

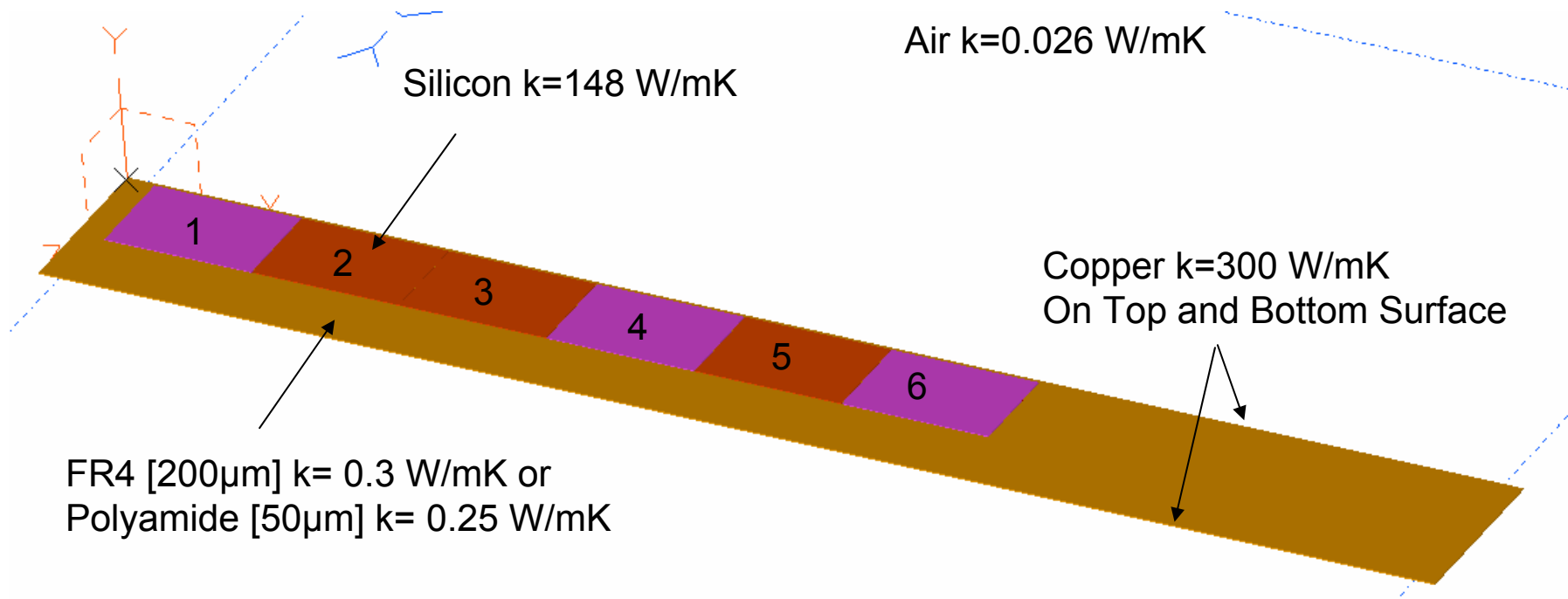
Plume



Thermal Simulation of a Flex+Sensor

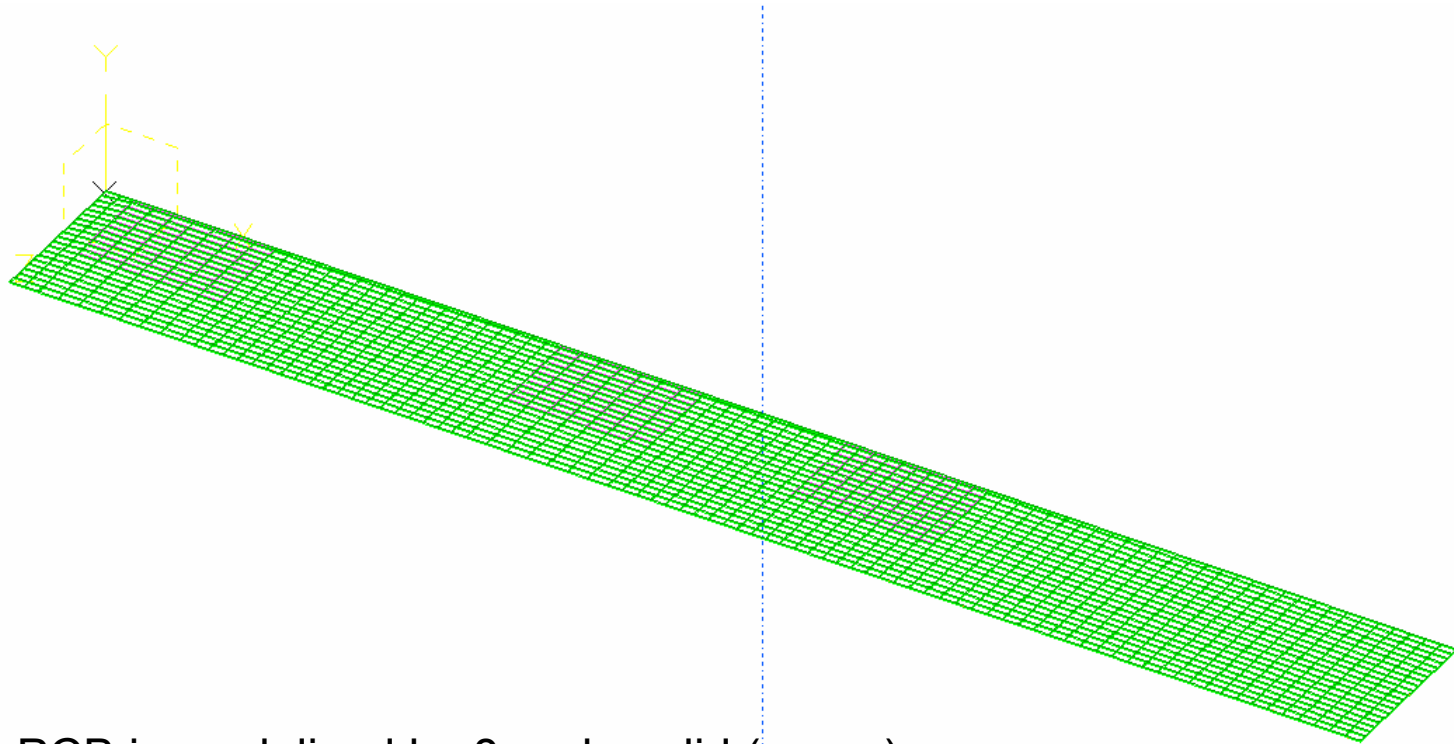
This paper summarize main simulations of the thermal behaviour of a module (flex+sensors).

Model of the PCB with the Sensors



- > A plate (flex) with the dimensions: 206 x 24.55 x 0.2 mm
- > On the plate: six sensors with the dimensions: 13.835 x 21.65 and a thickness of 0.12mm

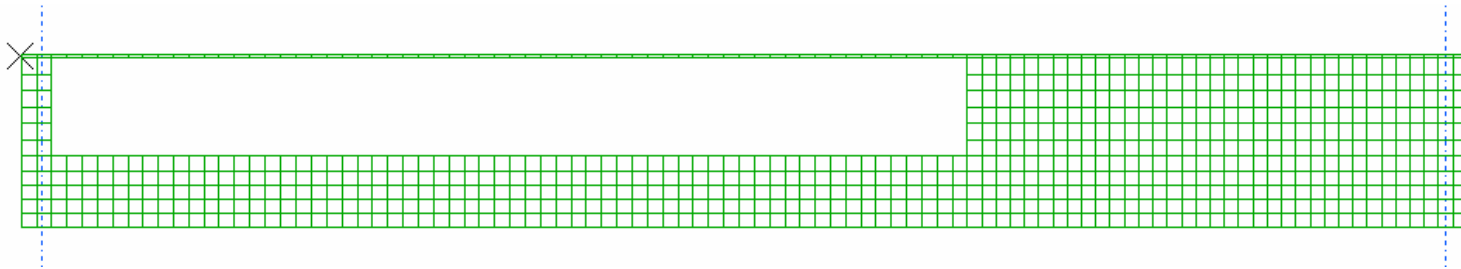
Meshing



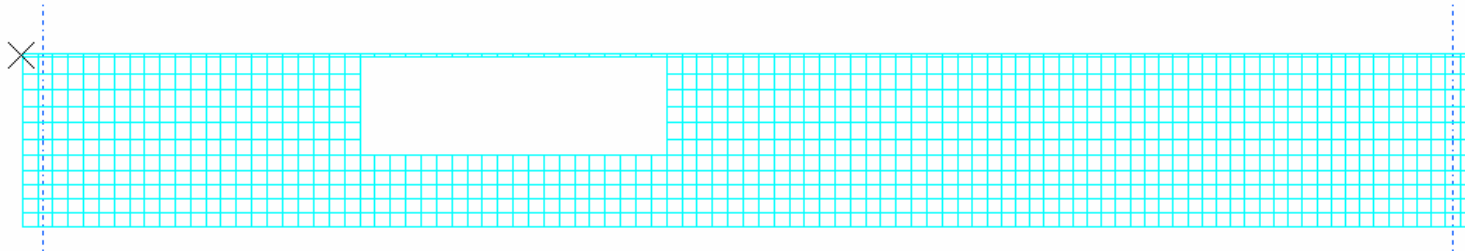
- > PCB is modelised by 8 node solid (green)
- > The sensors are modelised by 8 node solid (magenta)

Meshing Copper

- > Copper is modelised by 2D shell elements (dark green and cyan)



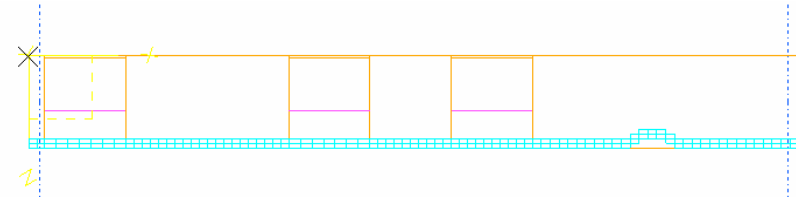
- > Copper on the top surface – $17\mu\text{m}$



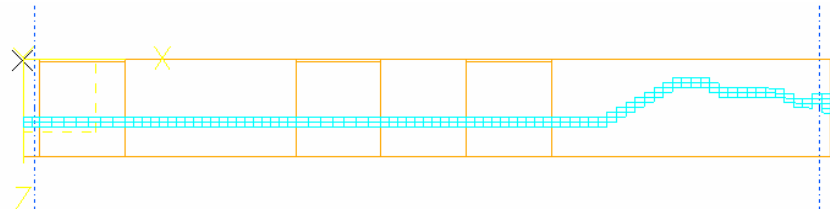
- > Copper on the bottom surface – $17\mu\text{m}$

Study Setup - Traces

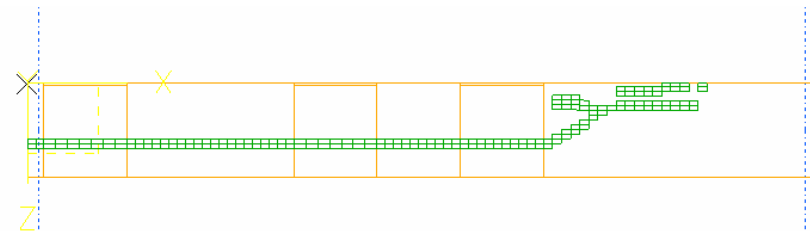
- > Analog Power Supply
 - 3.3V; 110mA
- > Analog Power Supply
 - 3.3V; 70 -110mA
- > The traces have no effect on the simulation



Digital power (bottom layer)



Analog power (bottom layer)

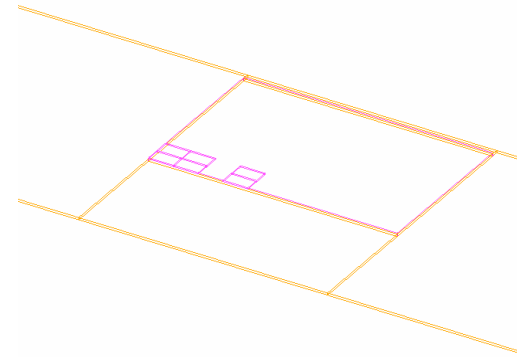


Ground trace on the top metal layer

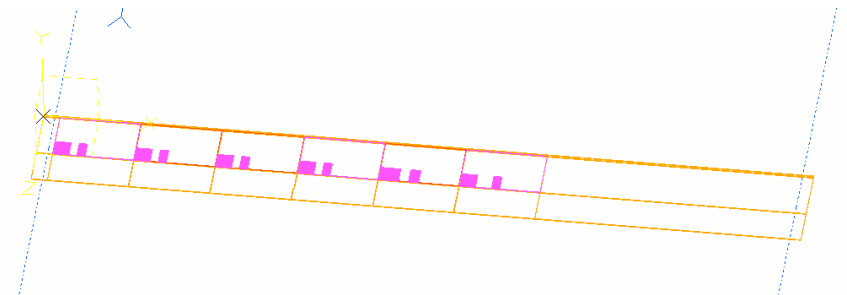
Study Setup...

- > Ambient Temperature
 - 20°C
- > Thermal B.C
 - Sensor Total Load = 730 mW
- > Free Convective Coupling
 - Free convection on top and side of the board
 - Multiplier: 4 – to fine tune the correlations based on measured results.

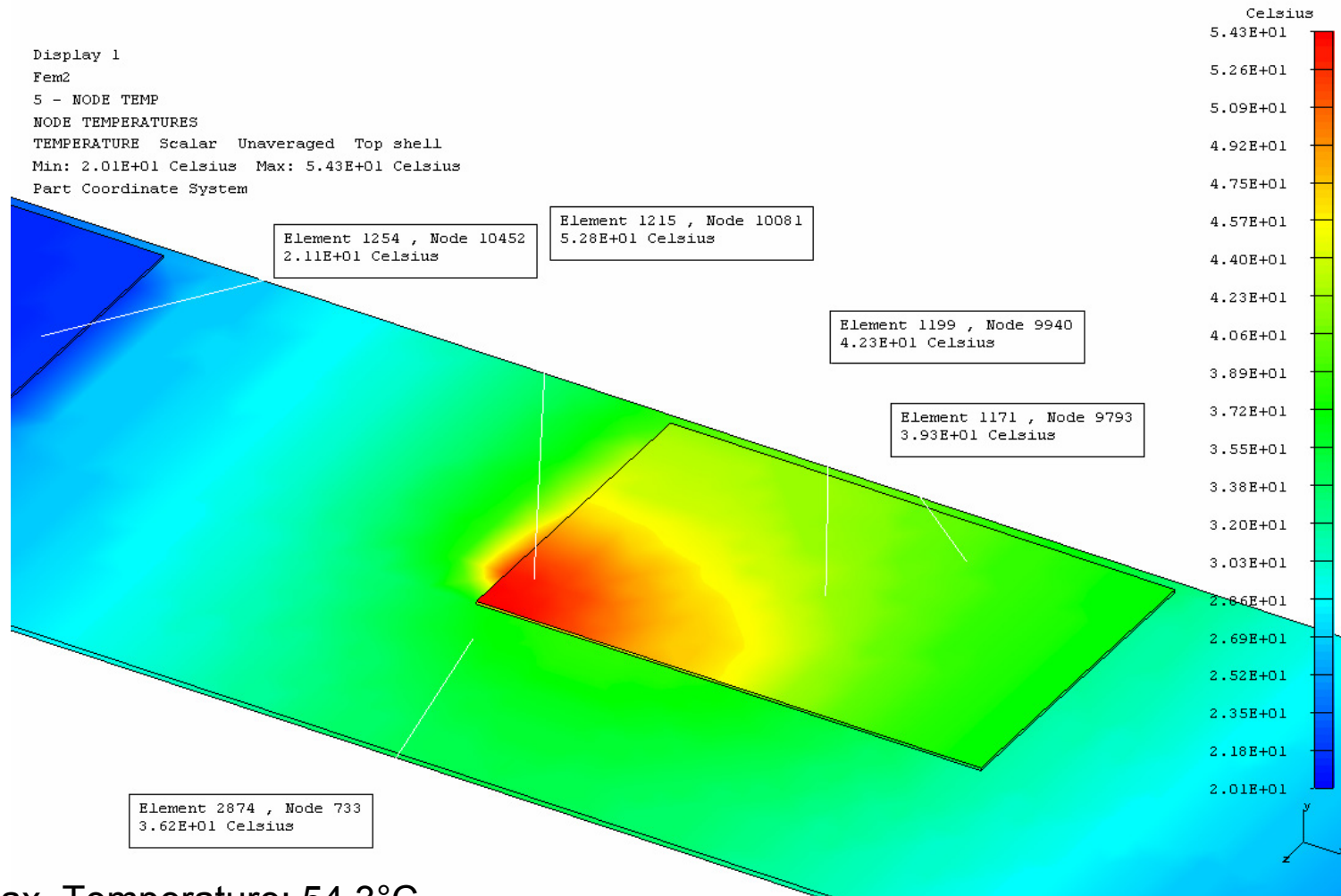
Single Sensor:



All Sensors:



Results: Only Sensor 6 operating



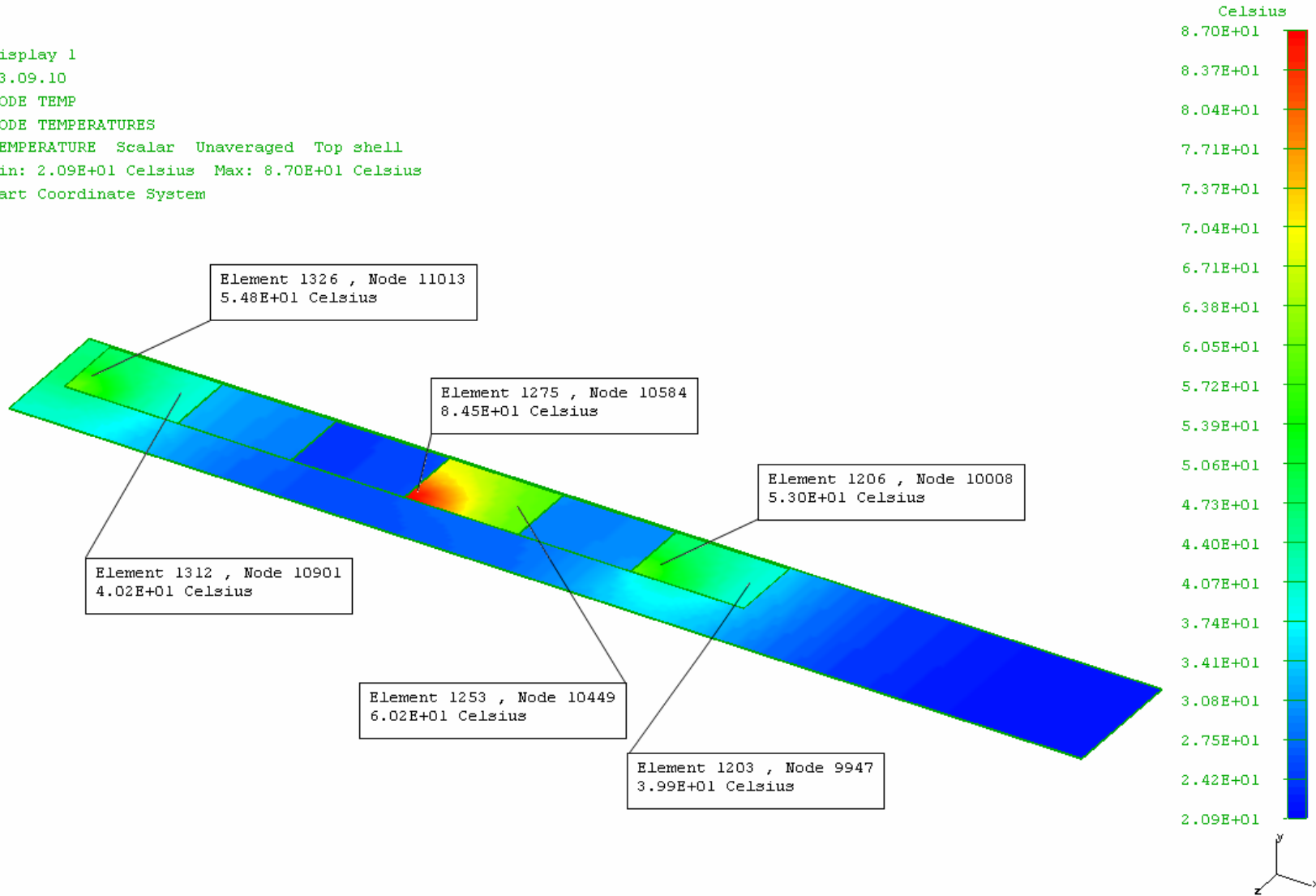
Max. Temperature: 54.3°C

Min. Temperature: 20.1°C

$\Delta T \sim 34K$

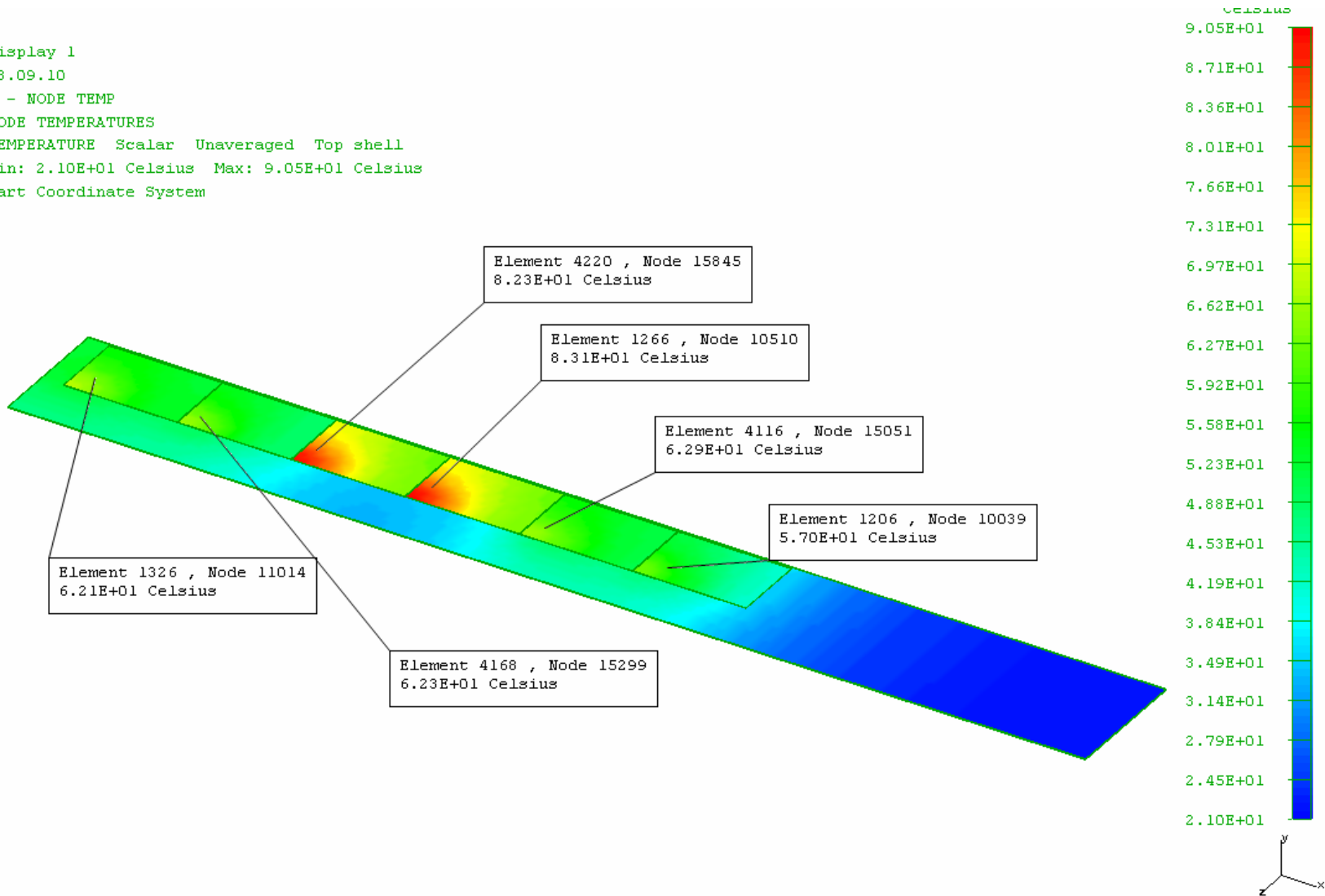
Results: 3 Sensor operating

Display 1
03.09.10
NODE TEMP
NODE TEMPERATURES
TEMPERATURE Scalar Unaveraged Top shell
Min: 2.09E+01 Celsius Max: 8.70E+01 Celsius
Part Coordinate System



Results: 6 Sensor operating

Display 1
03.09.10
3 - NODE TEMP
NODE TEMPERATURES
TEMPERATURE Scalar Unaveraged Top shell
Min: 2.10E+01 Celsius Max: 9.05E+01 Celsius
Part Coordinate System



Summarize

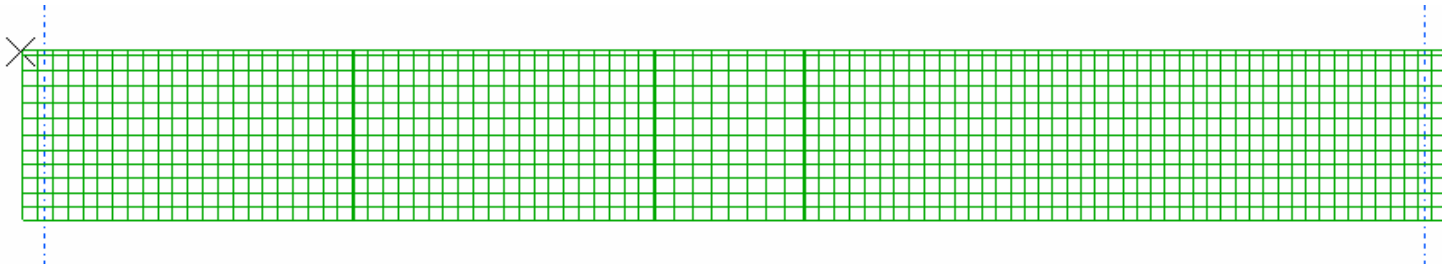
- > When 3 Sensors on, the Temperature rise to a maximum of 87°C
- > When all Sensors on, the Temperature rise to a maximum of 90.5°C
- > Sensor 3 and 4 are 20°C warmer (on the hottest point) compared to the other 4 sensors
 - Because of the missing copper on this position, the produced heat can't dissipate
(See page: 4)



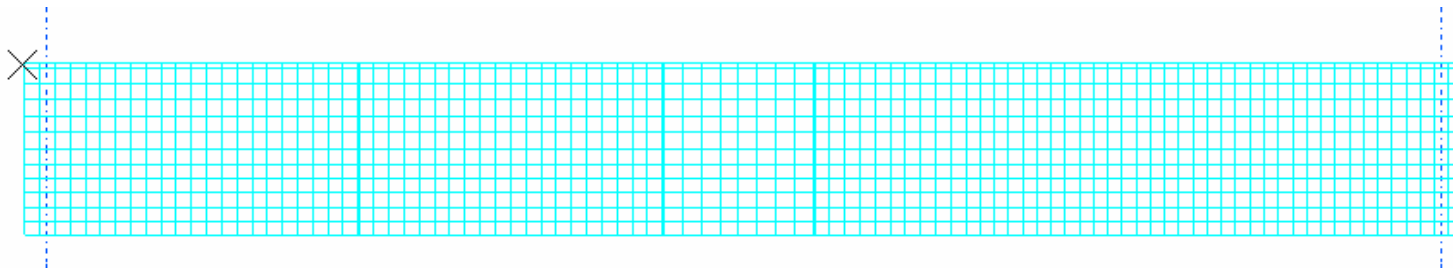
Influence of the copper on the flex

> To show the influence of the copper for the temperature- distribution the copper mesh is changed in the following way

> Copper is modelised by 2D shell elements (dark green and cyan)



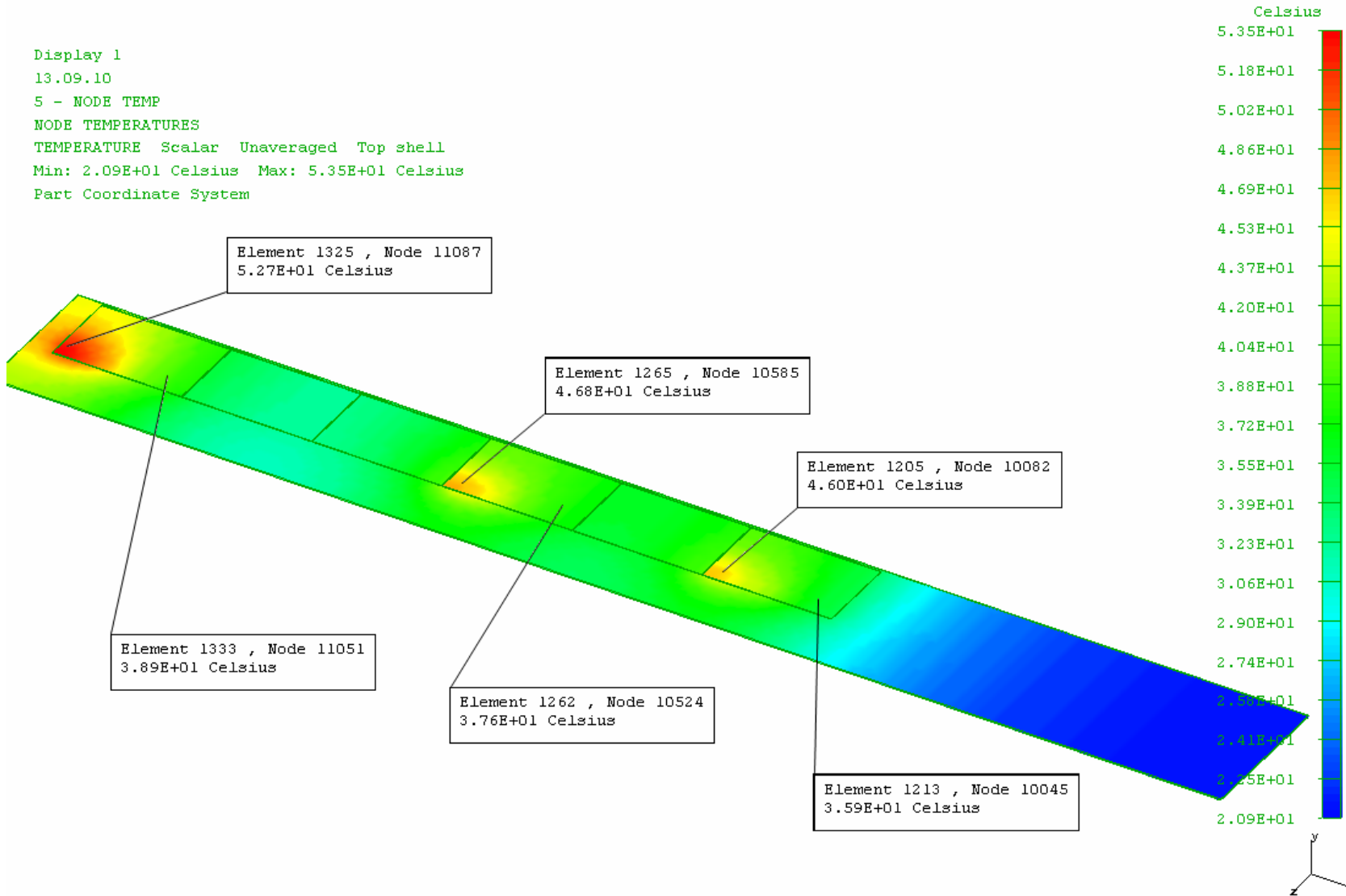
> Copper on the top surface – 17 μ m



> Copper on the bottom surface – 17 μ m

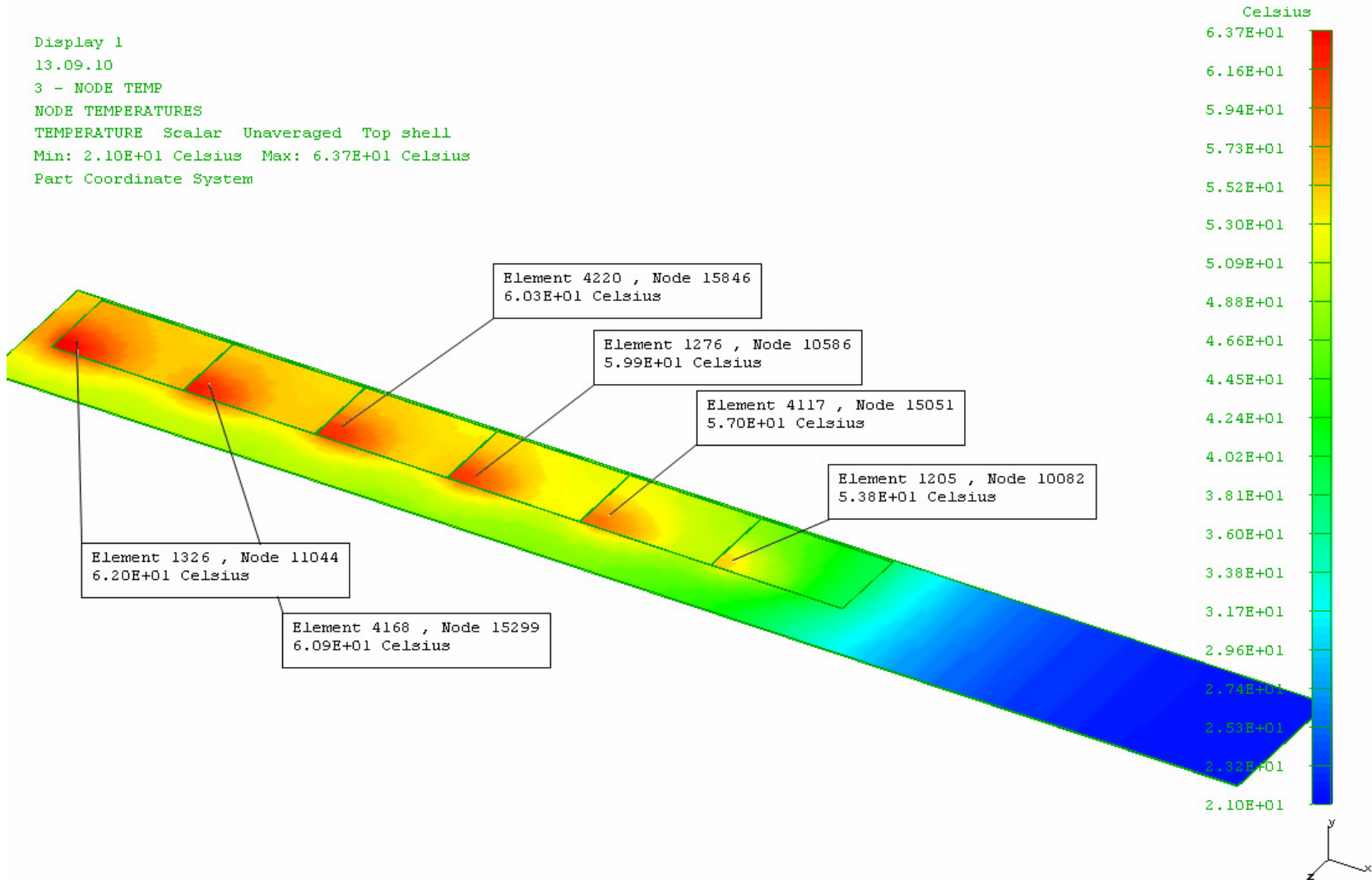
Results: 3 Sensor operating

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Display 1
13.09.10
5 - NODE TEMP
NODE TEMPERATURES
TEMPERATURE Scalar Unaveraged Top shell
Min: 2.09E+01 Celsius Max: 5.35E+01 Celsius
Part Coordinate System
```



Results: 6 Sensor operating

Display 1
13.09.10
3 - NODE TEMP
NODE TEMPERATURES
TEMPERATURE Scalar Unaveraged Top shell
Min: 2.10E+01 Celsius Max: 6.37E+01 Celsius
Part Coordinate System



Summarize (Flex with no missing copper)

- > When 3 Sensors on, the Temperature rise to a maximum of 53.5°C
- > When all Sensors on, the Temperature rise to a maximum of 63.7°C
- > The temperature difference of Sensor 6:

Operating Sensors	Temperature in °C	Temperature in °C Copper on the whole surface
6	54.3	46
1,4,6	55	53.8
1-6	57	53.8

- > When copper would be on the whole surface the maximum temperature of sensor 3 and 4 would sink to 60°C (from 83°C)



FR4 vs. Polyamide

Sensor	Maximum Temperature on Sensor in °C	
	FR 4	Polyamide
Sensor 6	54.3	54.9
Sensor 1	59.8	55.2
Sensor 4	87	90.2
Sensor 6	58.7	55.1
Sensor 1	67.7	63
Sensor 2	65.7	60
Sensor 3	90	91
Sensor 4	90	91
Sensor 5	65.8	60.8
Sensor 6	63.2	60

There is not much different in using a 200µm board with FR 4 or a 50µm board with Polyamide



Results: Different thickness of Copper

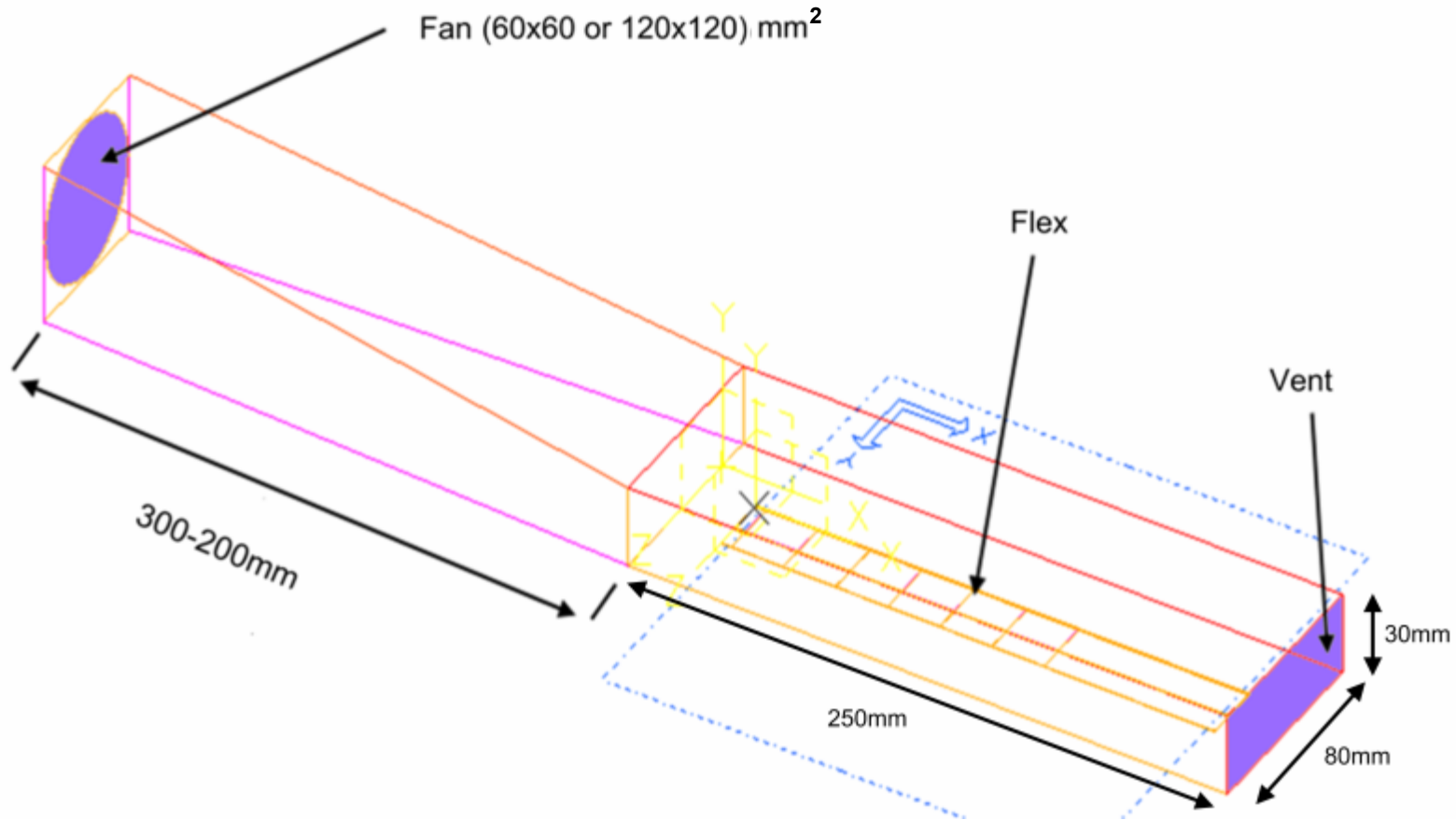
Thickness of Copper	Sensor	Maximum Temperature in °C	
		FR 4	Polyamide
5 μm	6	69.3	68
	1,4,6	87.1	90.2
	all	90.6	91
10 μm	6	63.1	60.6
	1,4,6	87	90
	all	90.5	91
17 μm	6	54.3	54.9
	1,4,6	87	90.2
	all	90.5	91

For one sensor (Sensor 6) operating, the temperature rises with a thinner copper layer. For three (Sensor 1,4 and 6) and six sensors operating, there is no difference in temperature for the different copper layers.

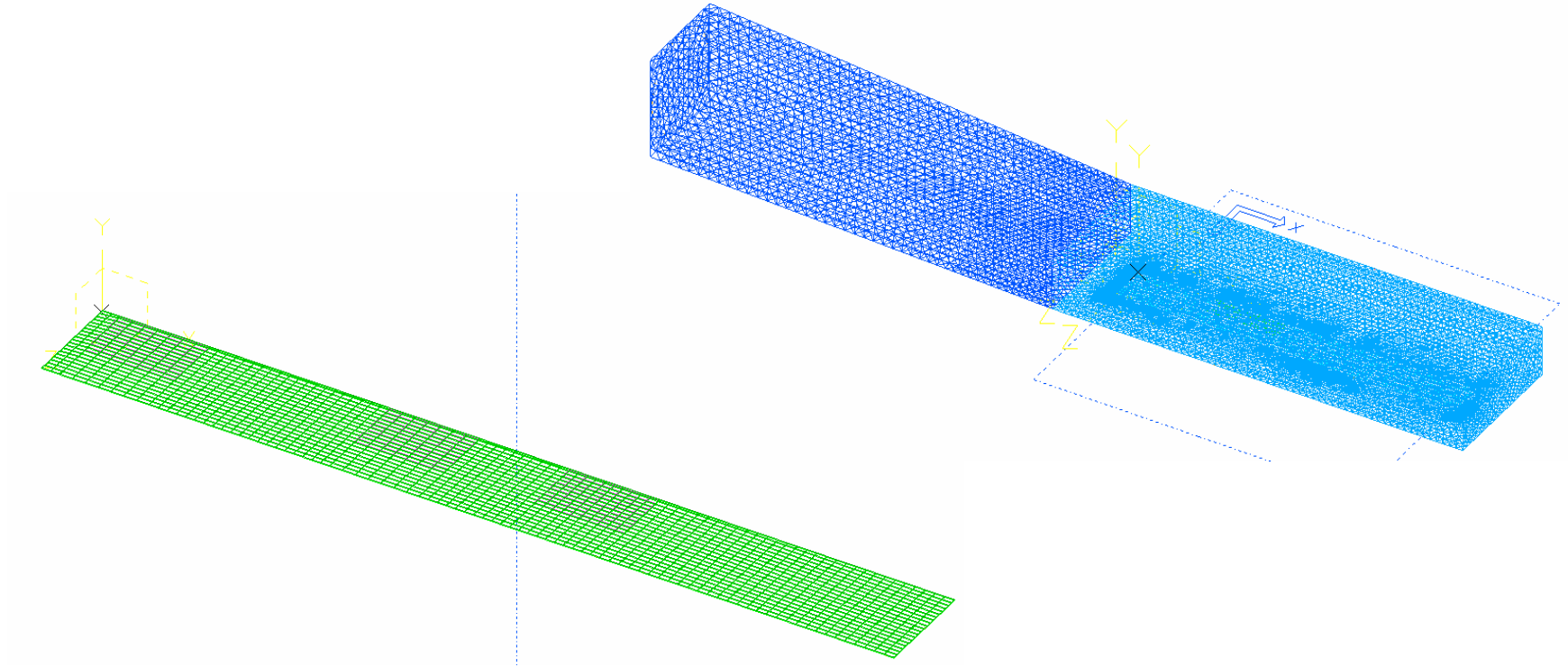


The flex inside the box

- The next part summarize the first simulation steps of the thermal behaviour of the flex+sensor placed in a box and cooled with a fan



Meshing

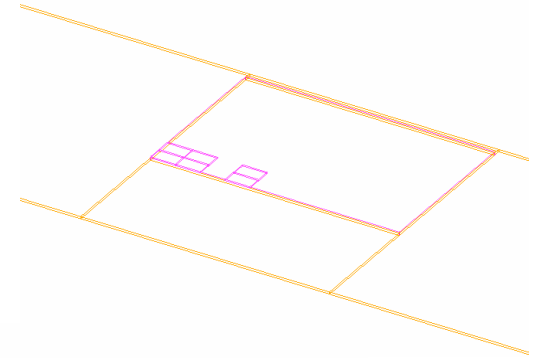


- PCB is modelised by 8 node solid (green)
- The sensors are modelised by 8 node solid (magenta)
- The air is modelised by 6 node solid parabolic tetrahedron (ligh/gray blue)

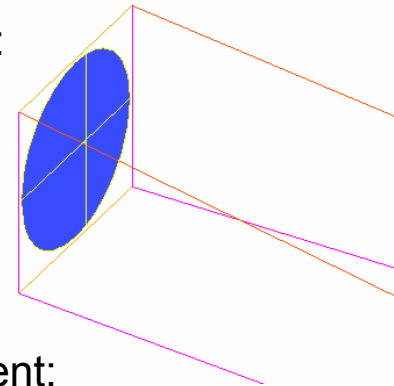
Study Setup...

- Ambient Temperature
 - 20°C
- Thermal B.C
 - Sensor 6
 - Total Load = 730 mW
- Free Convective Coupling
 - Free convection on the top of the board
 - Multiplier: 4
- Fan
 - Velocity 1m/s (changeable)
- Vent
 - Vent to ambient

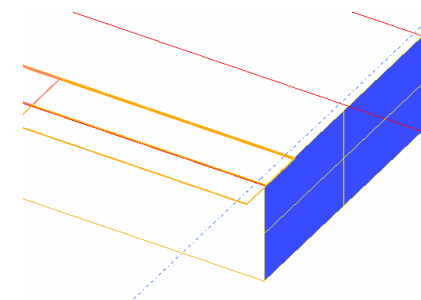
Sensor 6:



Fan:

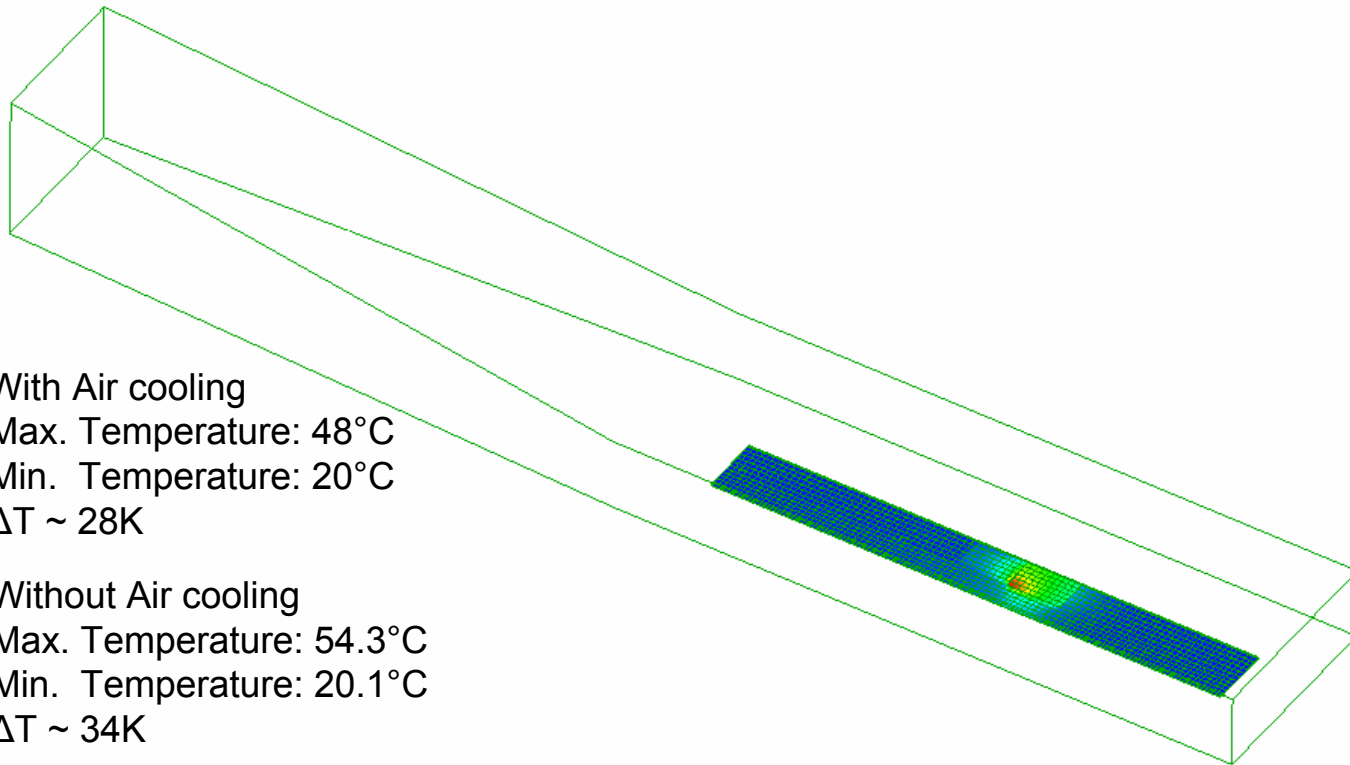


Vent:



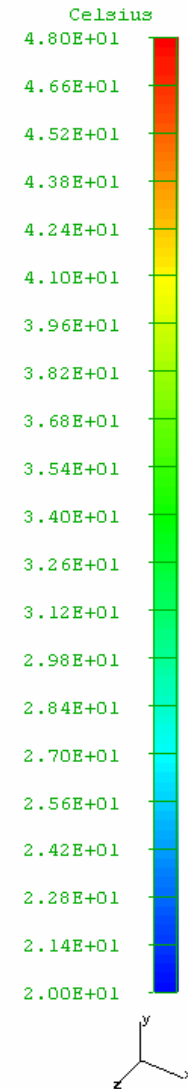
Result with air-volume and a Fan of (60x60)mm²

```
Display 1
COPY_OF_Fem1
SOLID-TEMP ON NODES
SOLID-TEMP / ON NODES
TEMPERATURE Scalar Unaveraged Top shell
Min: 2.00E+01 Celsius Max: 4.80E+01 Celsius
Part Coordinate System
```



With Air cooling
Max. Temperature: 48°C
Min. Temperature: 20°C
 $\Delta T \sim 28K$

Without Air cooling
Max. Temperature: 54.3°C
Min. Temperature: 20.1°C
 $\Delta T \sim 34K$



Conclusion

Velocity in m/s	Distance of the fan (60x60): 200mm Maximum Temperature in °C	Distance of the fan (60x60): 250mm Maximum Temperature in °C
0.5	48.4	48.4
1	48	48
2	47.6	47.6

There is no effect when the distance of the fan to the flex is changed.

Velocity in m/s	(60x60)mm ² Maximum Temperature in °C	(120x120)mm ² Maximum Temperature in °C
0.5	48.4	47.6
1	48	47.3
2	47.6	47

There is not much temperature-difference between the smaller and bigger fan – The different is ~ 1°C.

