SUCCESS **STORIES**

cadence®

Cradle CFD

Electronics and Thermal Management

HeatDesiner

Temperature Prediction of an LED Bicycle Headlight

CATEYE Co., Ltd. Case Study HeatDesigner Function

Temperature predictions of an LED bicycle headlight using HeatDesigner compare favorably with measured values

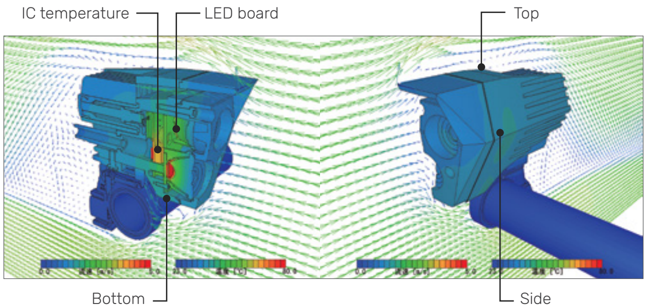
LED Bicycle Headlight

Today's high powered bicycle headlights use multiple LED light clusters to produce high intensity lighting that can approach the candlepower output of an automobile low beam headlight. This high output produces much heat. As a result, designing the bicycle headlight to maximize heat release becomes crucial.

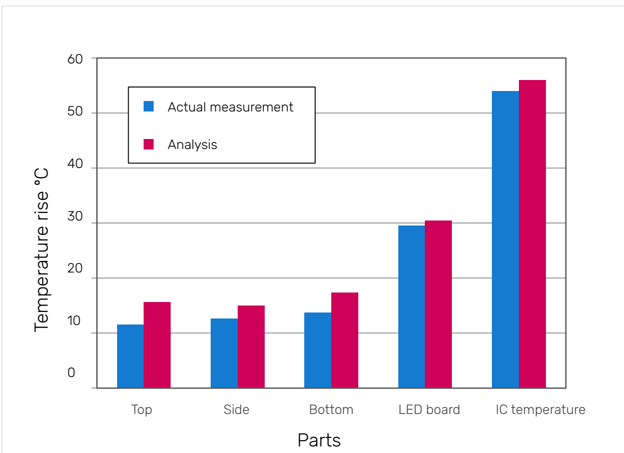
CFD analysis was used to calculate the temperature rise in the Cateye HL-EL930RC bicycle headlight and identify thermal paths. The temperature predictions were compared to measured values, and the thermal paths showed the amount of heat release from each section of the light. This methodology can be used to design more efficient high output bike lights.

LED bicycle headlight (HL-EL930RC)

Measurement and simulation



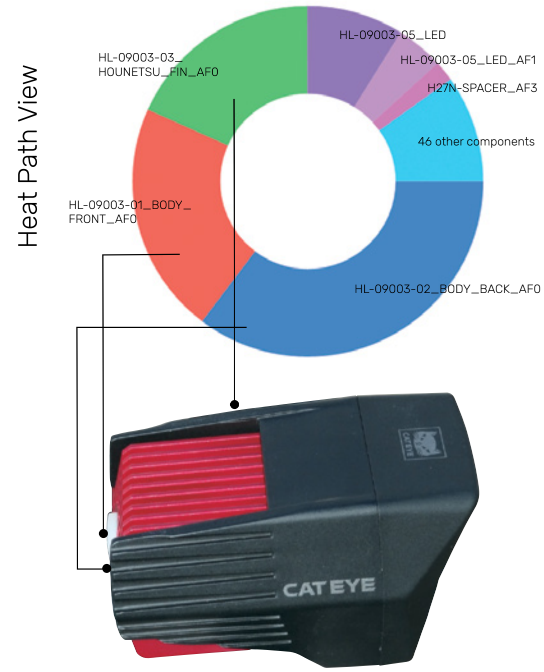
Simulated velocity vectors and temperature distribution



Temperature rise of each part

Simulates temperature with high accuracy

Enables accurate comparison of different designs prior to hardware fabrication

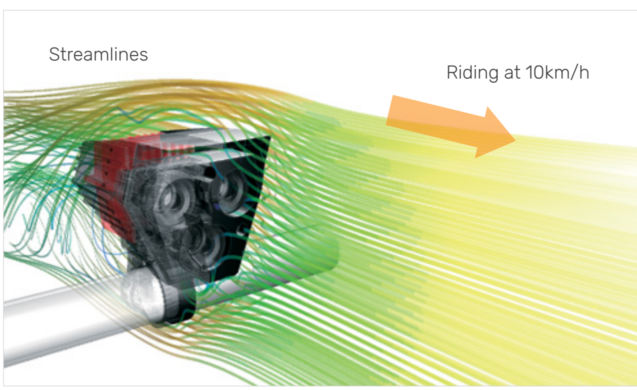


Contribution of each section of the light to convection heat release into the air

Identies which sections of the light contribute the most heat release

This information can be used to improve and optimize the design

Benets of simulation



Streamlines of air ow around the bike light

Customer Comments

CFD was used to evaluate heat release performance and predict temperature rise of a high output LED bicycle headlight. Test measurements validated the analytical predictions. Prototype development time and costs were reduced by accurately predicting temperatures for dierent headlight shapes and materials. HeatDesigner is an excellent design simulation tool for products subject to demanding thermal challenges.

scSTREAM

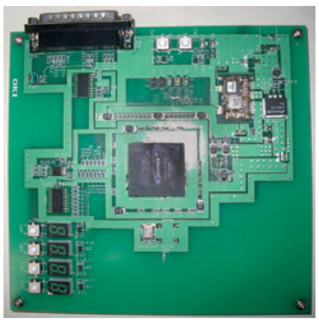
Heat Release Design for Printed Circuit Board

Case Study for OKI Printed Circuits Co., Ltd.

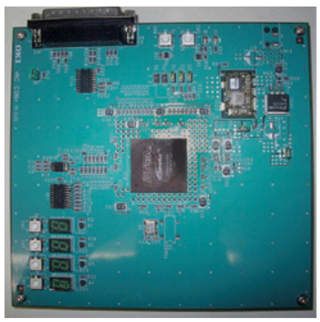
The number of prototypes has been reduced successfully using scSTREAM

Model

Dimension: 150×150×1.6t(mm)
Num. of Layers: FR-4 2 Layers
Circuits: Altera FPGA BGA package Peripheral circuit
Operation: 66MHz Shift Register



2 Layers (Before)



10 Layers (After)

* Both cases are identical in circuit schematic, parts placement, and total thickness of PCB.

If the heat release could be mainly through natural convectioninstead of forced convection, it is possible to;

1) Reduce the space for cooling fan, ow path, etc.
2) Reduce noise level and improve the acoustic environment
3) Improve quality and reliability
4) Reduce the cost

Design Changes

For increasing the thermal conductivity of PCB

- The number of layers; 2 layers -->10 layers
- Halogen-free insulation
- Increase the residual copper area ratio

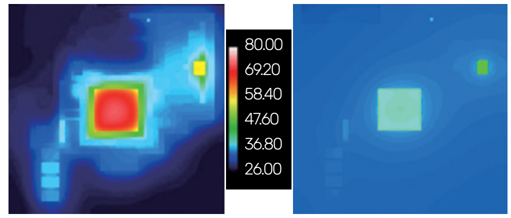
For improving thermal conductivity of Board in PKG

- Ground connection of Chip NC pins

For improving thermal heat transfer in PCB

- Additional aluminum n at the back and at the edge of PCB
- Additional pin-n at the dead space of PCB

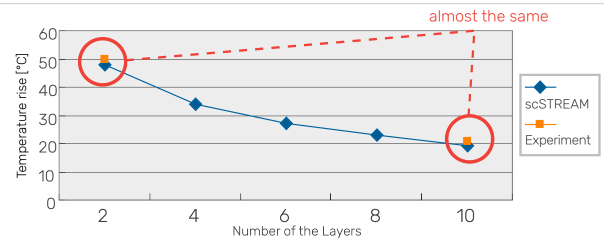
Analysis Results



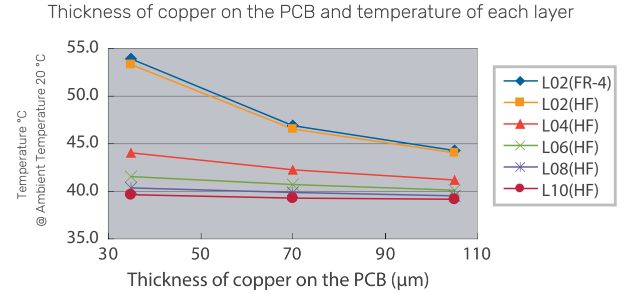
2 Layers (Before) 10 Layers (After)

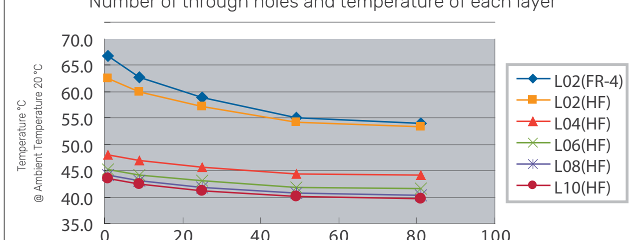
Only with the design changes on PCB, temperature goes down by more than 30 [°C]!

Temperature Comparison between scSTREAM and Experiment



Temperature for various di,erent number of layers are predicted. Adequate design can be provided to accommodate each customer's need.





Customer Comments

This is the era that even manufacturers of printed circuit board use CFD software in order to improve their designs and make a better proposal.

For proposing the best solution, Software Cradle's scSTREAM is a dependable tool on thermal design and assessment.

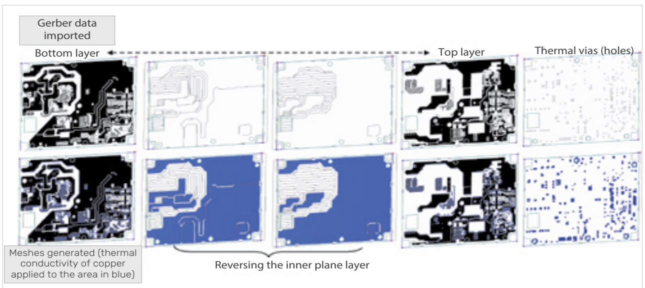
scSTREAM/HeatDesiner

Gerber Data Import and Other Functions

scSTREAM and HeatDesigner Features

Estimating the Heat Dissipation from a Circuit Board (by Importing Data in Gerber)

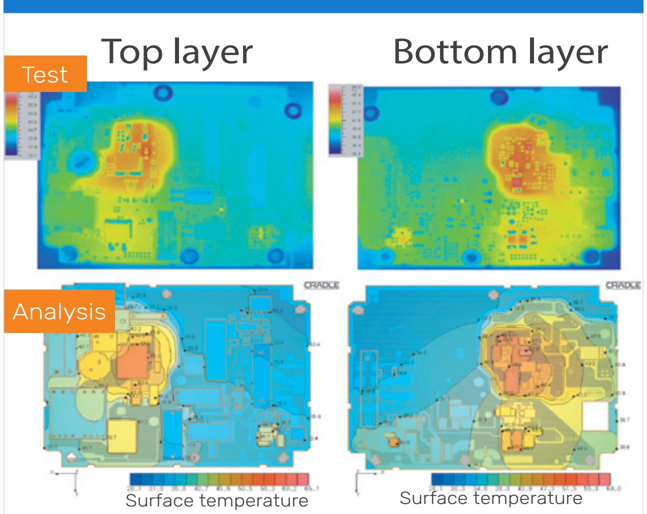
Import data in the standardized Gerber format (RS-2740, a type of board circuit format) to estimate the heat dissipation from the board while including the eects of the wiring distribution.



Accounts for:

- Heat dissipation distribution of circuit pattern
- Heat transfer through thermal vias (holes)

Simulate more accurate board temperature distribution

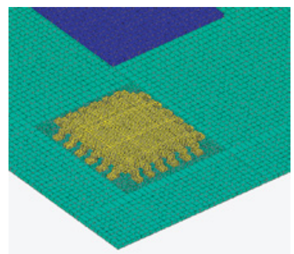


Comparison between standard procedure and Gerber data application		
Number of mesh elements	Standard procedure	Gerber application
	14.2 million	7.6 million
Time taken when calculated using 4 cores (Convergence)	18 hours 780 cycles	13.5 hours 290 cycles
Memory	7.6 GB	4.8 GB
Model generation	Allocate the pattern, deform it, and generate parts onto circuit	Import Gerber data

By applying Gerber data, model generation workload is reduced to less than a tenth of its original amount

Multi-Block Meshing (Partially Detailed Meshing)

Structured meshes can be refined in specific areas.



Generates detailed meshes for the intricate parts to ensure the model quality

Without multi-blocks

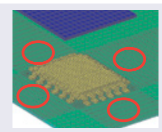
Meshes are coarsely generated. Intricate parts are not precisely represented.

Helps to generate meshes efficiently and improves representation accuracy of specific area

- Controls calculation time and memory share
- Improves calculation accuracy

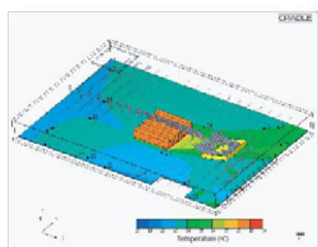
Without multi-blocks

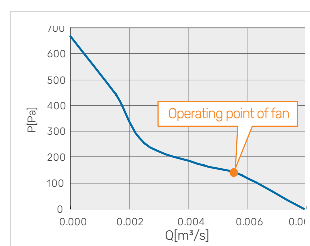
Due to fragmentation, meshes are unnecessarily generated, and can be overly assembled in some places.



Eect of a Diagonally Allocated Fan

A fan can be placed diagonally, which allows analysis of a more complicated heat dissipation mechanism.





PQ characteristics can also be considered

PICLS

Wow! Was it this easy?!

Non-experts can start thermal analysis right away with easy operation in 2D and real-time results.

PICLS PICLS Lite

http://www.cradle-cfd.com/picls/

PICLS is a thermal simulation tool which helps designers easily perform thermal simulation of PCBs. Even if you are unfamiliar with thermal simulation, you will obtain a simulation result without stress through the tool's easy and

quick operation in 2D. You can import the data of a PCB created in PICLS to scSTREAM and HeatDesigner, that is, you can pass the analysis data seamlessly from the PCB design stage to the mechanical design stage.

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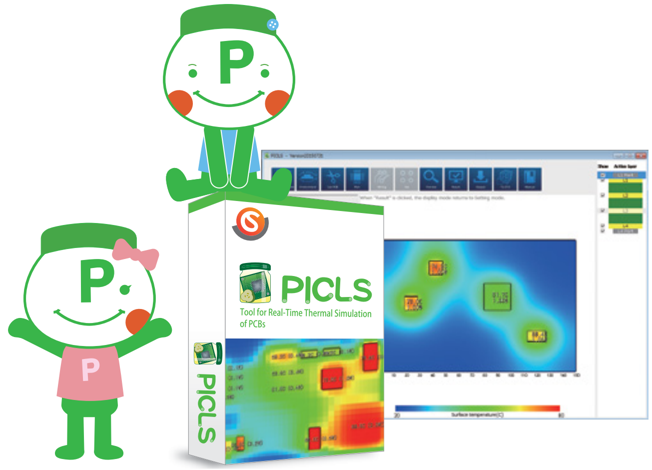
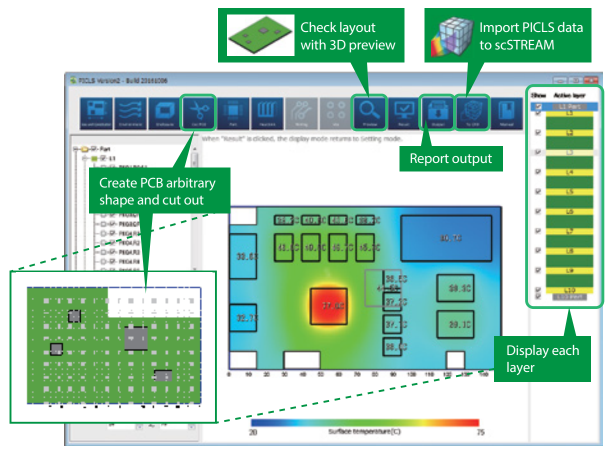




Advantages

- Easy to use
  (Operation in 2D, integrated GUI for pre- and post-processing
- Inexpensive
- Capable of real-time analysis

Thermal countermeasures using PICLS

- Checking the layout of components to avoid interference of heat between them
- Troubleshooting thermal issues of current products
- Examining thermal interferences of part layouts
- Considering heat release depending on a wiring pattern (coverage ratio)
- Examining the location and the number of thermal vias
- Examining the performance of a heatsink
- Examining the size of a PCB
- Examining the number of layers and the thickness of copper foil
- Considering natural/forced air cooling
- Considering radiant heat
- Considering heatsinks (number of ns, size)
- Examining heat dissipation performances by connection to enclosure
- Considering PCB mounting environment

Functions available in PICLS and PICLS Lite

* PICLS Lite is provided online

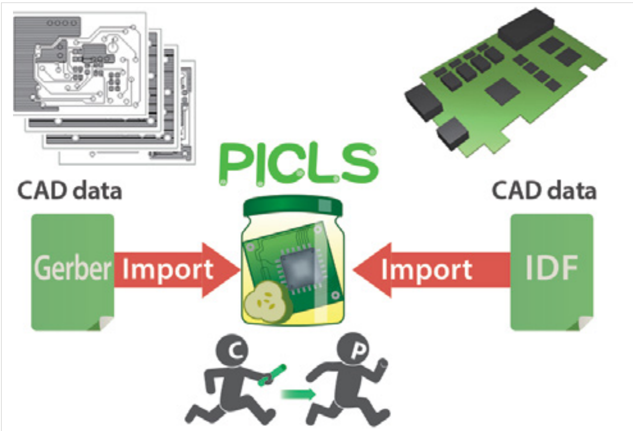
○ ...PICLS and PICLS Lite	● ...PICLS only

- ○ Multiple layers
- ● IDF3.0 interface
- ● Considering a heatsink
- ○ 3D preview
- ○ Displaying each layer
- ● Library
- ● Drill data import
- ○ Automatic report output
- ○ Forced air cooling
- ○ Radiation
- ○ Temperature margin, alert function
- ○ Wiring area specication
- ○ Thermal via
- ● Consideration of simple enclosure
- ● Wiring data (Gerber) import
- ○ Cutting out a PCB
- ○ Real-time display
- ○ Contact thermal resistance

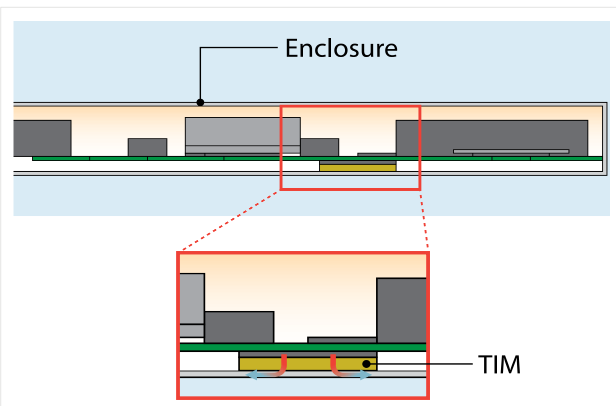
PICLS

Main features of PICLS and PICLS Lite

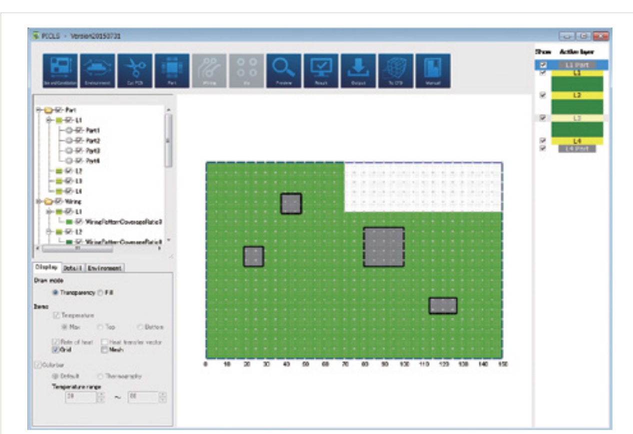
Modeling



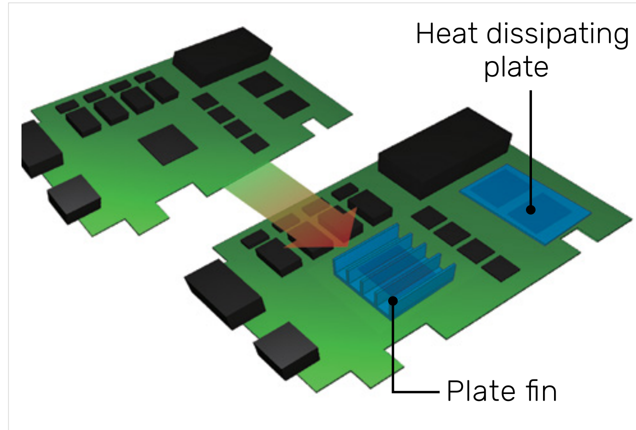
External file interface
You can import IDF 3.0 and Gerber data
PICLS



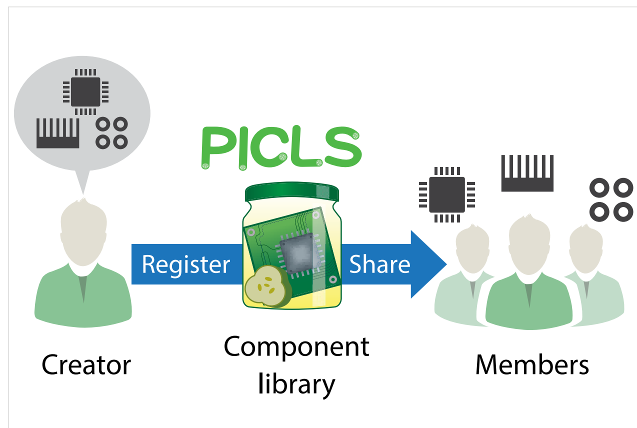
Consideration of simple enclosure
YYou can consider heat dissipation by connection to enclosure
PICLS
PICLS Lite



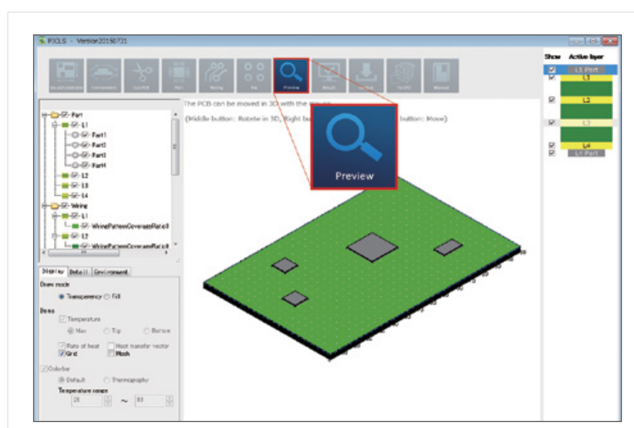
Cutting out a PCB
You can create PCB of arbitrary shape using cut-put function
PICLS
PICLS Lite



Heatsink
You can allocate and display parts such as plate ns and heat dissipation plates
PICLS

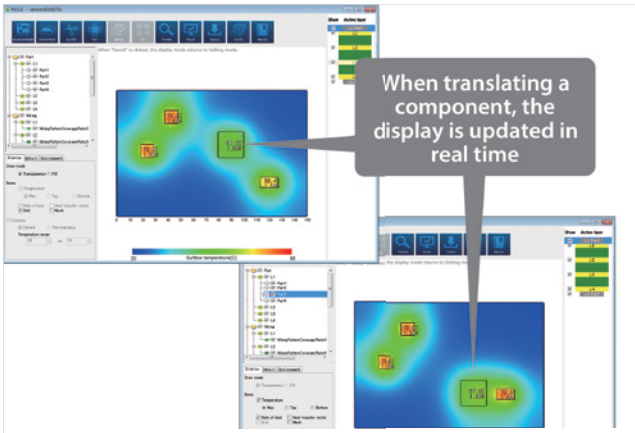


Library
You can register and reuse created parts to the library
PICLS



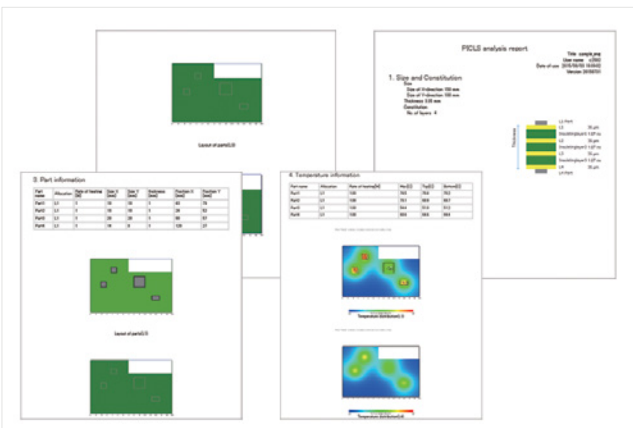
Preview
You can check the layout of components in the 3D image
PICLS
PICLS Lite

Calculation and Post-Processing



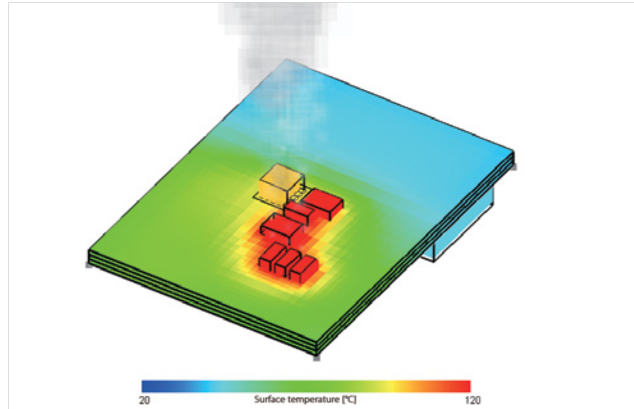
Real-time display
The translation of components is displayed in real time

PICLS
PICLS Lite



Report output
You can output analysis results as reports

PICLS
PICLS Lite



Alert function
You can check parts whose temperature is higher than threshold

PICLS
PICLS Lite

System Cong uration

Compliant OS
Windows 10, Windows 11 (Veried by version 21H2, 22H2) Windows Server 2022
Recommended environment
[Memory] 2.0 GB or more [Hard disk] 0.5 GB or more free capacity recommended [Display resolution] 1920 x 1080 or more [Graphics] Graphics card that supports OpenGL

PICLS

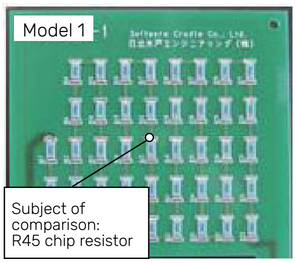
Changing Printed Board Layout to Lower Device Temperature: Prediction and Measurements

Using PICLS to perform thermal analyses and predict temperatures of chip resistors

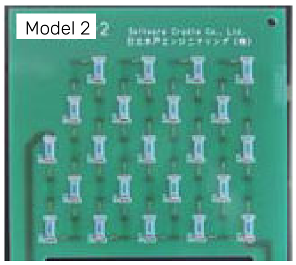
Thermal Analyses of Printed Boards

Analysis targets

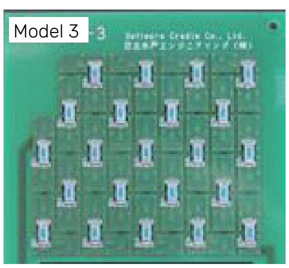
Original



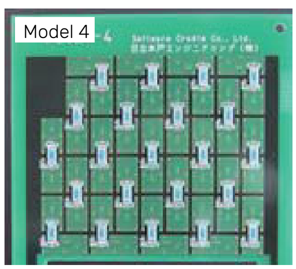
Half the resistors allocated on the back



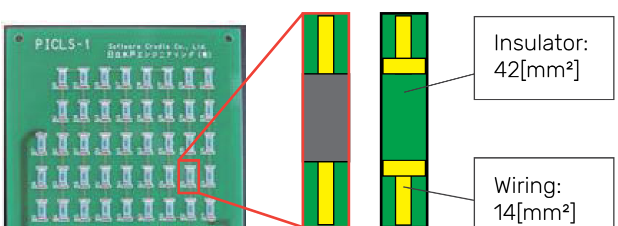
Copper foils and vias added



Solid layer added to the inner layer

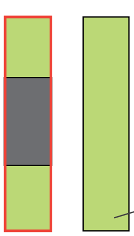


Modeling



Actual printed board

PICLS



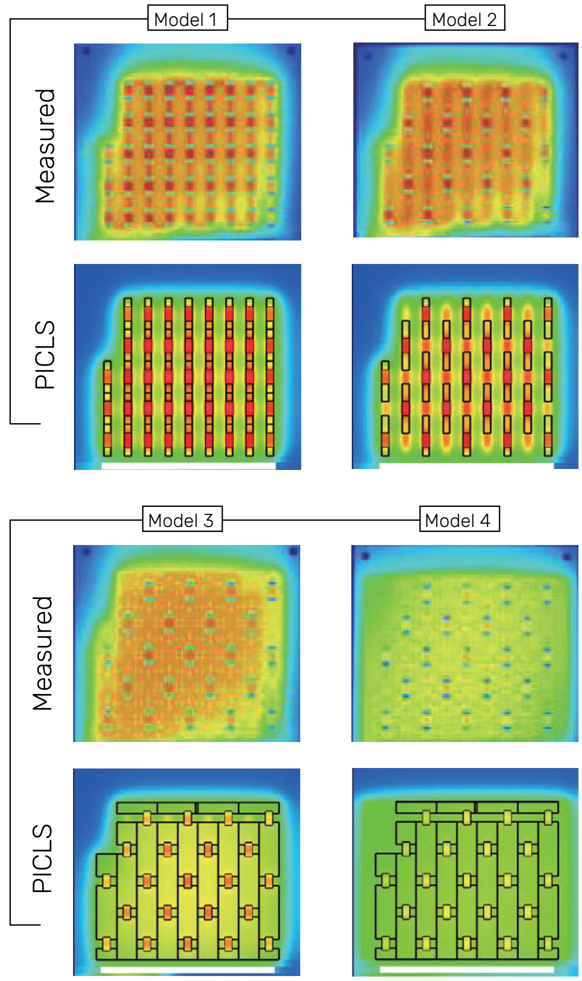
Uniform thermal properties assigned to models based on proportion of wirings to insulator.

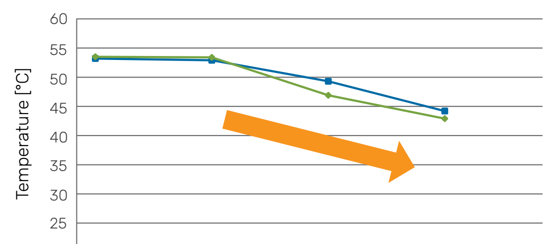
14÷42 0.33
Wiring pattern
coverage ratio of 33%

Time needed to generate model:
5 minutes Time needed for calculation: Seconds

Analysis results

Analysis targets





	Model 1	Model 2	Model 3	Model 4
Actual test	53.2	52.9	49.3	44.2
Thermal analyses using PICLS	53.5	53.4	46.9	42.9

Note

The R45 chip resistor temperatures are shown in the graph for the four models. Both measurement and analysis results show decreasing temperatures proceeding from Model 1 to 4. PICLS can be used to identify temperature trends for different model layouts and features.

PICLS can be used during conceptual design, to quickly evaluate the effects of electronic component allocation and thermal vias on printed circuit board device temperatures.

SC/Tetra

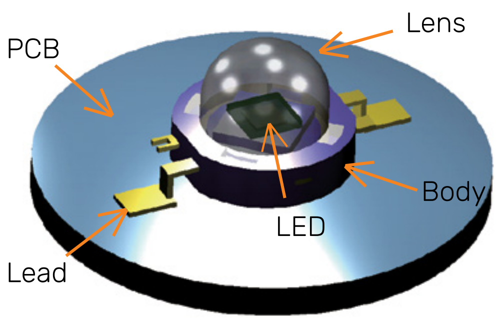
Heat Release of LED Device

Case study of SC/Tetra

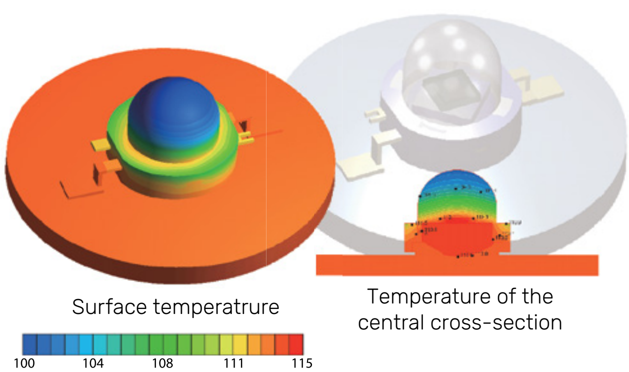
Comparison of SC/Tetra analysis result with experimental result for heat release of LED device

Heat release analysis of LED device

Analysis targets

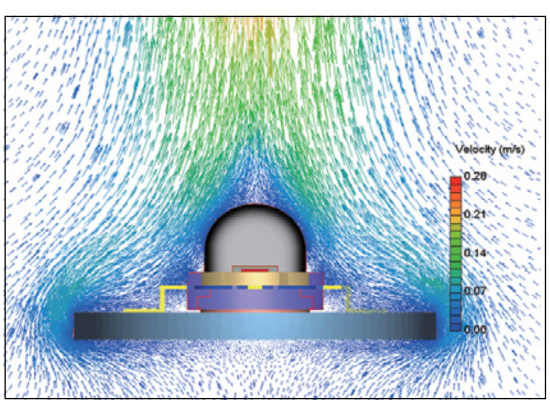


Surface and cross-section temperature distribution

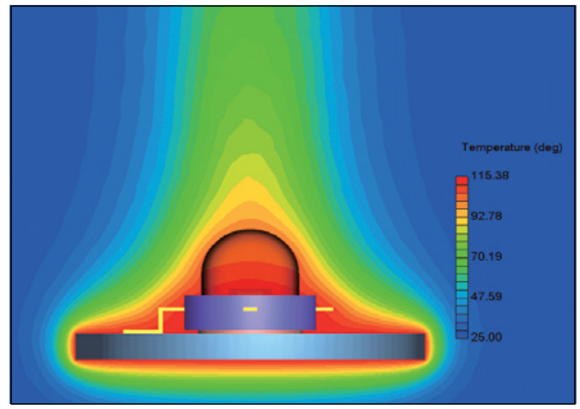


Heat of LED device is released mainly through PCB on which the device is installed and/or heat sink installed on the back of the PCB. SC/Tetra successfully simulates the phenomenon of heat release from the PCB.

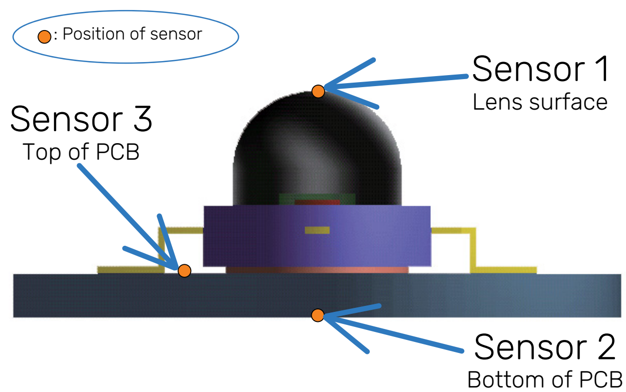
Flow pattern around the device (vector map)

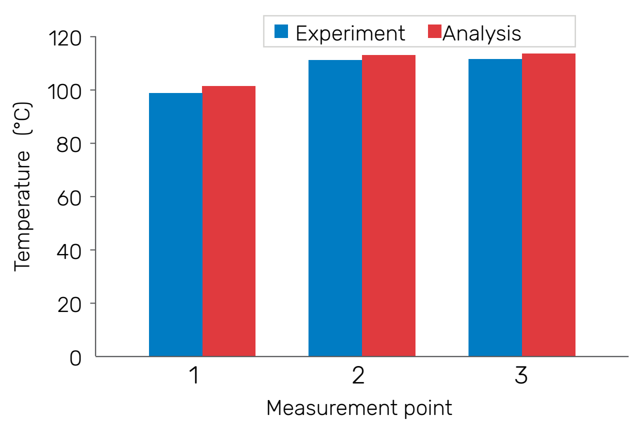


Fluid temperature distribution around the device (contour map)



Comparison between experimental and analysis values (temperature)





Note

In this analysis, simulation is performed with consideration on heat release through PCB as well as heat release due to natural convection of ambient air. The analysis result is almost the same with the experimental result (approximately 2.2 °C dierence), which is adequate to simulate the tendency of the phenomenon.

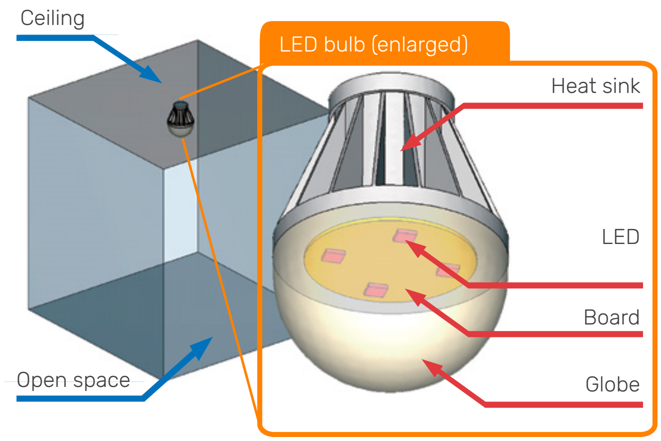
SC/Tetra

Thermal Fluid Analysis on LED Bulb

SC/Tetra Function

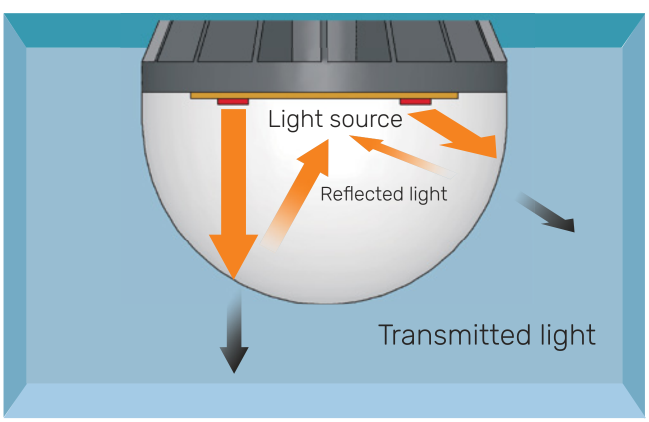
Investigating the Thermal Eect of Bulb Cover Transmittance using SC/Tetra

Details of Analysis Model

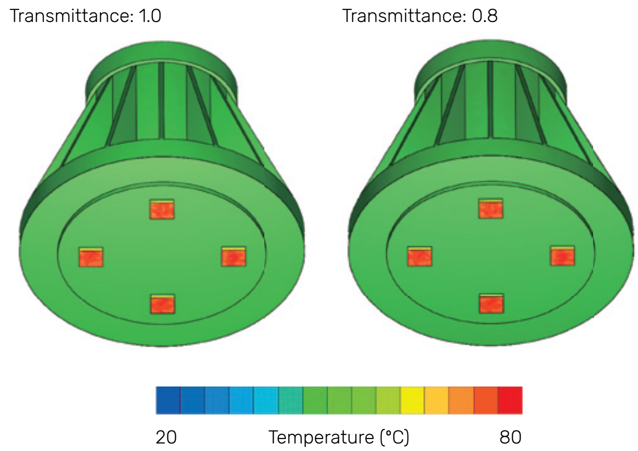


Eect of Bulb Cover Transmittance

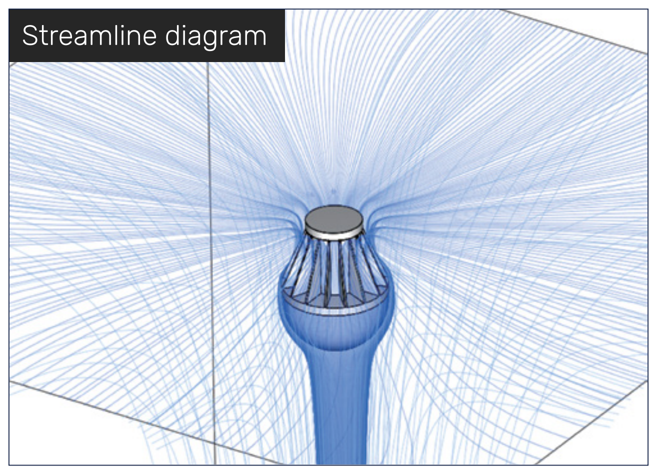
Once emitted from the light source, light is transmitted and reflected. The latter is partially absorbed as heat within the globe, hence changing the temperature of the various bulb components. The surface temperature distribution changes depending on the degree of transmittance.

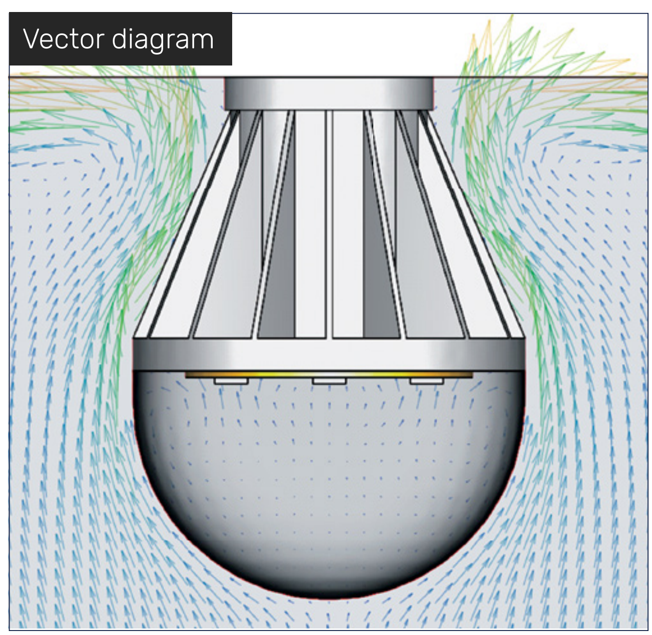


How Surface Temp. Distribution Changes by Different Transmittance



Eect of Bulb Cover Transmittance



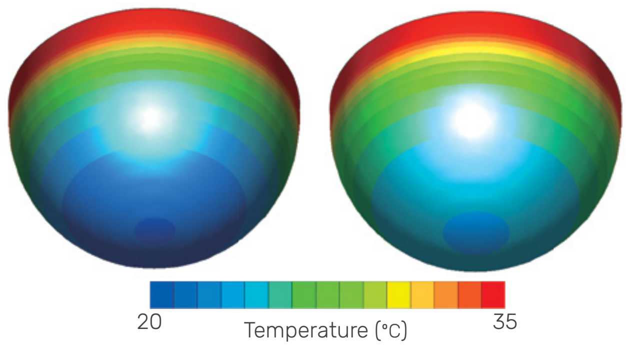


Displaying the streamline

SC/Tetra depicts the flow path in 3D, allowing users to examine details, such as whether there is air in the gaps between fins.

Displaying the vectors

Flow speed is displayed as vectors with a color distribution from blue to red and arrows in different sizes. The arrows indicate directions. This output is often used as a cross section diagram of the target.



Globe surface temperature changes by approx. 3 degrees

Note

There is a growing demand for LED light bulbs because of their energy efficiency, small size, and long-lasting brightness. LED bulbs can also be adjusted to change color temperature and stretch the width of the beam to create innovative lighting effects. CFD simulation allows better understanding of the physical phenomena, bringing a great advantage to designers in the development of such highly competitive products with superior qualities.

scSTREAM

Heat Dissipation of Lighting Equipment and Optimization

Optional Function

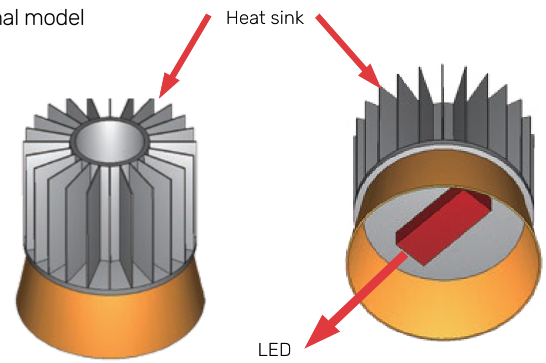
Eective Use of Optimization Tool for Heat Sink Design

Purpose of Optimization

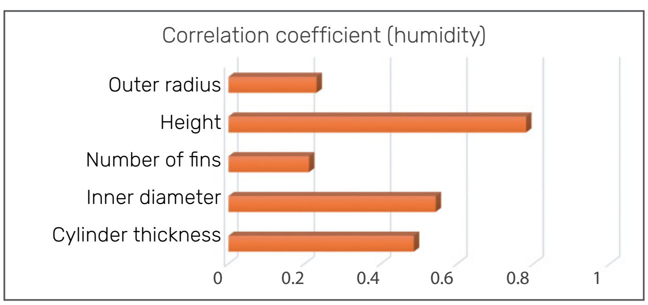
The modeling of heat sink needs to:

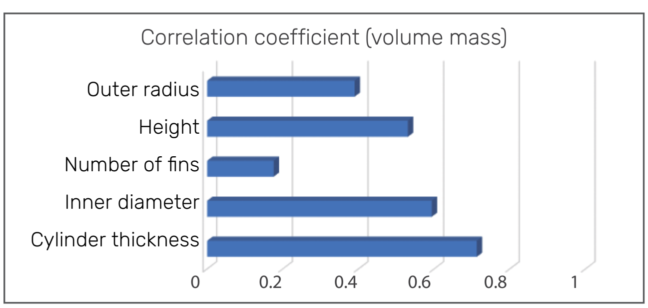
- Reduce the LED temperature to the regulation
  Rising LED temperature [°T°C]: Minimized (°T: below 40°C)
- Miniaturize itself
  Heat sink volume [weight]: Minimized (below 0.0005m³)

Original model



Sampling results





The strong correlation between the number of fins, fin height and outer radius shows that the increase in these factors encourages temperature reduction.

In terms of volume mass, the correlation between the number of fins, fin height, and outer radius is strong.

Optimization methods

Experiment plan and sampling method

- Central composite design ⇒43 samples

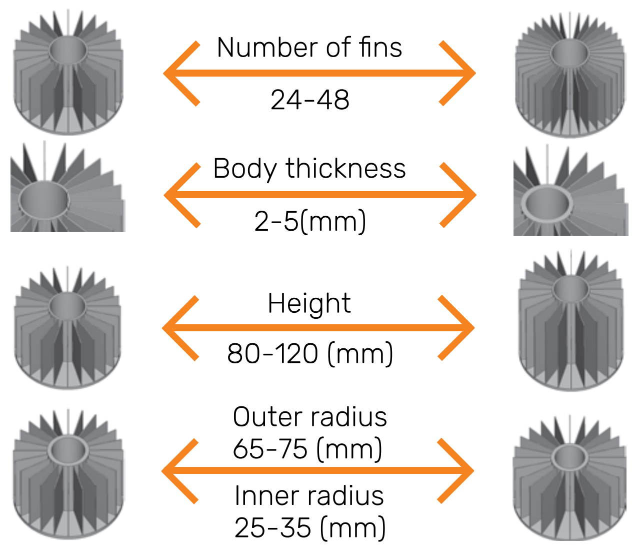
Approximation of multiobjective optimization

- Method of application ⇒RBG
- Method of multiobjective optimization ⇒NSEA+

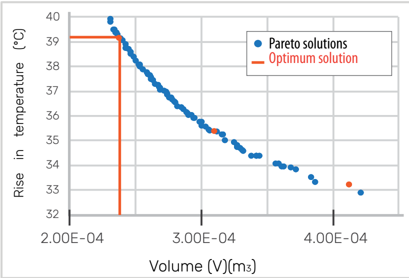
Applications used

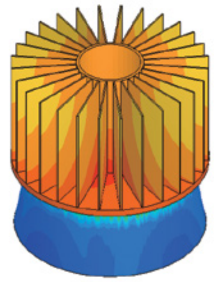
- scSTREAM
- Optimus® for Cradle

Design variables



Change design variables for sampling





Priority on light weight

Volume	2.40×10-4 [m^3]
Rise in temperature	39.1 [°C]
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Heat sink height	82.5 [mm]
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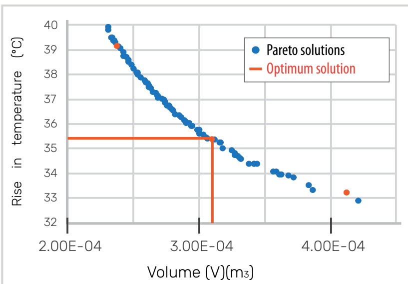

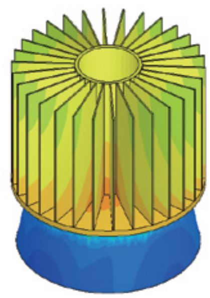

Priority on balance

Volume	3.11×10-4 [m^3]
Rise in temperature	35.4 [°C]
Number of fins	30 [pieces]
Heat sink height	104.9 [mm]
Thickness of cylinder	2.9 [mm]
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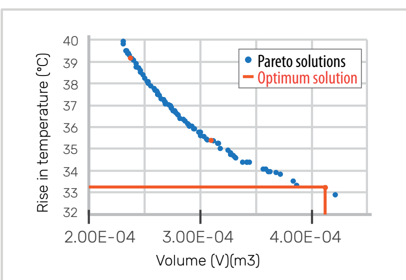

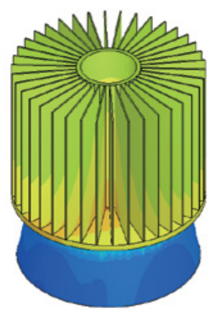

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Note

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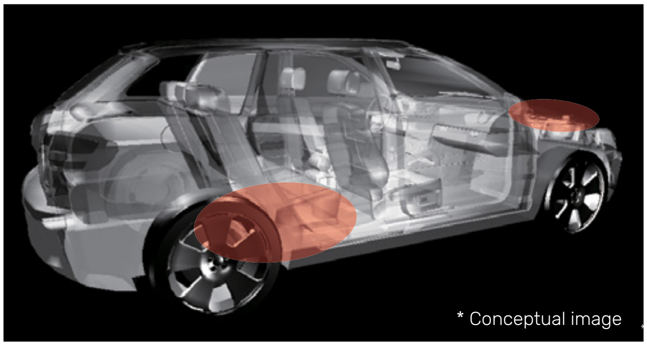
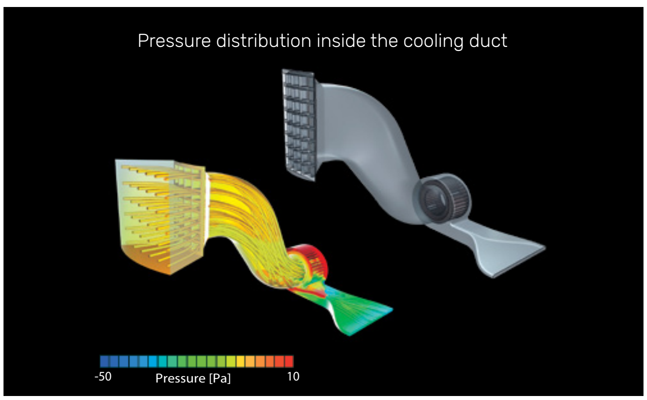
scSTREAM

Analysis of Cooling Systems for Hybrid and Electric Vehicles (HEV/EV)



Battery Cooling Fan Module



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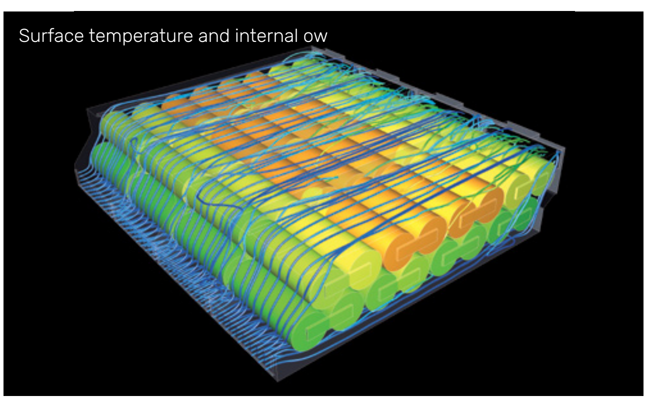
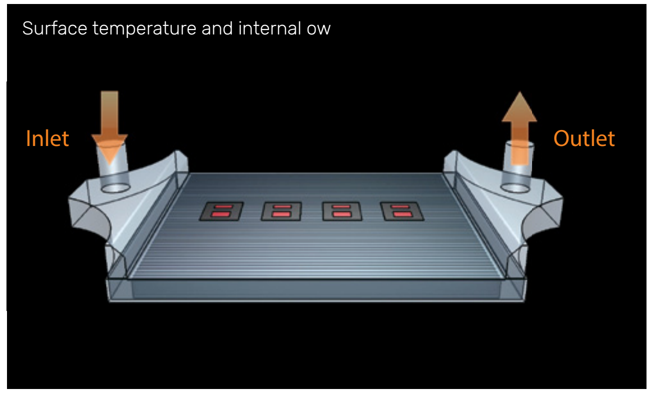
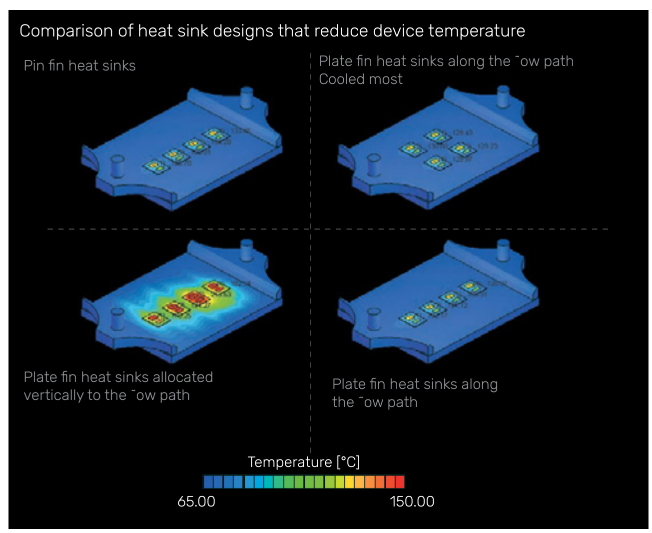


Direct Liquid Cooled IGBT Module



The IGBT (Insulated Gate Bipolar Transistors) plays an essential role in activating the inverter within the PCU (Power Control Unit), the main HEV/EV control module, to generate three-phase electric power.

The IGBT output must be adjusted depending on the vehicle size class. With a larger output, more heat will be generated from the IGBT, which makes cooling performance a crucial factor when designing IGBT modules. Simulation enables engineers to visually evaluate the impact of heat sink shape, observe the effect of heat dissipation, the difference in heat distribution, and other temperature critical patterns. This helps engineers to understand the thermal contributions from each component and determine the optimal design.



SC/Tetra / scSTREAM / HeatDesiner

Heat Dissipation of Lighting Equipment and Optimization

Optional Function

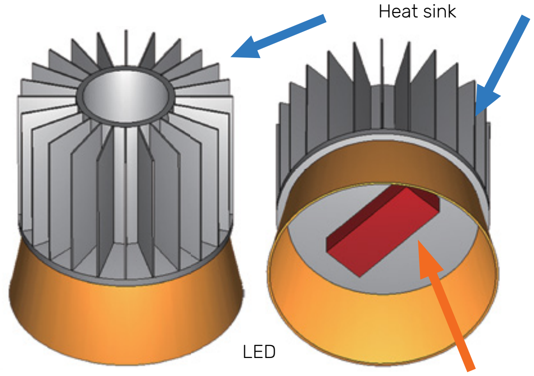
Eective Use of Optimization Tool for Heat Sink Design

Purpose of Optimization

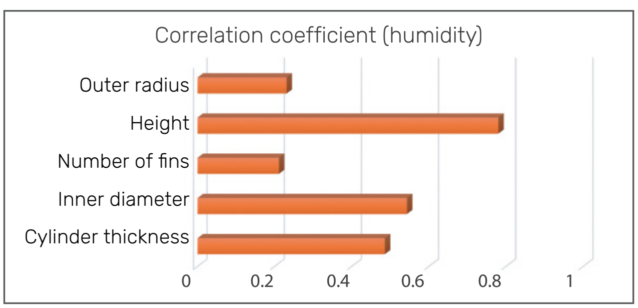
The modeling of heat sink needs to:

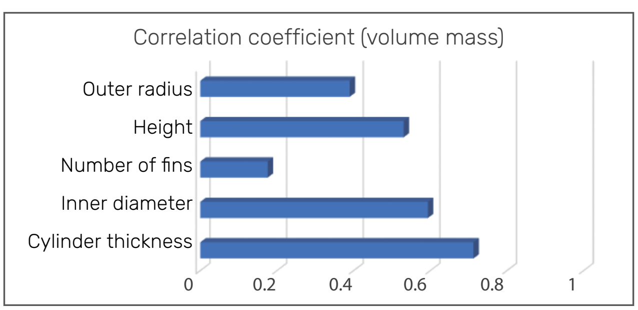
- Reduce the LED temperature to the regulation
  Rising LED temperature [°T°C]: Minimized (°T: below 40°C)
- Miniaturize itself
  Heat sink volume [weight]: Minimized (below 0.0005m³)

Original model



Sampling results





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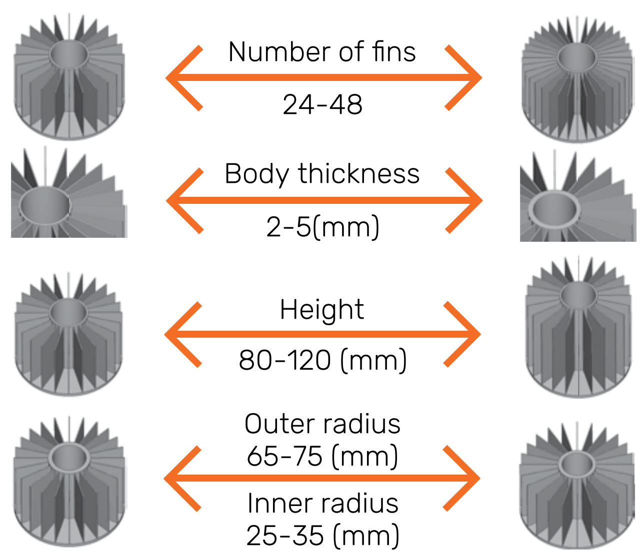

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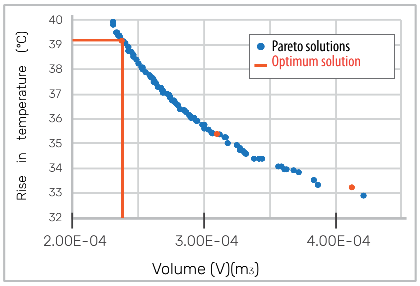

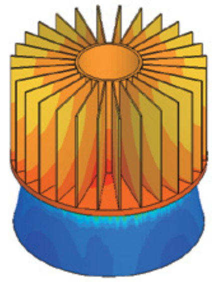

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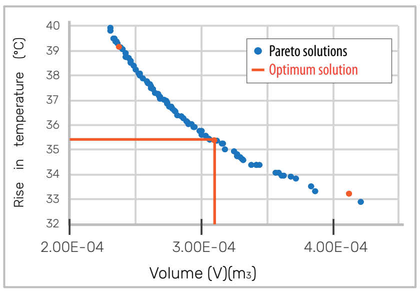

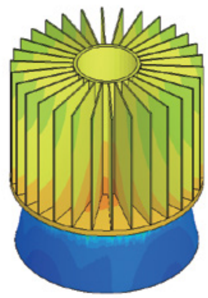

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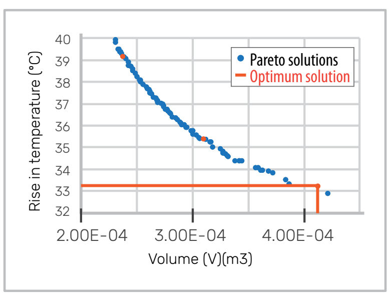

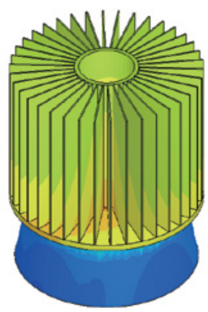

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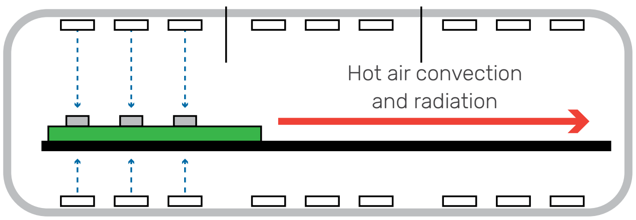
HeatDesiner / SC/Tetra

Predicting Temperature Changes and Chip Standing Phenomenon for a Printed Board During Reow Process

HeatDesigner and SC/Tetra used to analyze the reow process for a printed board assembly

Simulating Temperature Changes on a Printed Board During Reow Process Using HeatDesigner

Analysis model

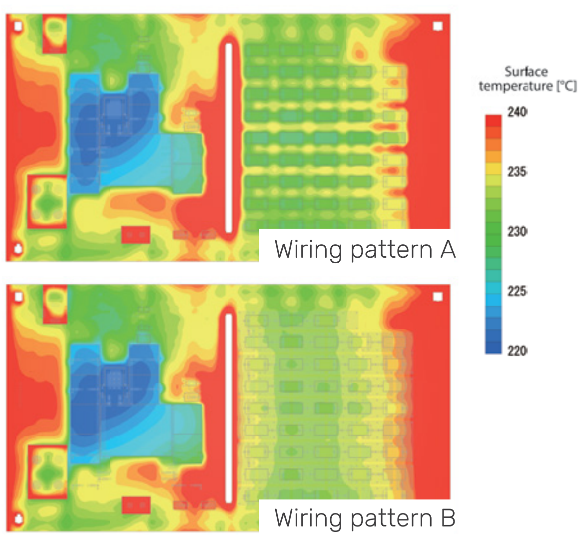


Reflow furnace

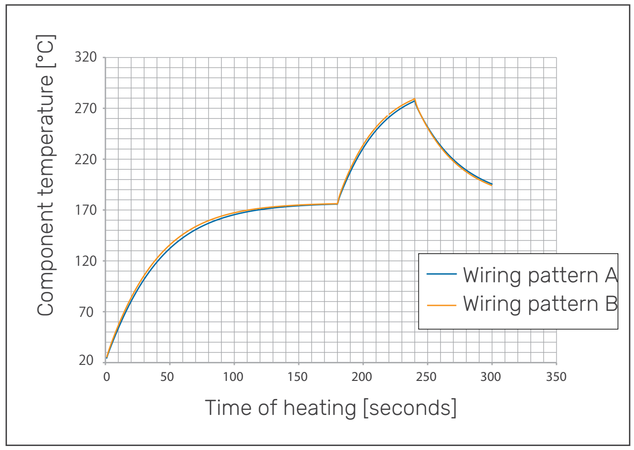
A transient thermal uid analysis is conducted, simulating hot air convection, radiation and heating within the reow furnace

Wiring patterns, component allocations, and material changes can be evaluated.

Analysis results



Temperature distribution on printed board after 200 seconds

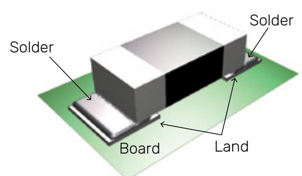


Chip resistor temperature changes as function of time

- Printed board temperature is affected by wiring patterns and component allocation.

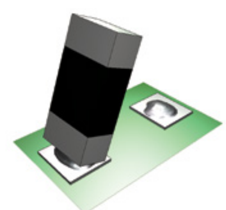
Simulating Chip Standing Phenomenon Using SC/Tetra

Analysis model



Chip resistor (0402 size)

Analysis results



Time dependent behavior of molten solder is analyzed using the VOF (Volume Of Fluid) method. If the solder is misaligned, the chip resistor can translate and rotate due to the force from the molten solder.

Note

Analysis results show the occurrence of the chip standing phenomenon (known as Manhattan phenomenon), due to the force generated by the solder acting on the chip resistor. The effects of soldering time, amount of solder, and positions of the chip resistor can be evaluated using the simulation.

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