2019 | MSC 台灣用戶大會
CAE模擬推動智能革新

台灣・台北　10月4日

HEXAGON | MSC Software

# CFD simulation for Reflow Soldering Process and Clean room Environment

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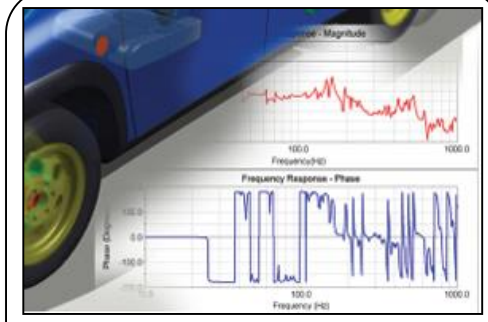
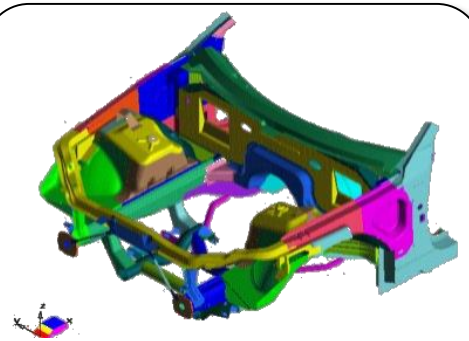
Group Leader Engineering Service Gr.4

Jun Eto

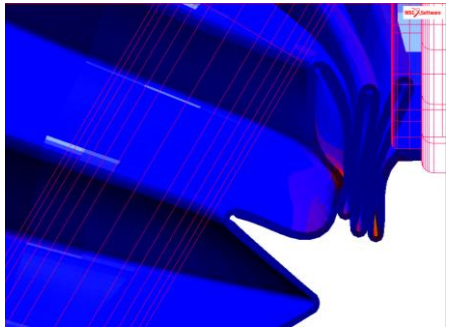
# Software Portfolio of MSC Software



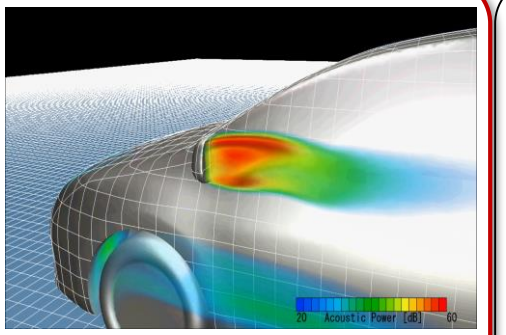
**MBS : Adams**



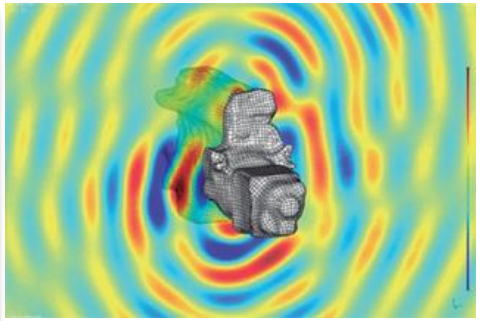
Strength, NVH, Fatigue & etc.
**MSC Nastran**



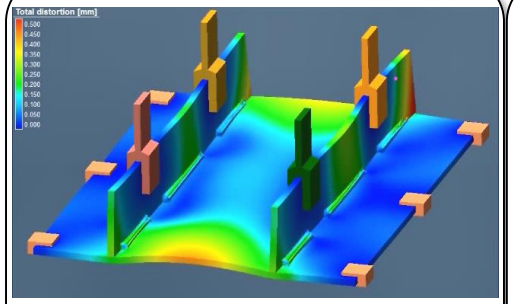
Highly Nonlinear Structural FEA
**Marc**



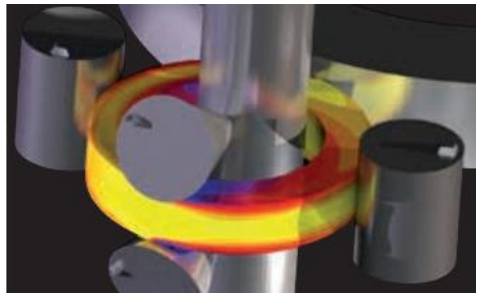
**CFD : scFLOW,scSTREAM**



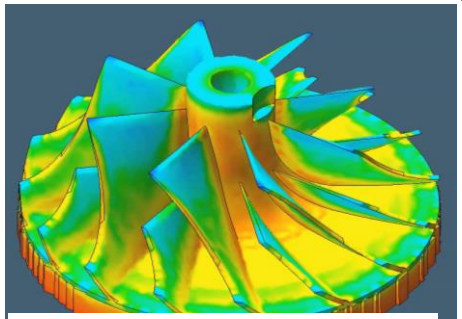
**Acoustic : Actran**



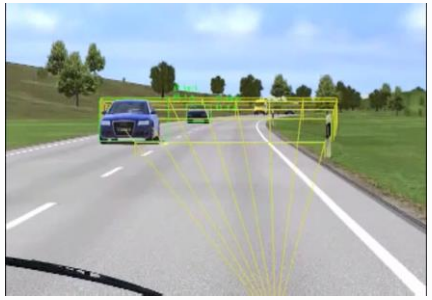
Welding Simulation
**Simufact Welding**



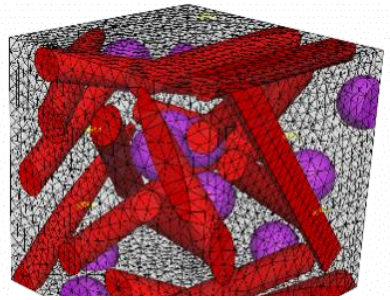
Forming Simulation
**Simufact Forming**



Additive Manufacturing
**Simufact Additive**



Virtual Environment
**VIRES VTD**

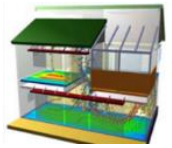


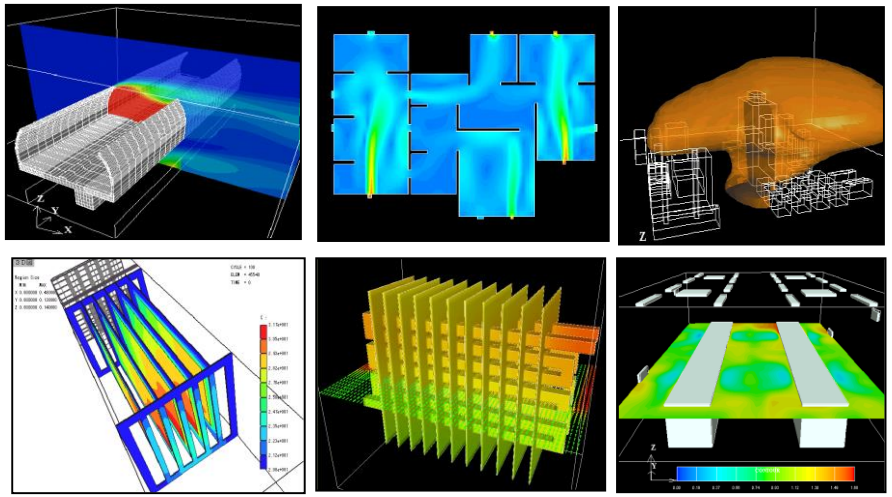
Composite material
**Digimat**

# scSTREAM

Thermofluid Analysis System
with Structured Mesh Generator

**scSTREAM**



Application Fields

- Construction and civil engineering
- City environment
- Chemical Reaction

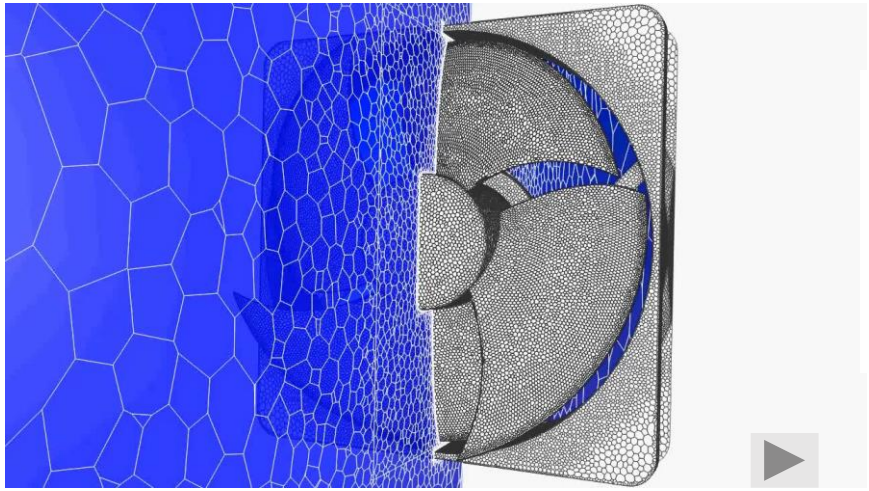
- ✓ Robust solver and simplification of geometry enable steady and hi-speed computation

- ☐ Heat radiation / Solar radiation
- ☐ Fan model / Air-Conditioning model
- ☐ Multi-fluid flow / Free surface flow
- ☐ Humidity / Condensation, Solidification / Melting
- ☐ Diffusion / Chemical reaction / Combustion
- ☐ Non-Newtonian fluid (shear heating considered)
- ☐ Porous media, Heat conduction panel

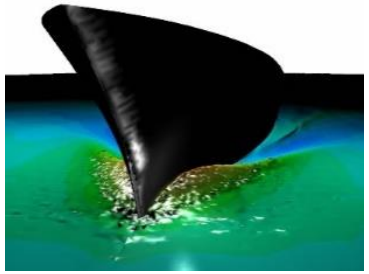
# scFLOW

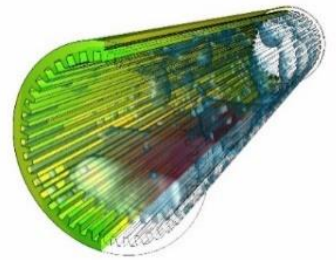
Unstructured mesh

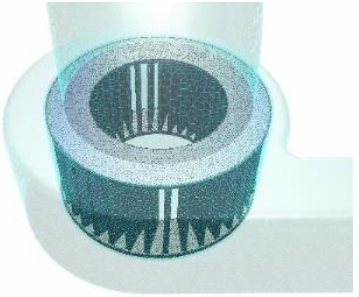
**scFLOW**

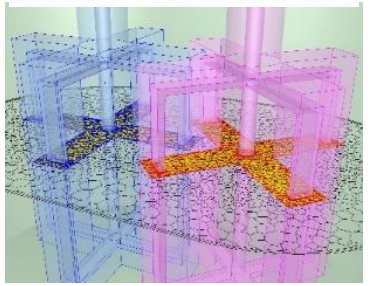


Click on figure









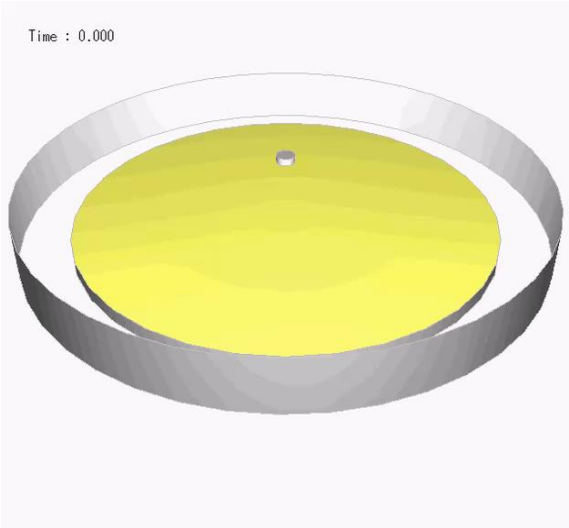
- ✓ Robust auto-mesh generator enables capturing complex geometry
- ✓ Best-in-class computation speed, complex modeling and high-quality meshing

Application Fields

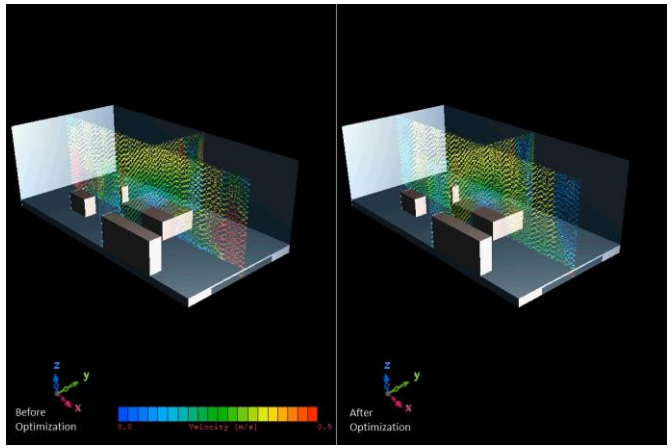
- Automotive
- Mechanical and Heavy Manufacturing
- Electrical and Electronics
- Chemical Reaction

- ☐ Polyhedral mesher
- ☐ Moving elements (discontinuous mesh)
- ☐ Oversetmesh
- ☐ Free surface
- ☐ Phase change

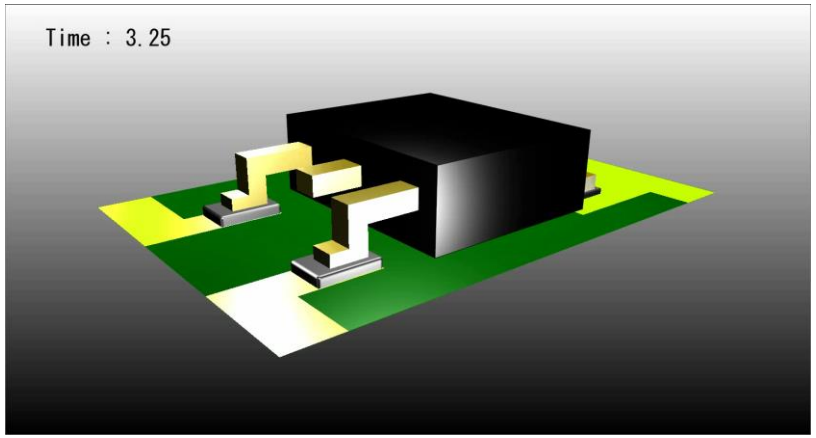
# Use cases for semiconductor manufacturing and mounting process



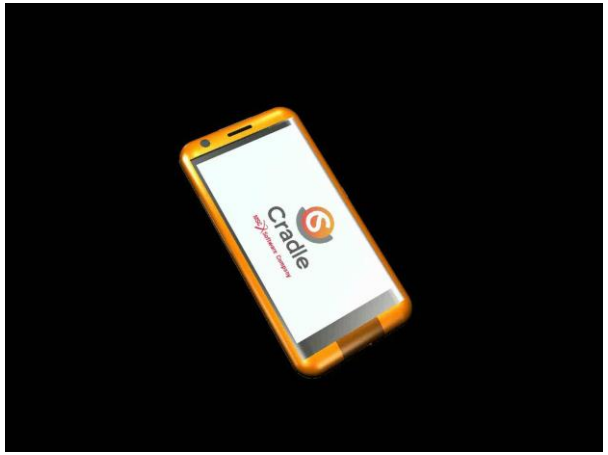

Single wafer cleaning




Clean room




Soldering

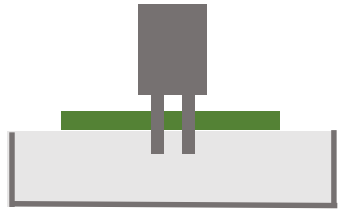



Thermal design

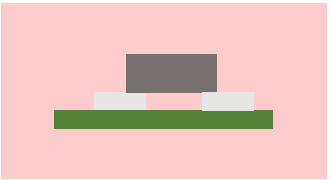
# Soldering process

- Process of connecting components terminal and PCB wiring with solder

- Flow(Wave) soldering
  - Dipping PCB in the bath of solder
  - Used for THD(Through hole device)
    - Ex. DIP,SIP packages

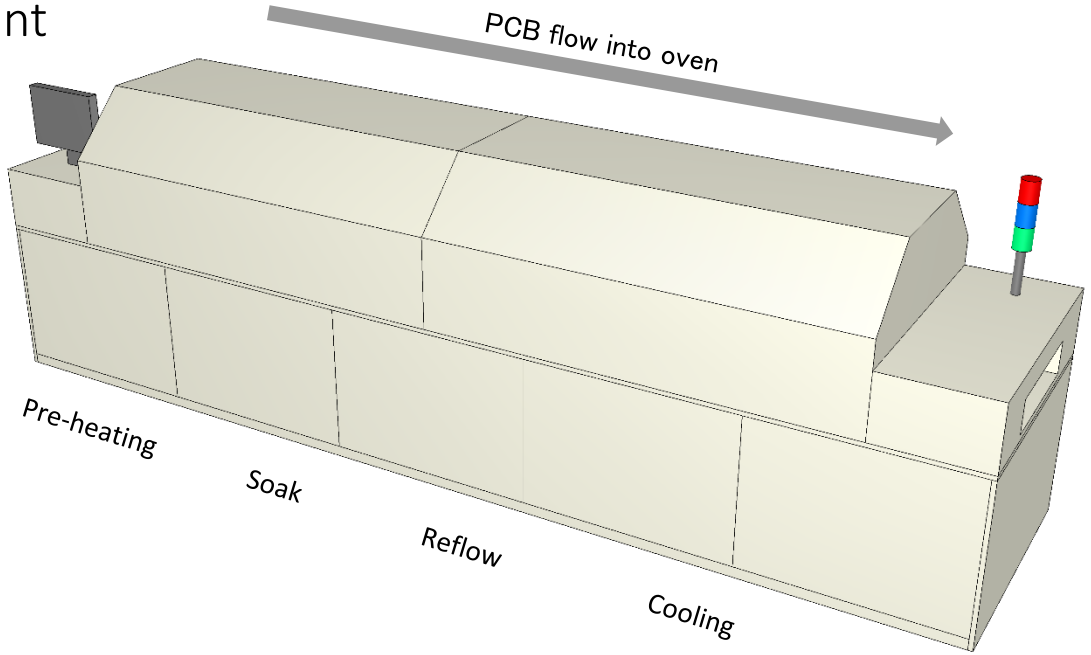


- Reflow soldering
  - PCB is heated in a reflow oven.
  - Used for SMD(Surface mounted device)
    - Ex. BGA packages
  - Dominant technology because suitable for automation



# Reflow soldering

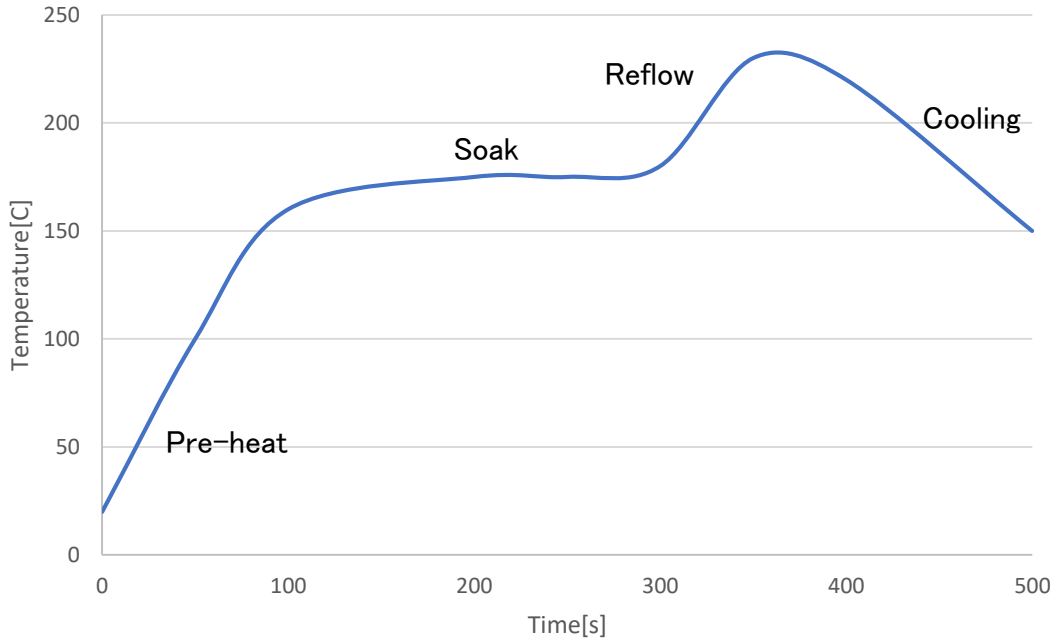
- Reflow process
  - Pre-heating
    - PCB temperature is raised
  - Soak
    - Temperature below melting point
  - Reflow
    - Solder paste melts
  - Cooling
    - Solder solidifies



# Design requirement and challenge of reflow profile

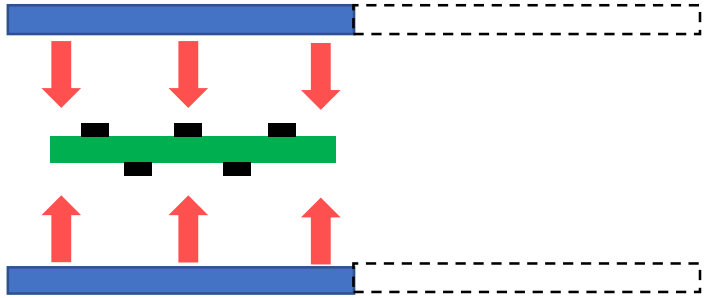
- **Requirement**
  - Keep temperature rising speed in pre-heat
  - Give all components the required temperature in soak
  - Rise to a temperature above the melting point

- **Challenge**
  - Temperature is varied depends on PCB
  - Temperature doesn’t become uniform in PCB
  - As a result, contact failure occurs



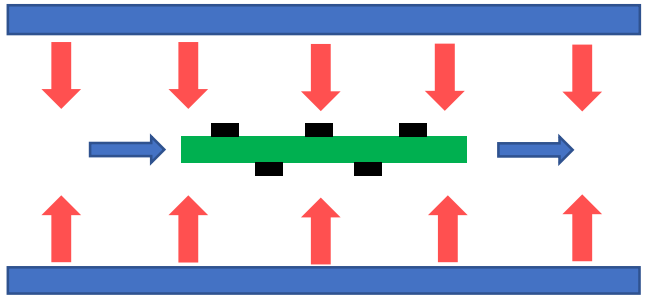
# Simulation model

- Simplified reflow model
  - Methods
    - PCB movement can not be considered
    - Change only temperature and flow rate of heating air flow
  - Strong points
    - Calculation time is short
  - Weak points
    - Accuracy of wind distribution on PCB



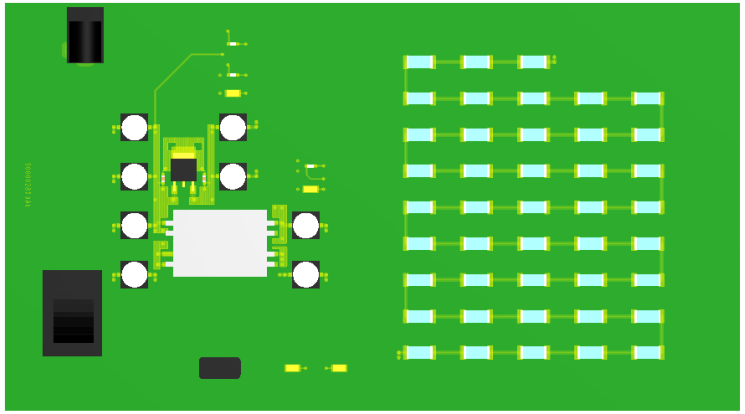
# Simulation model

- **Detailed reflow model**
  - Methods
    - PCB movement can be considered
  - Strong points
    - Accuracy of wind distribution on PCB
  - Weak points
    - Calculation time is long

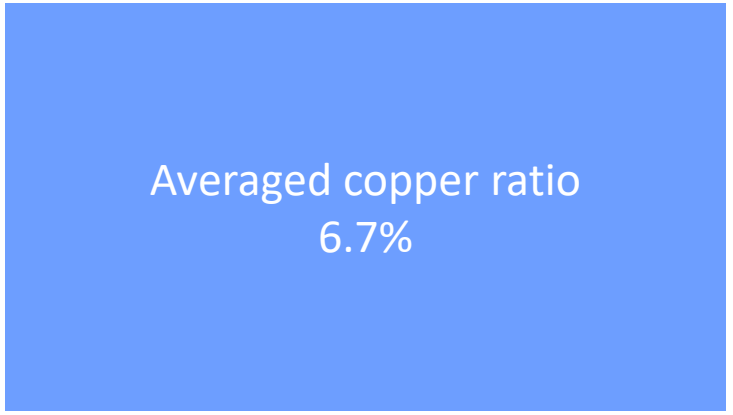


# Simulation model

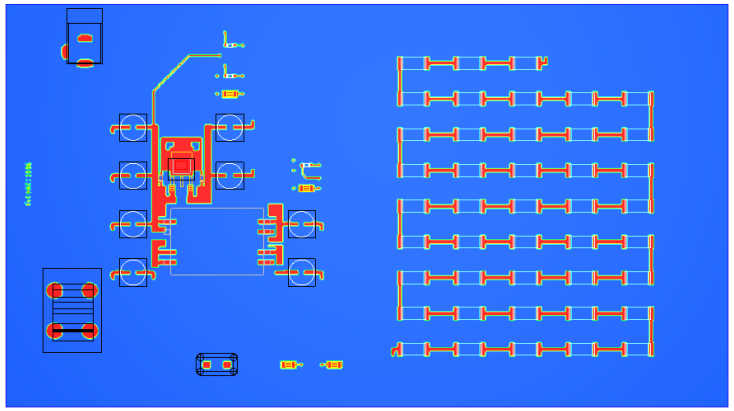
- **Simplified PCB model**
  - Wiring pattern modeling
    - Equivalent thermal conductivity
- **Detailed PCB model**
  - Wiring pattern modeling
    - Creation wiring pattern shape using Gerber data



Wiring pattern(Gerber data)



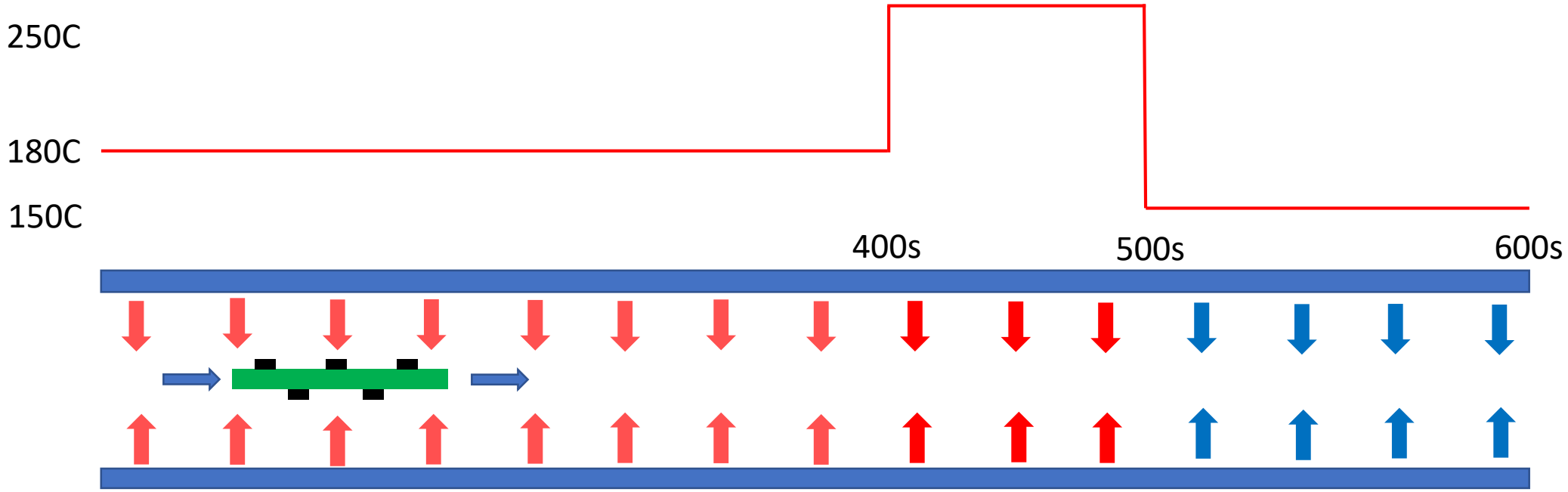

Uniform equivalent thermal conductivity



Distribution of thermal conductivity generated from Gerber data

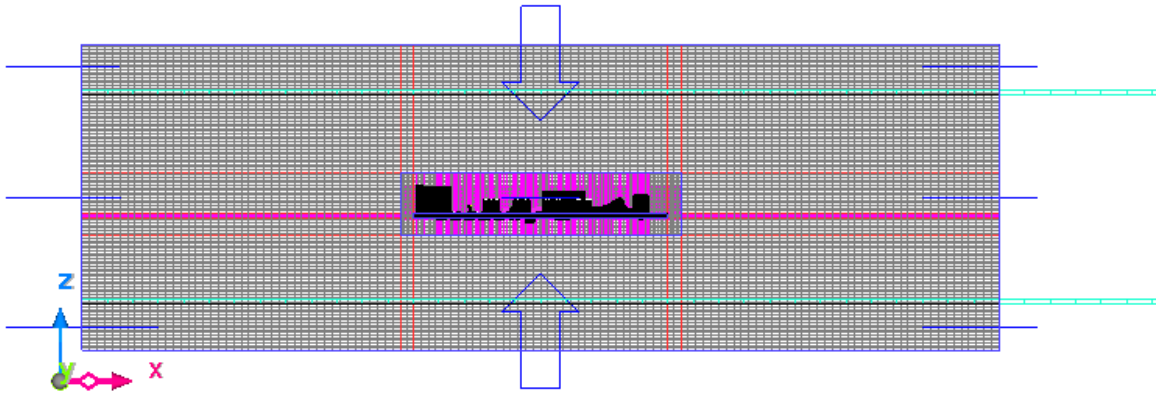
# Condition

- Oven conveyor speed
  - 5 mm/s
- Heating time
  - 600 sec
- Heater temperature profile



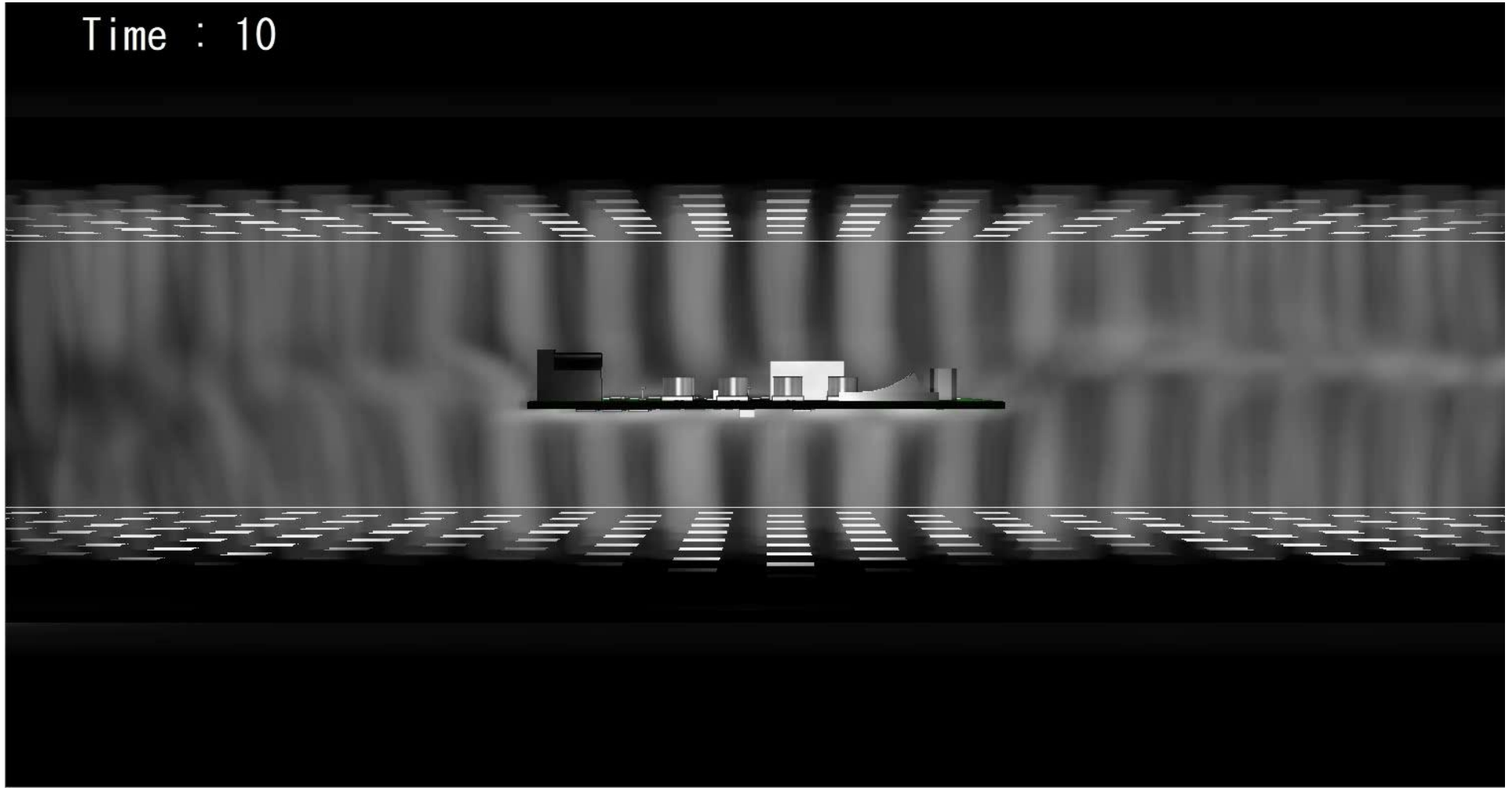
# Condition

- **Modeling**
  - Detailed reflow and PCB model
- **Analysis type**
  - Turbulence flow, thermal, radiation, Moving object
  - Standard k-ε model for turbulence model
- **Meshing**
  - 5 million elements
    - Wiring pattern resolutions is 0.2mm



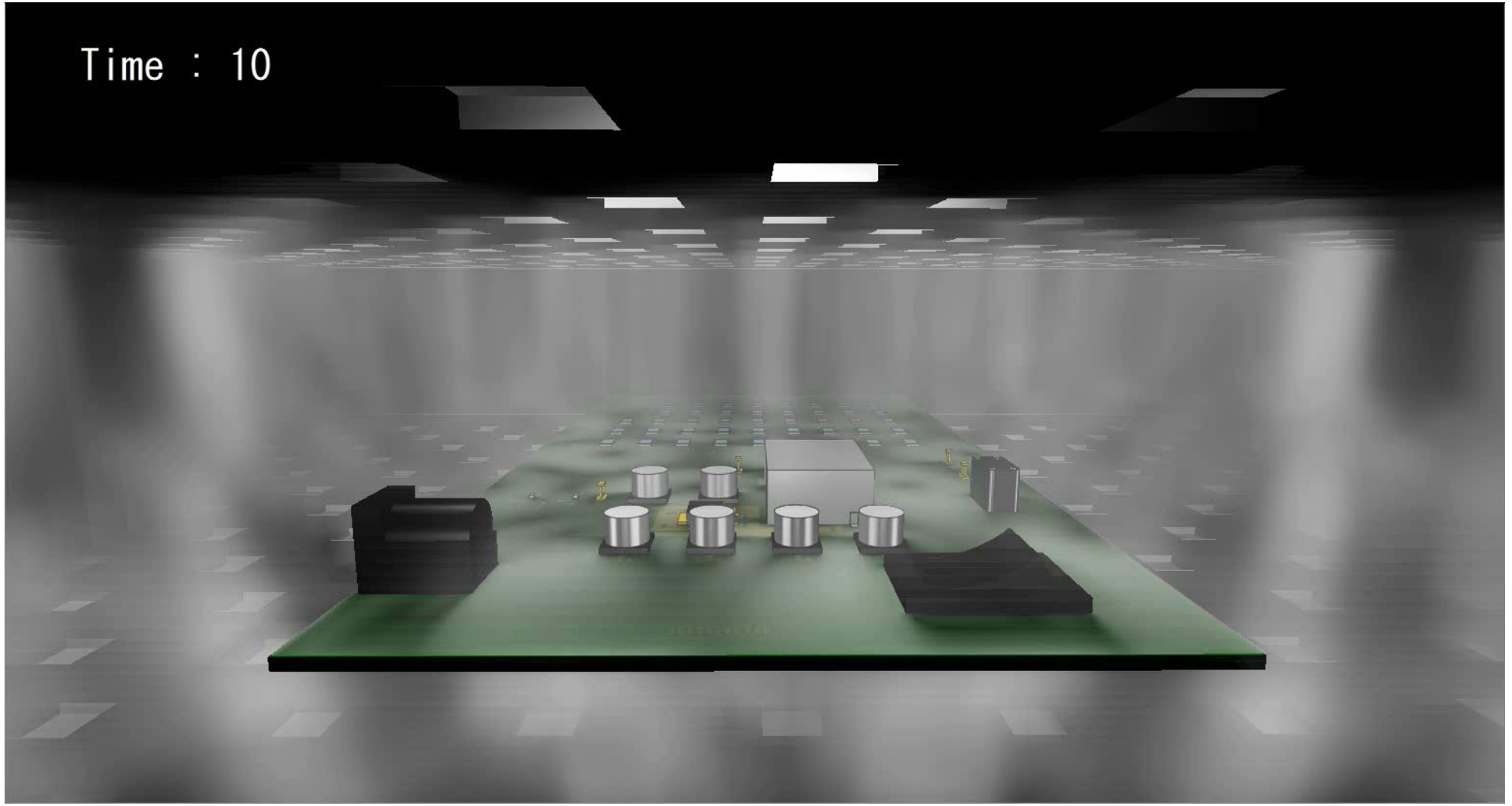
# Result

- Airflow in oven



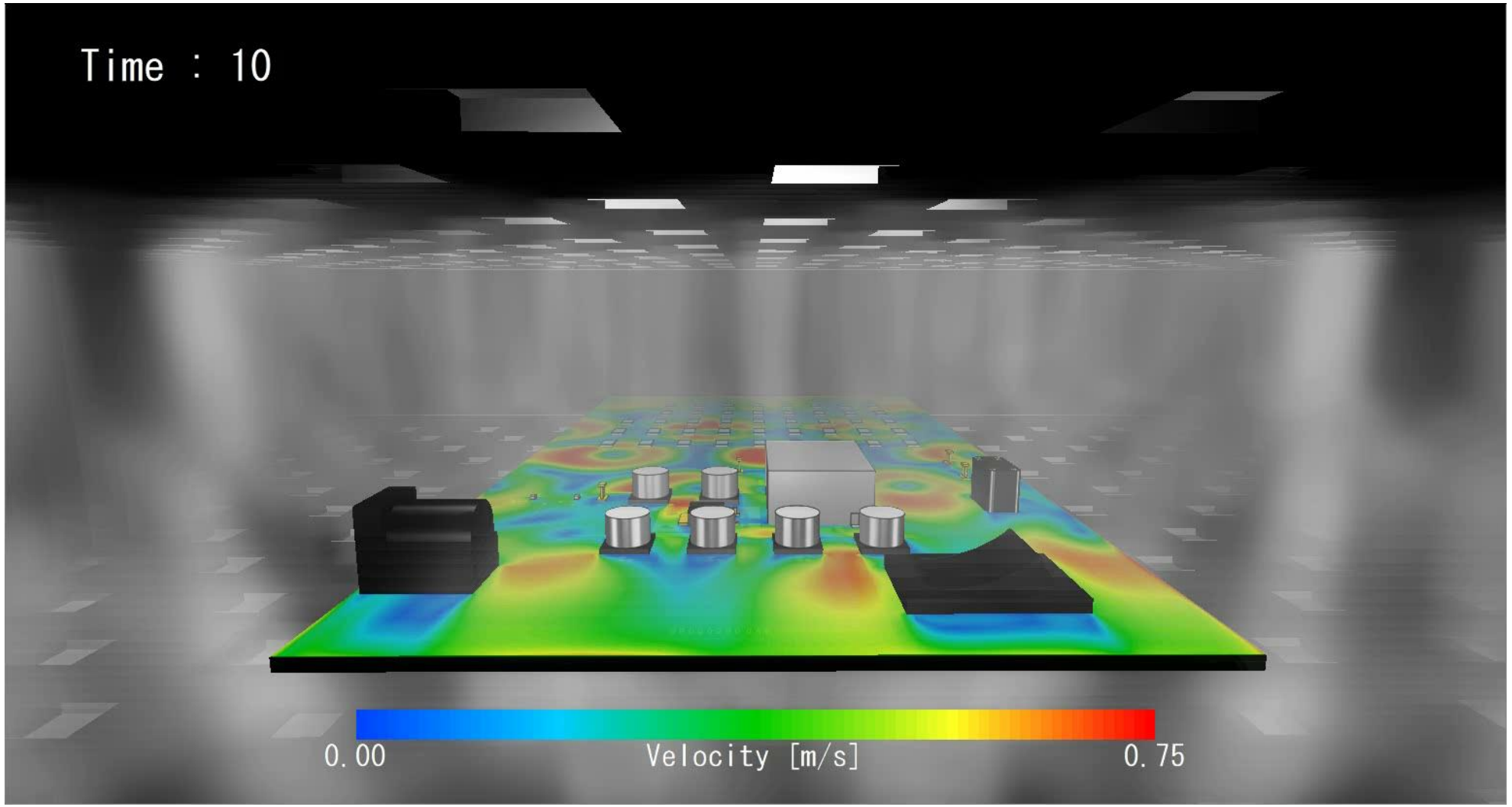
# Result

- Airflow in oven



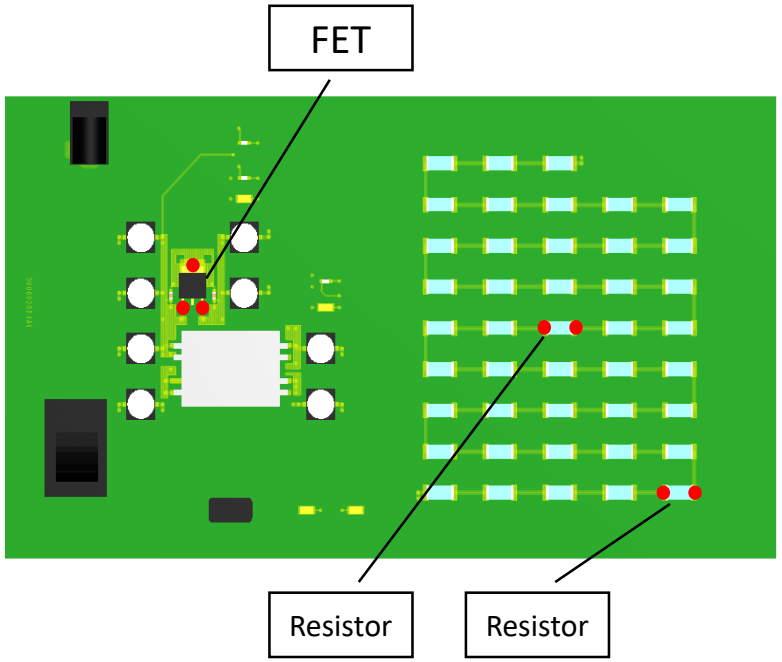
# Result

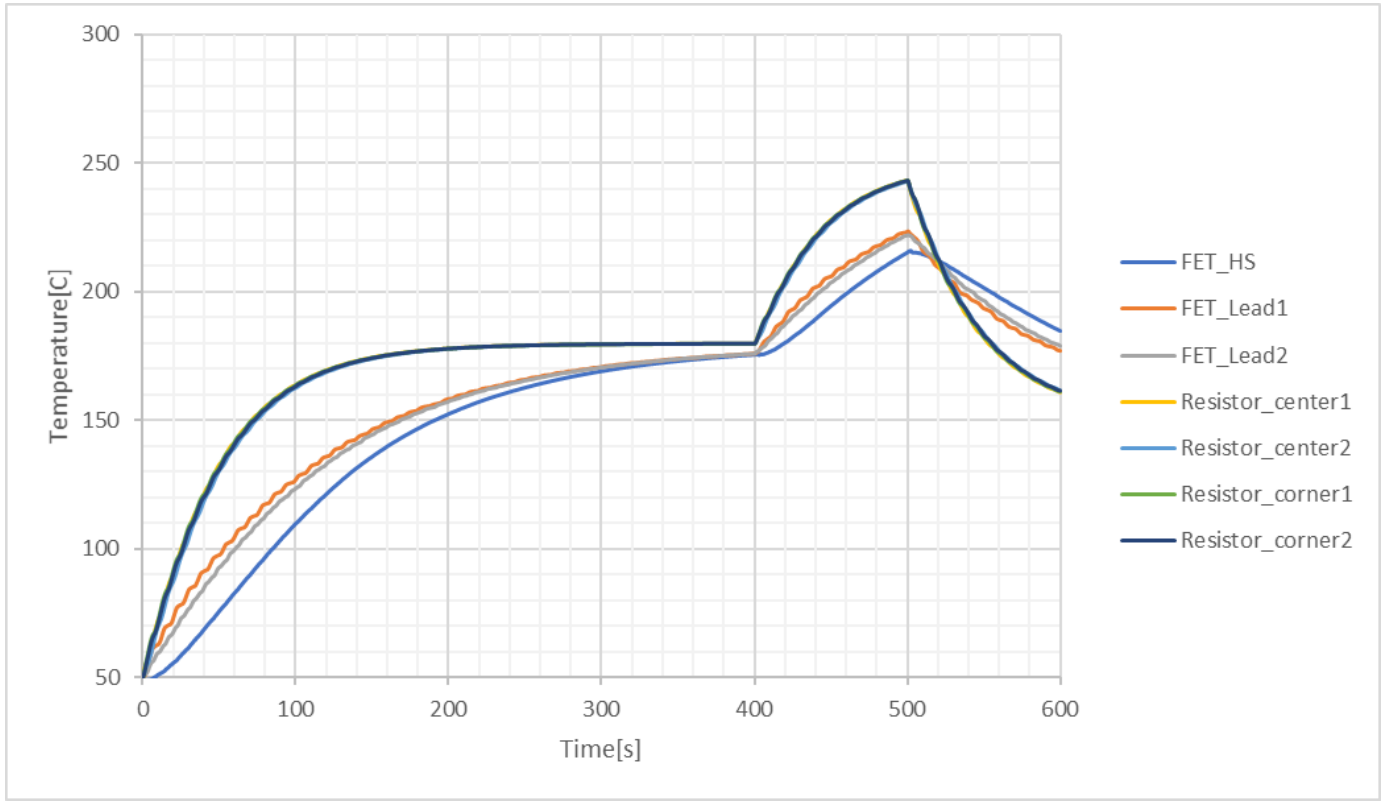
- Airflow in oven



# Result

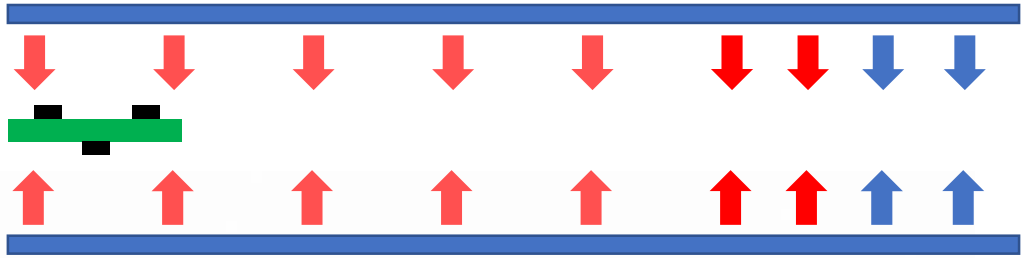
- Time series of solder temperature

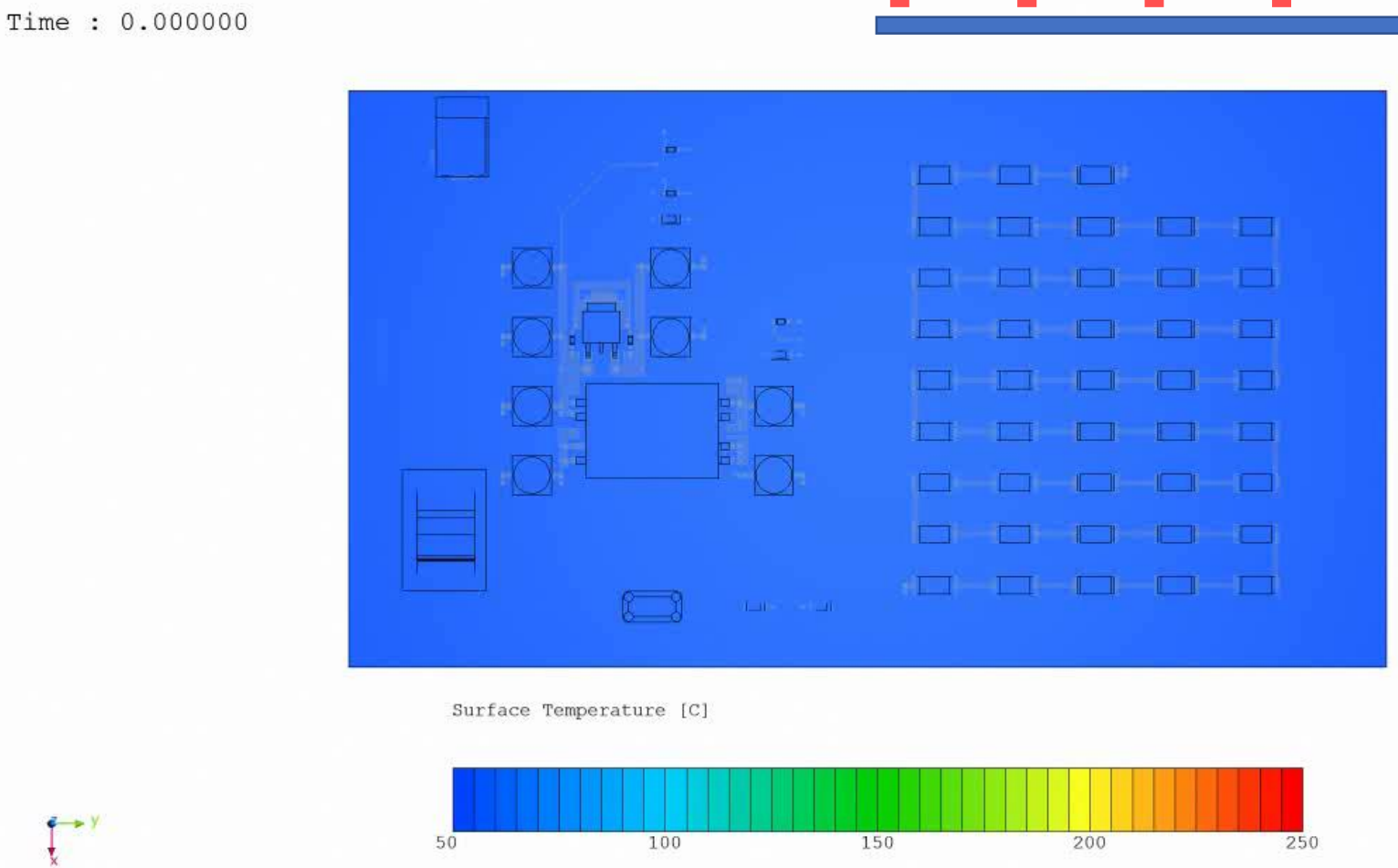


# Result

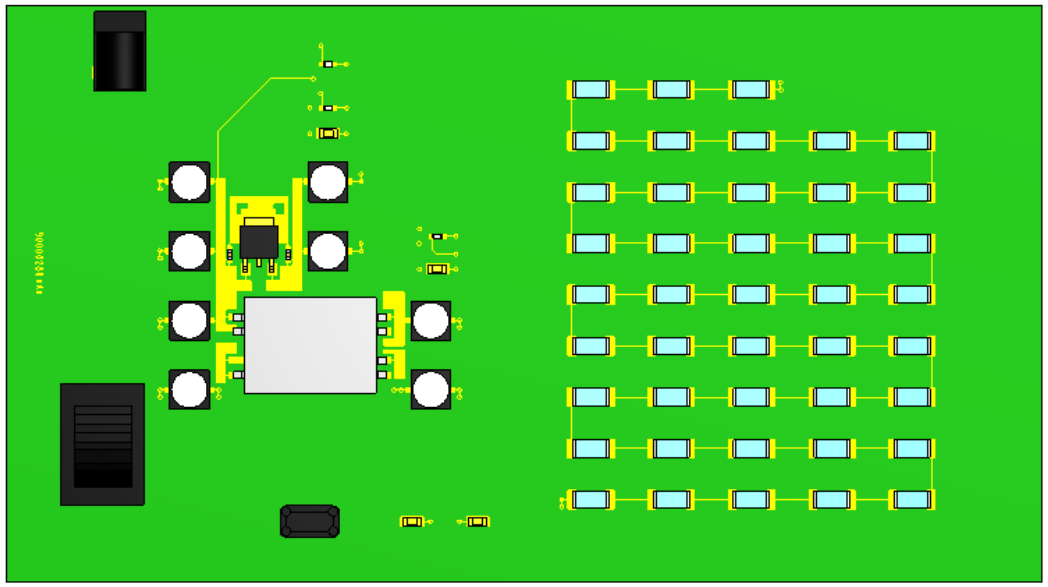
- Temperature distribution of PCB



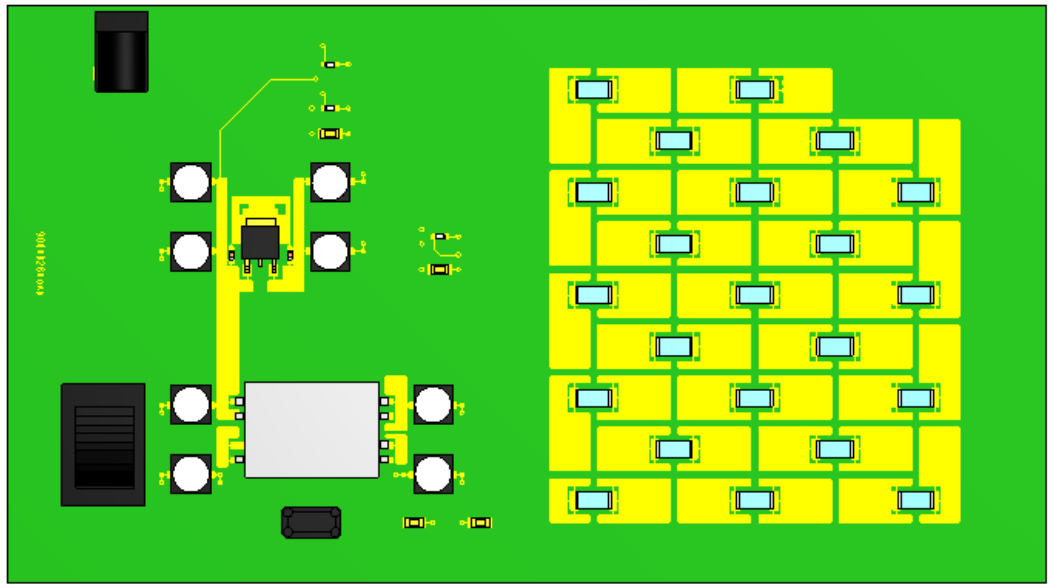


# Case study

- Changing wiring pattern layout



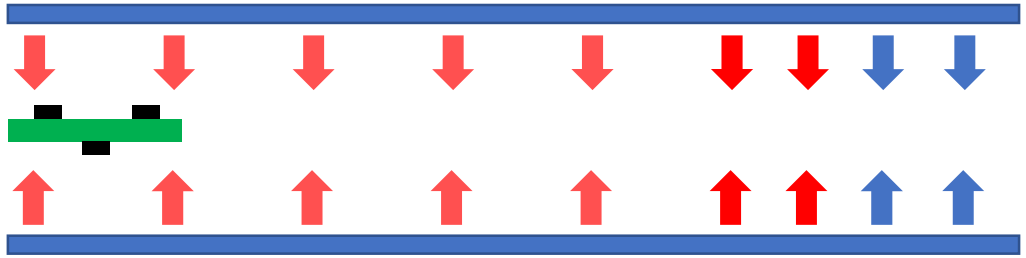
Original

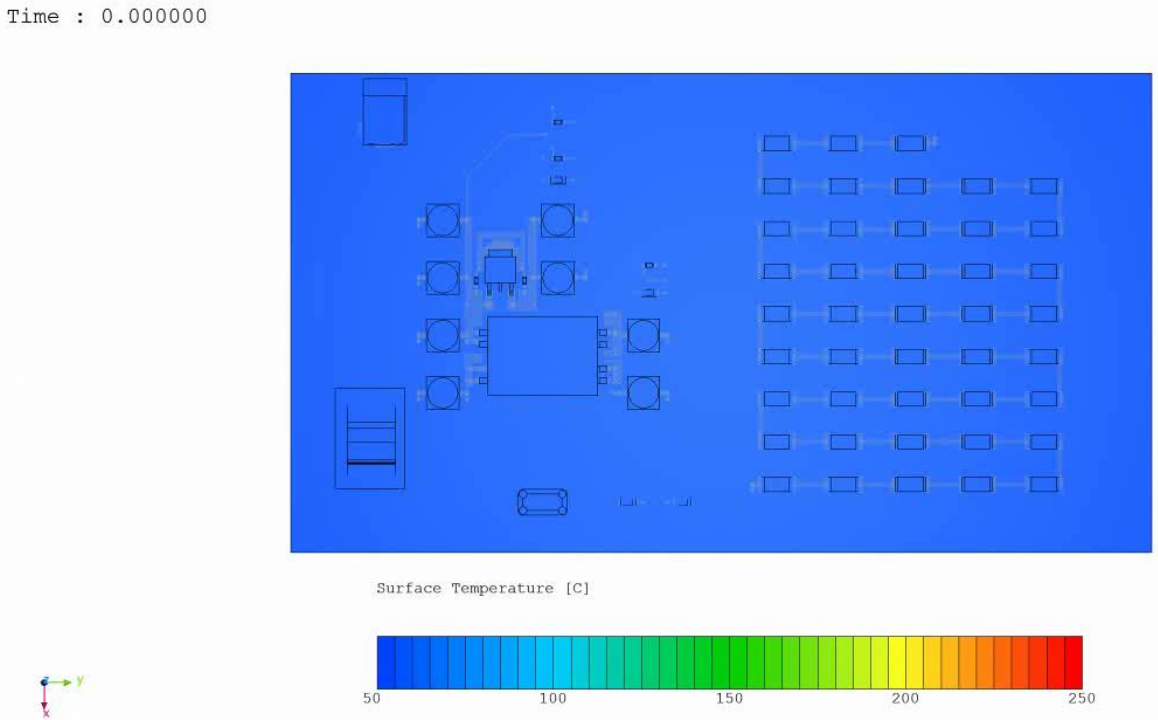


Modified wiring pattern

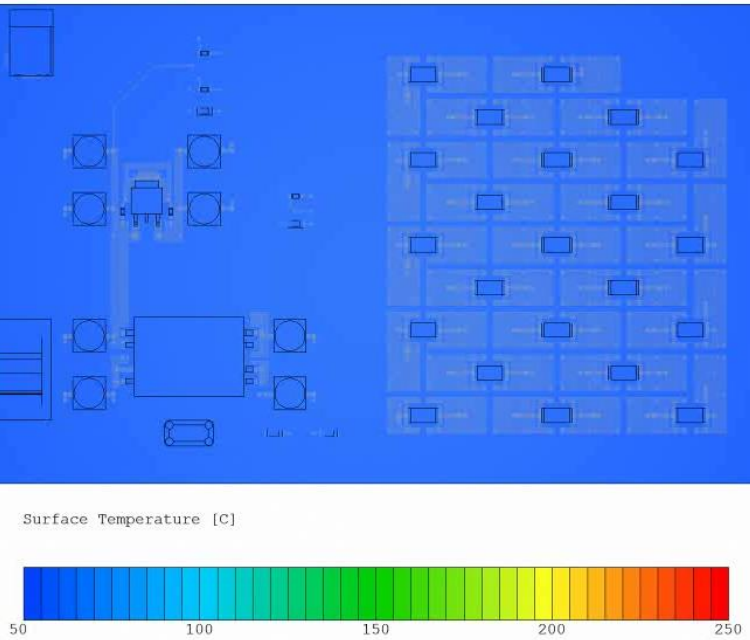
# Result

- Temperature distribution of PCB





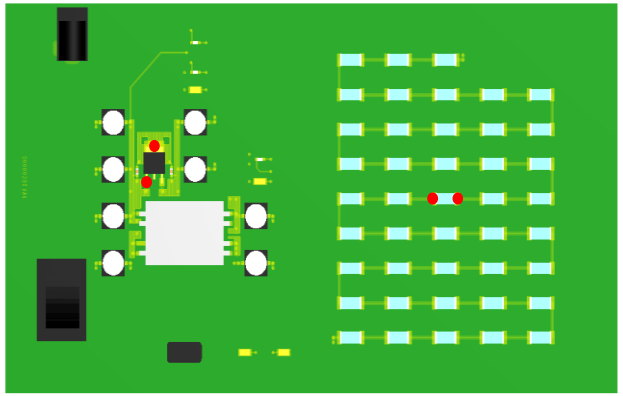

Original

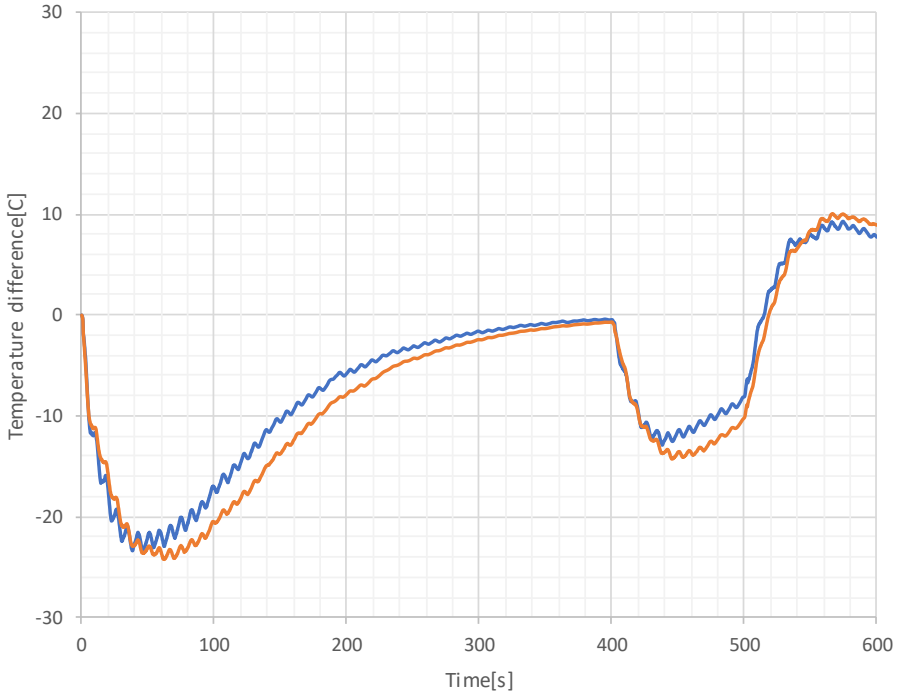



Modified wiring pattern

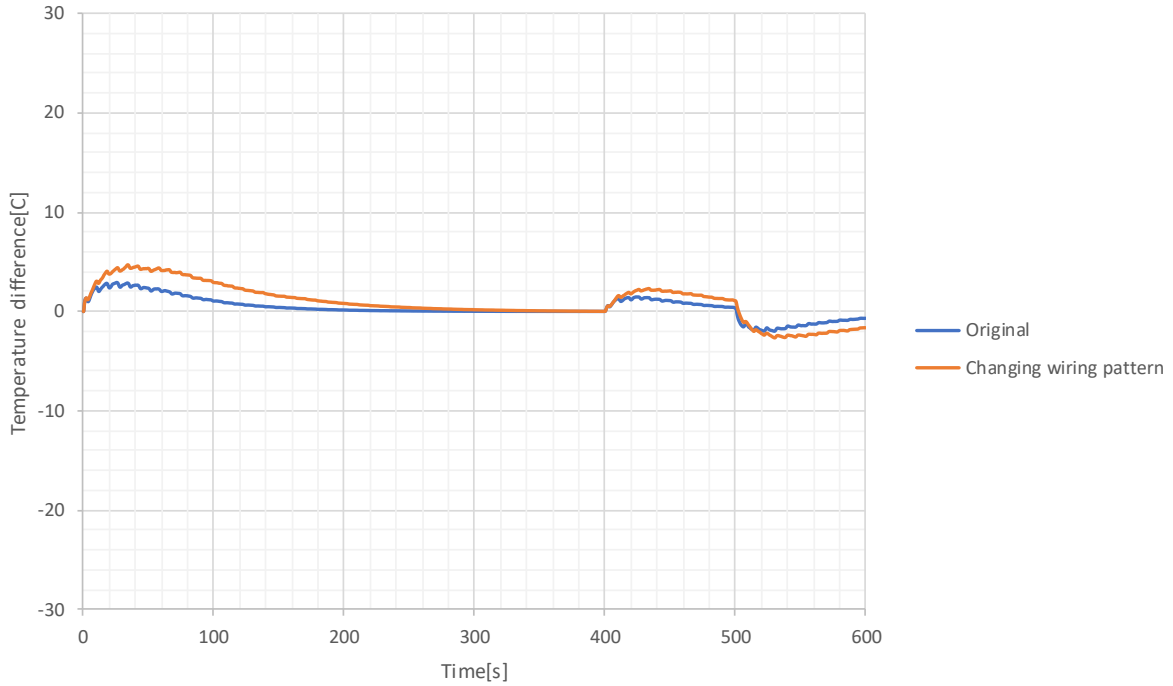
# Result

- Temperature difference between leads






FET

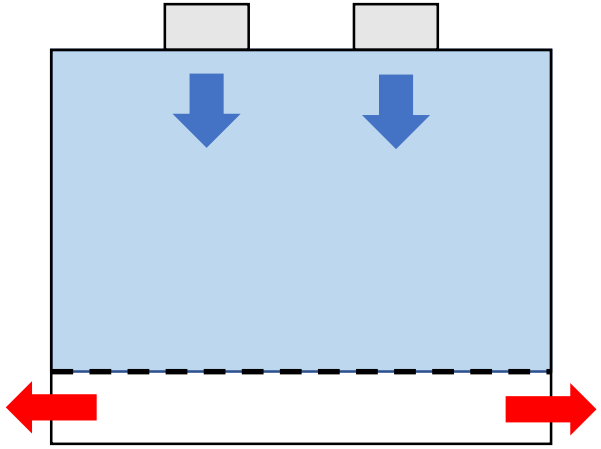



Resistor

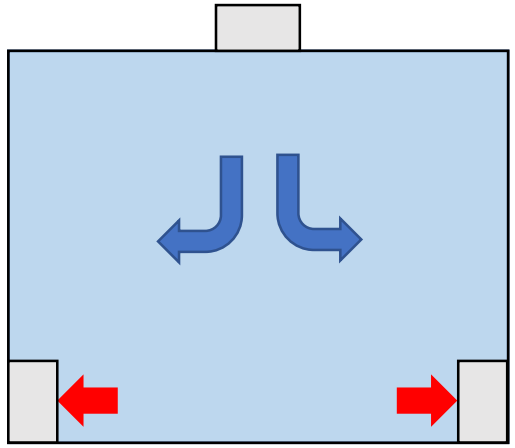
# Clean room

- A room for the manufacture that is maintained at high level cleanliness

- Principle for cleanliness
  - Do not bring in
  - Do not generate
  - Avoid sedimentation
  - Clear the air



Laminar flow system



Turbulence flow system

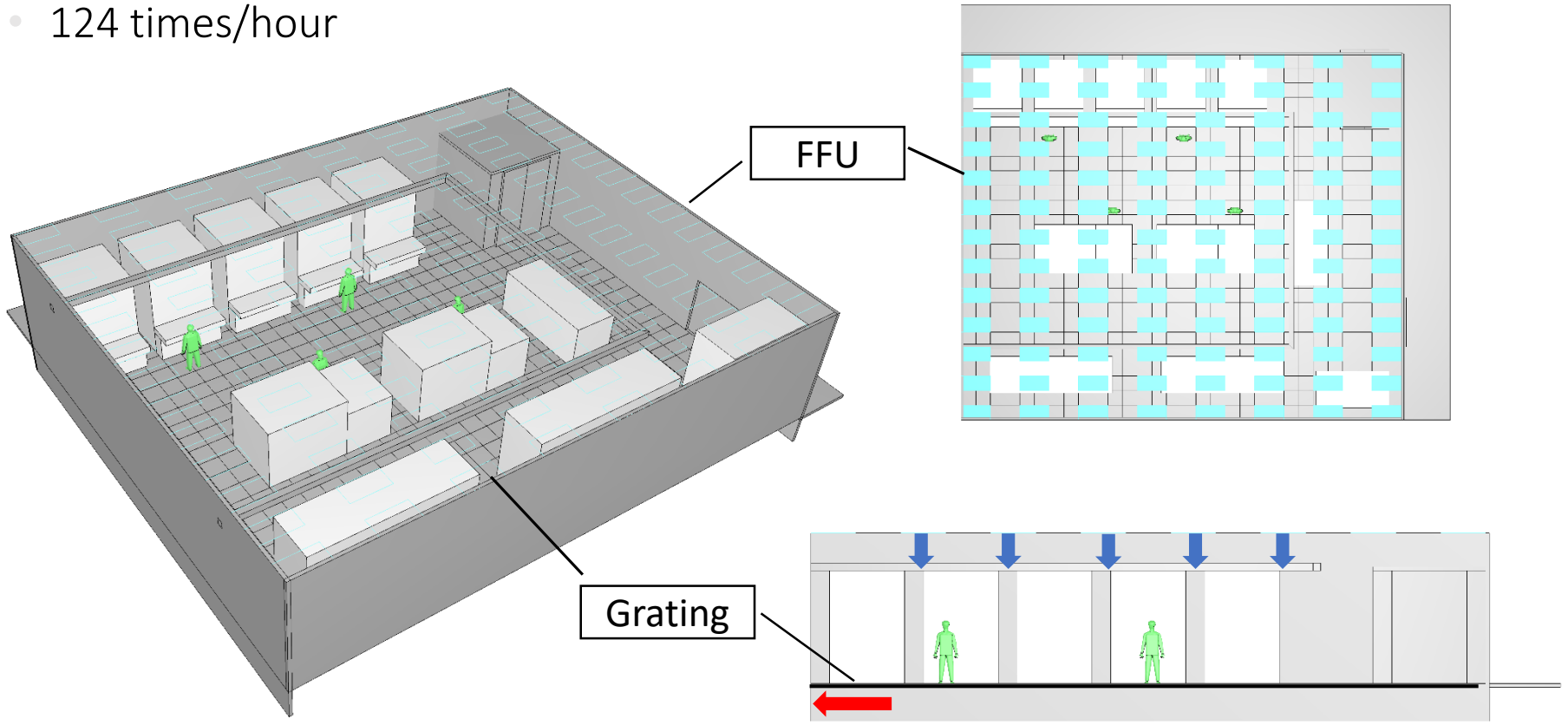
# Design requirement and challenge of clean room

- **Requirement**
  - Ventilation frequency for demand cleanliness class
  - Uniform flow pattern

- **Challenge**
  - Non-uniform flow occurs due to shape and heat of machinery
  - An area with poor ventilation performance occurs

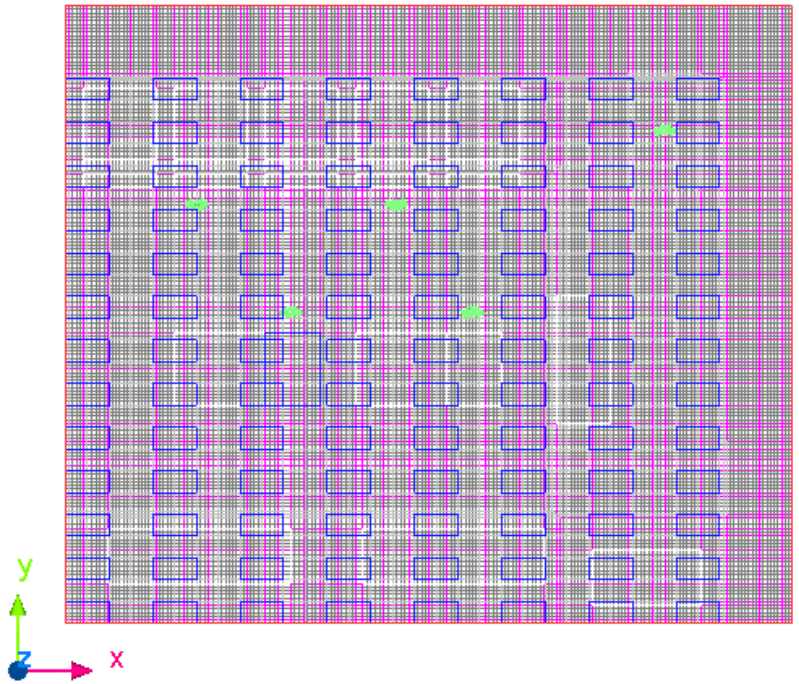
# Simulation model

- Size
  - 18m x 15m x 4m
- Ventilation frequency
  - 124 times/hour



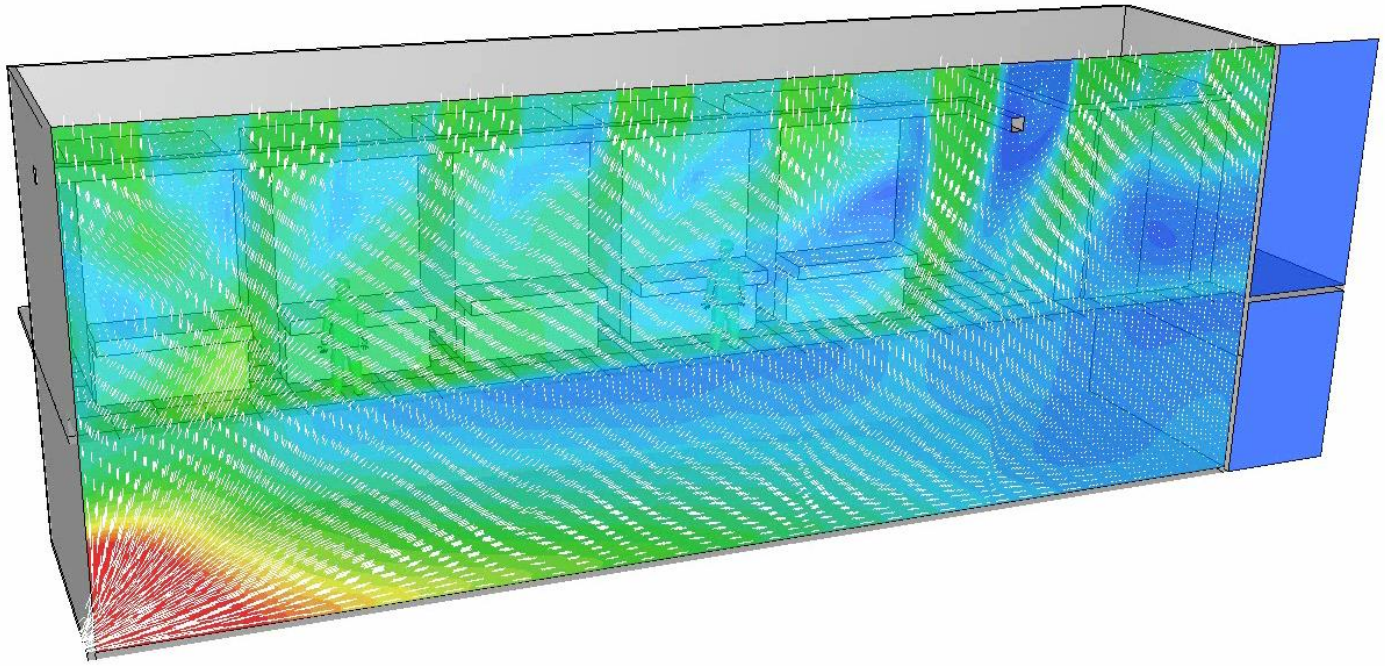
# Condition

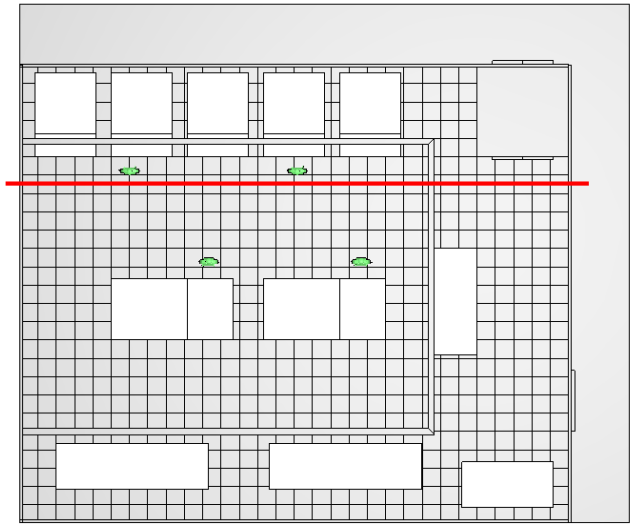
- **Grating**
  - Opening ratio 60%
- **Analysis type**
  - Turbulence flow, thermal, Ventilation efficiency
  - Standard k-ε model for turbulence model
  - Steady state
- **Meshing**
  - 2 million elements

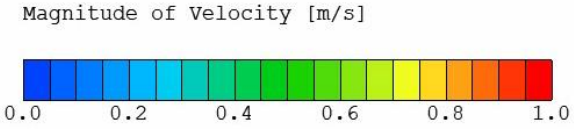



# Result

- Velocity distribution

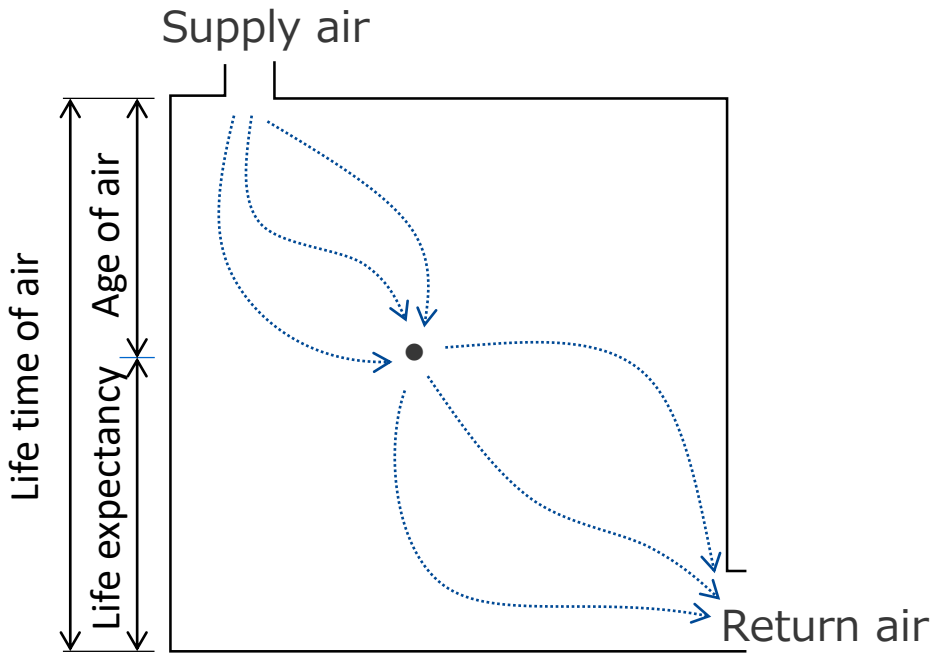







# Ventilation efficiency

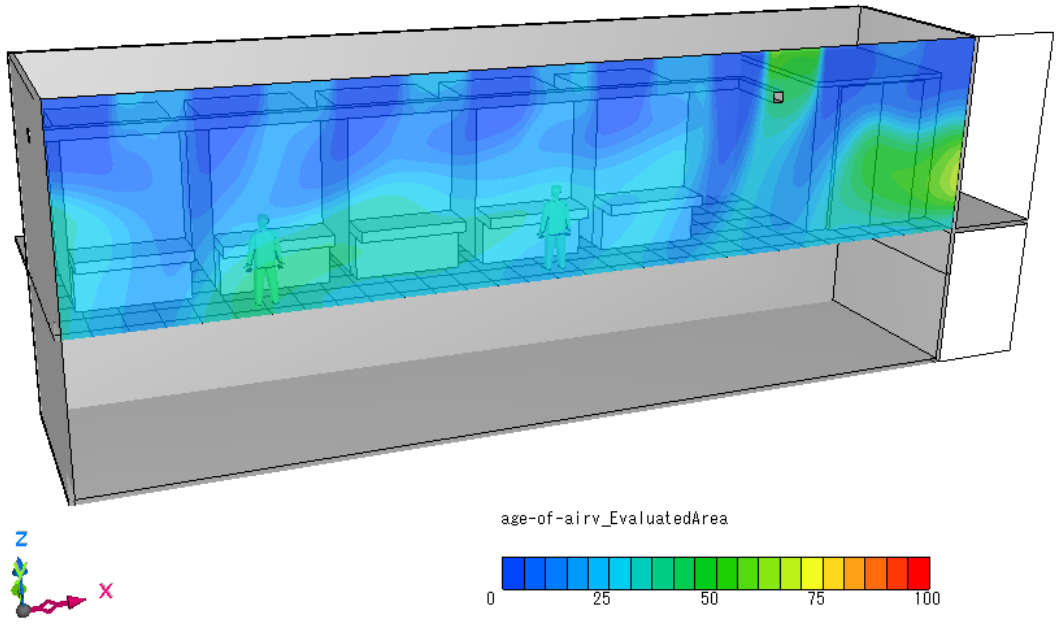
- Age of air, Life expectancy of air, Life time of air



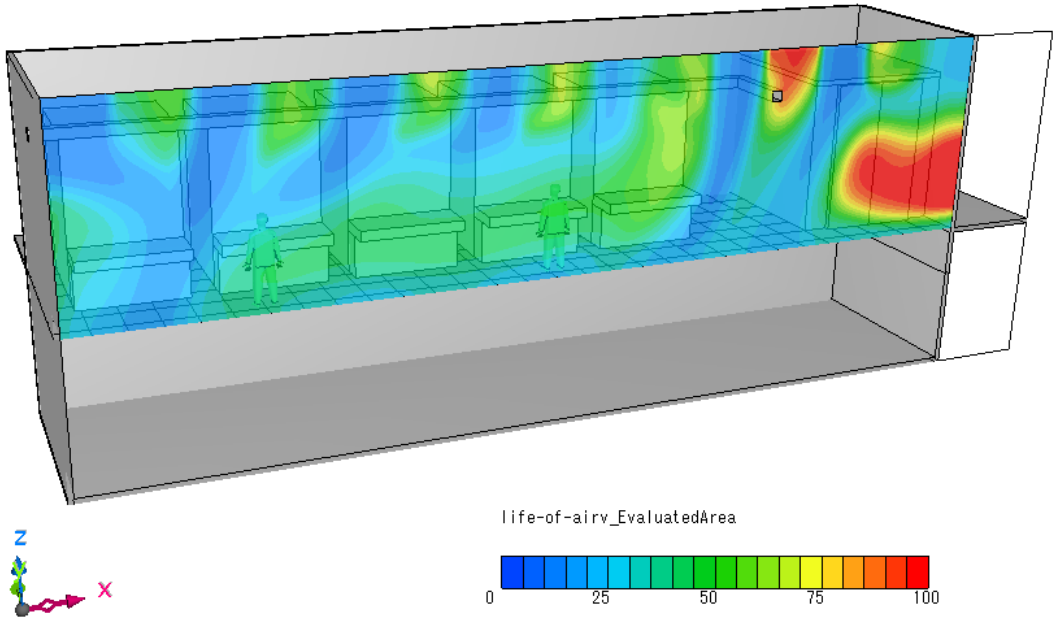

Age of air
: Time to reach from supply air
Life expectancy of air
: Time to reach return air from observation point
Life time of air
: Time from air supply to return air

# Result

- Ventilation efficiency



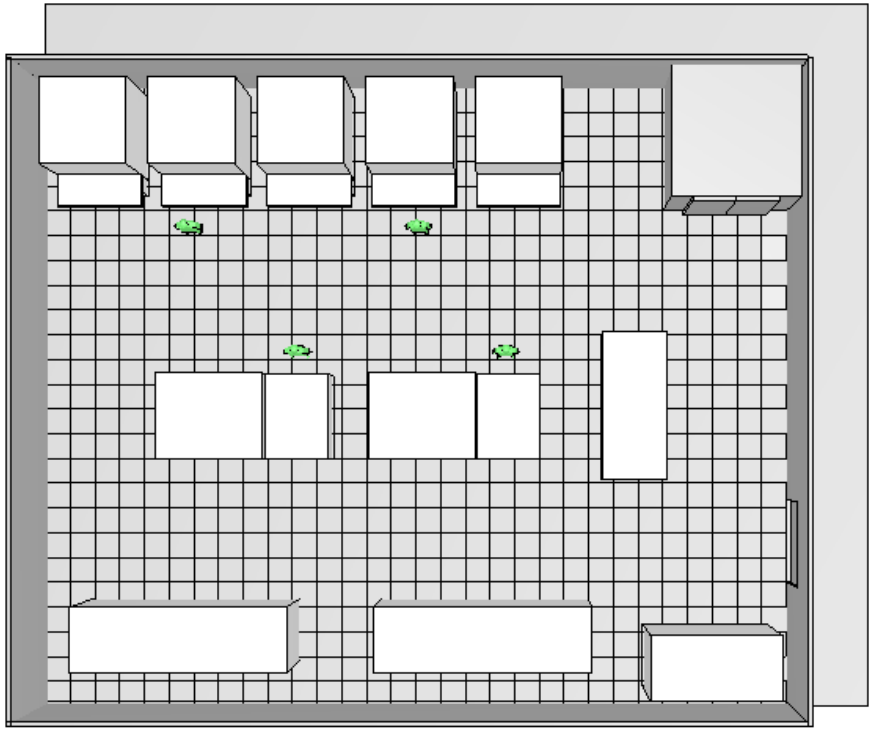

Age of air



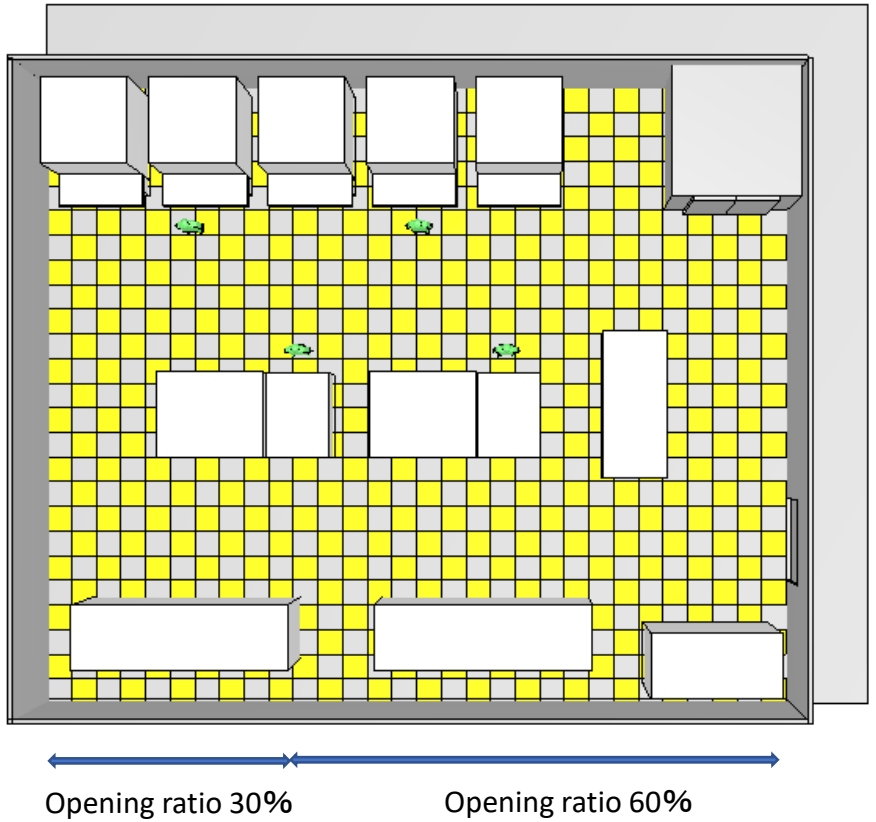

Life time of air

# Case study

- Changing grating pattern



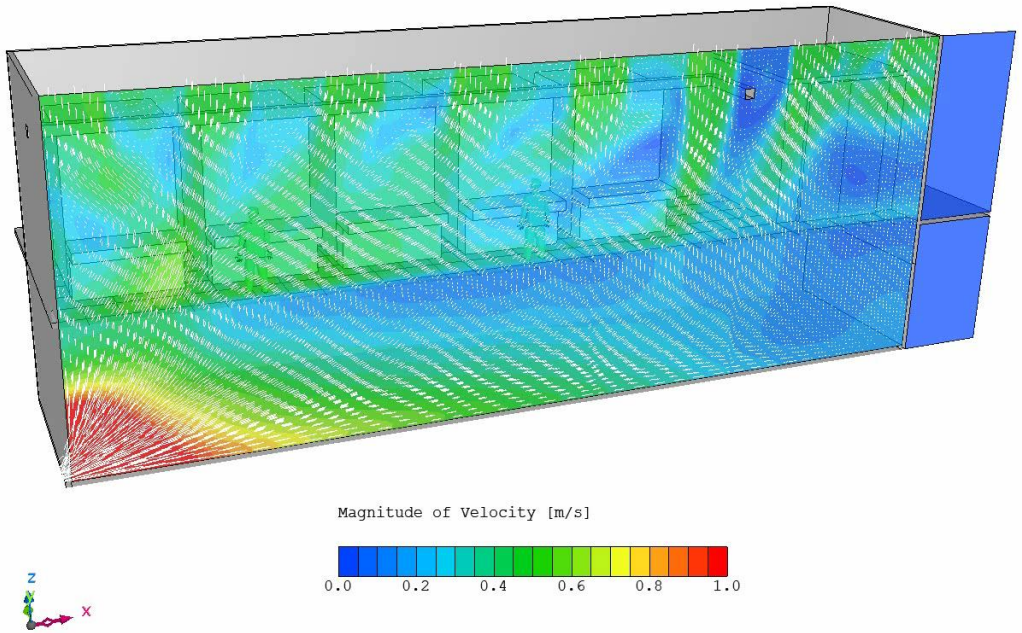
Original



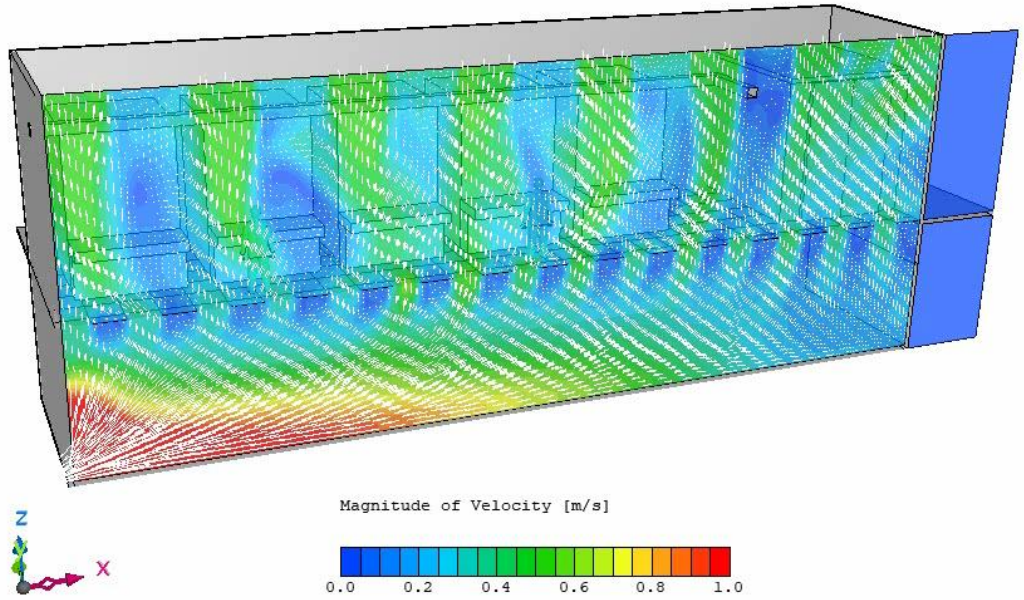

Changing grating pattern

# Result

- Velocity distribution




Original

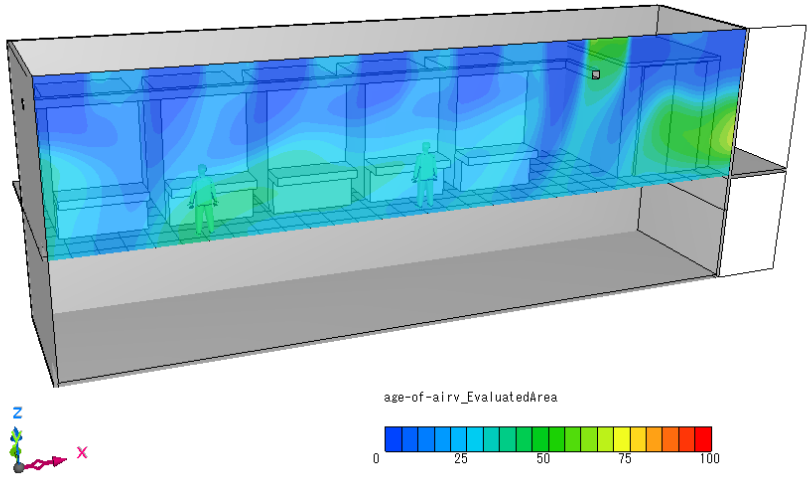


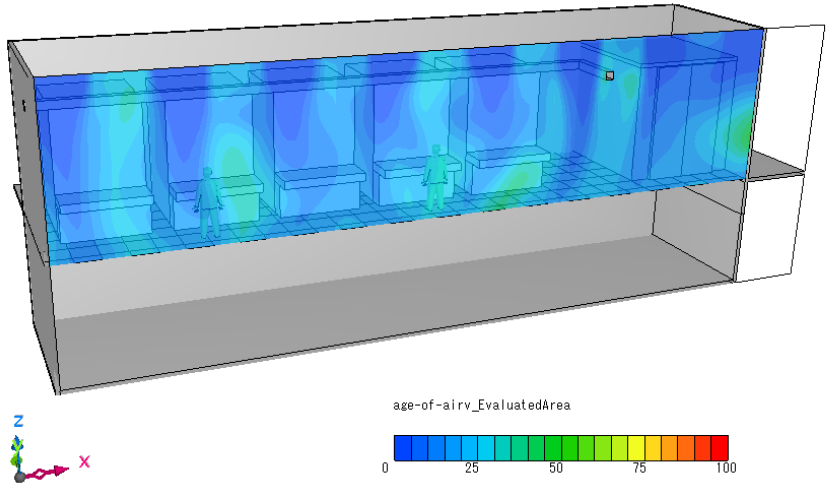

Changing grating pattern

# Result

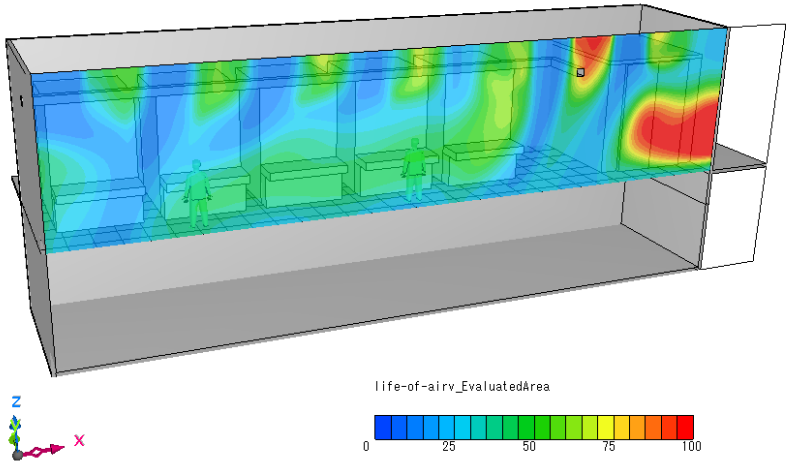
- Ventilation efficiency

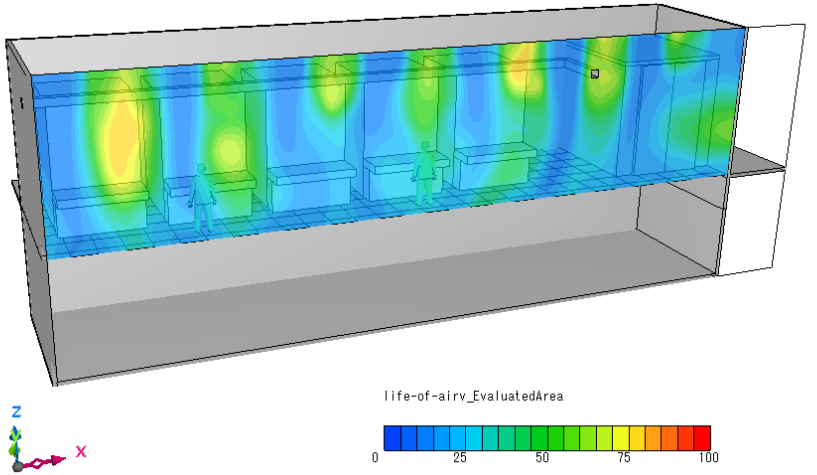
Age of air




Life time of air



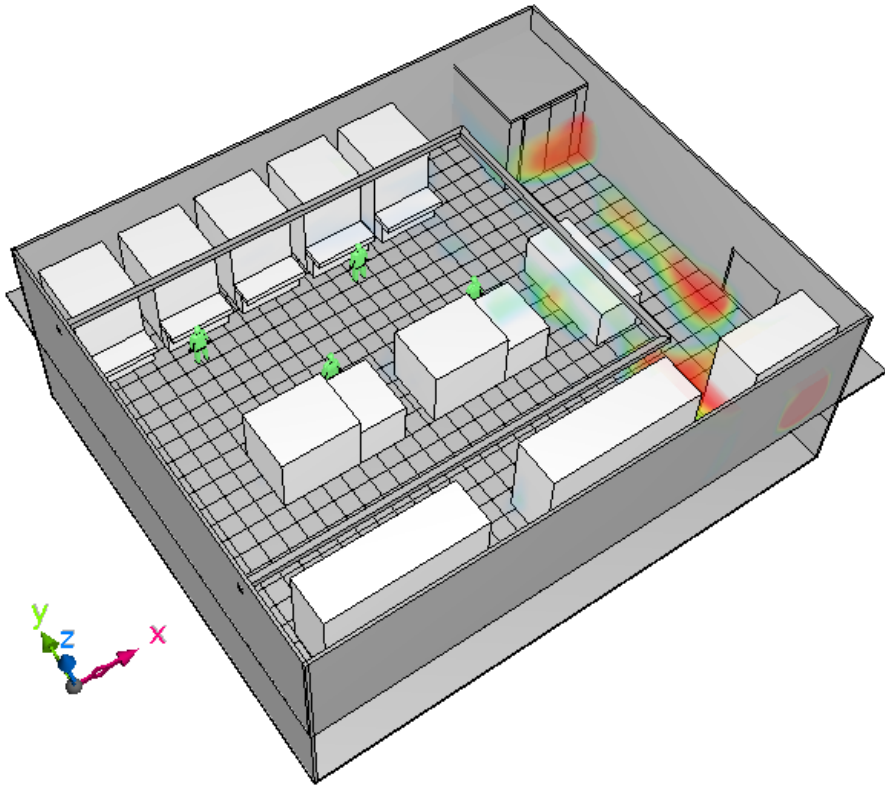




Original

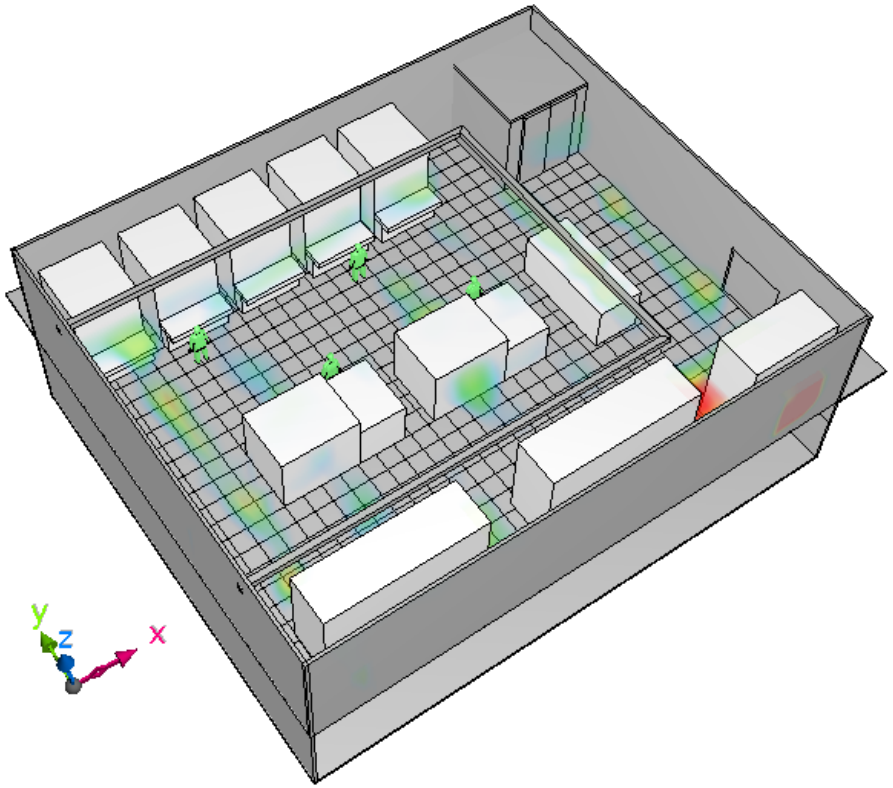
Changing grating pattern

# Result

- Life time of air




Original




Changing grating pattern

# Summary

- Reflow process can be simulated by scSTREAM.
- Highly accurate simulation is possible with considering detailed wiring and oven model.
- Therefore it can find out changes in solder temperature due to changes in wiring pattern.

- Clean room can be simulated by scSTREAM.
- As a result, it is possible to find non-uniform flow are, also it can be improved by design change.
- Visualize ventilation efficiency to identify area with high risk contamination.

2019 | MSC 台灣用戶大會
CAE模擬推動智能革新

台灣 • 台北　10月4日

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# Thank You