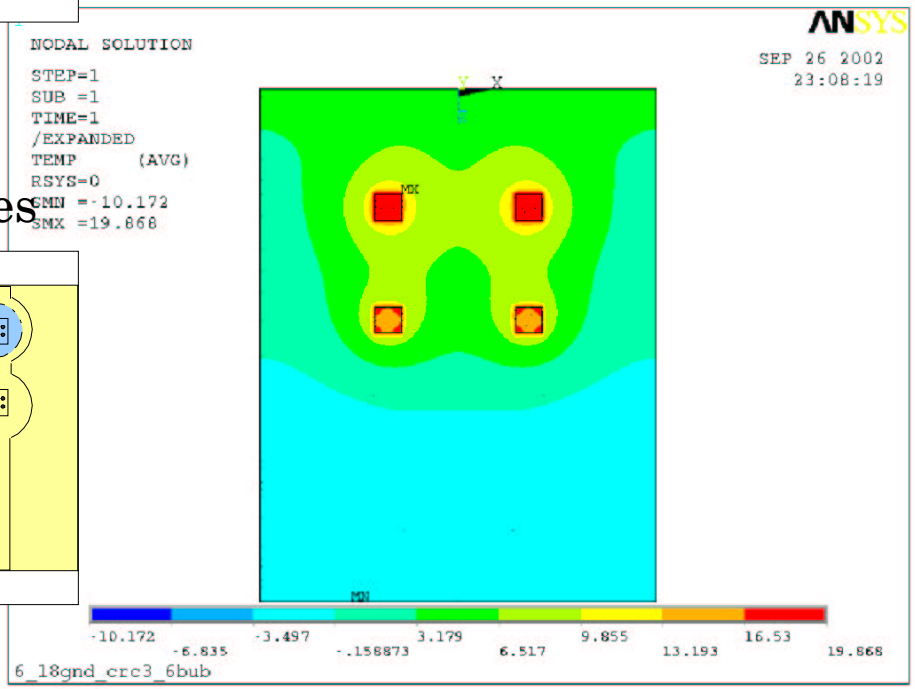


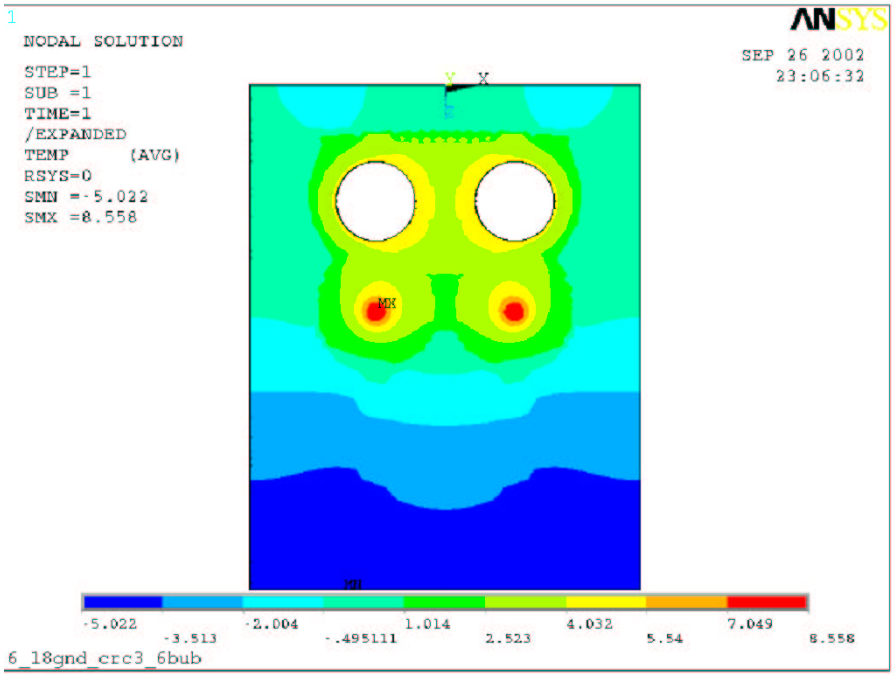
Glue



2 holes





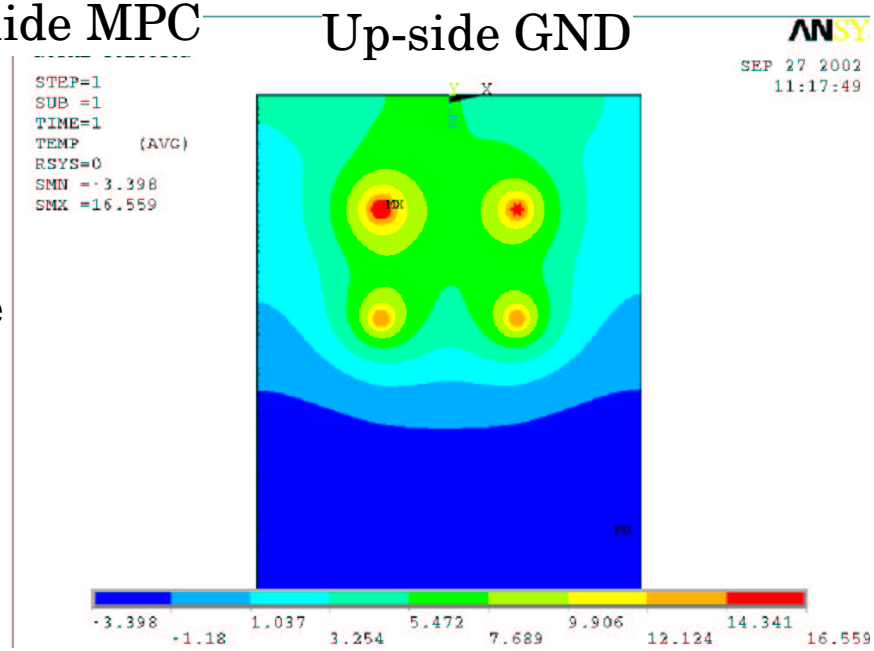


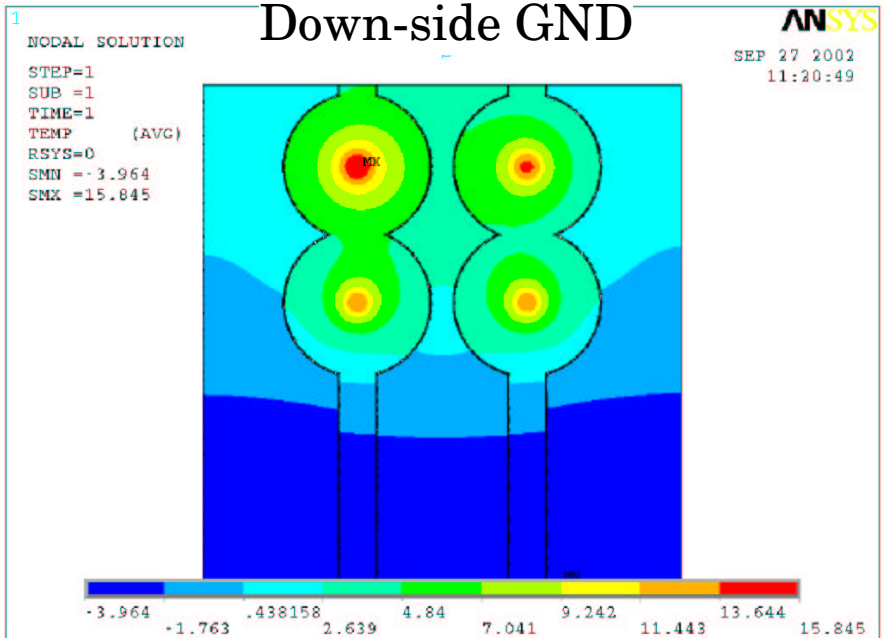
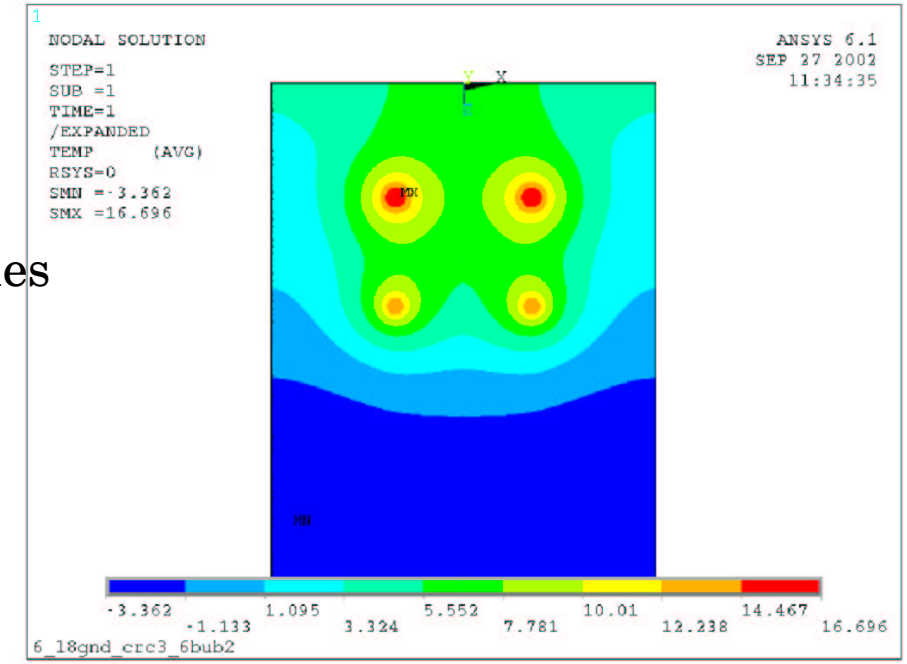
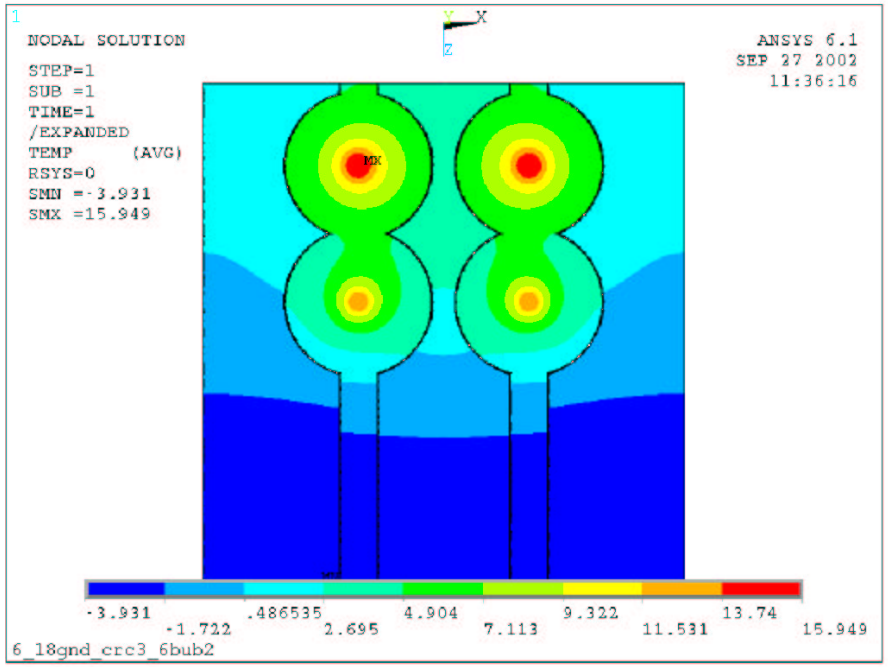
Polyimide MPC

Up-side GND

Down-side GND

1 hole





2 holes