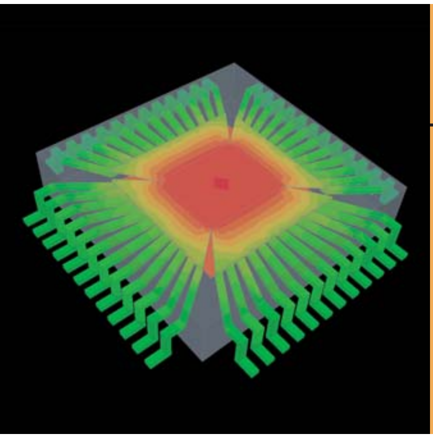
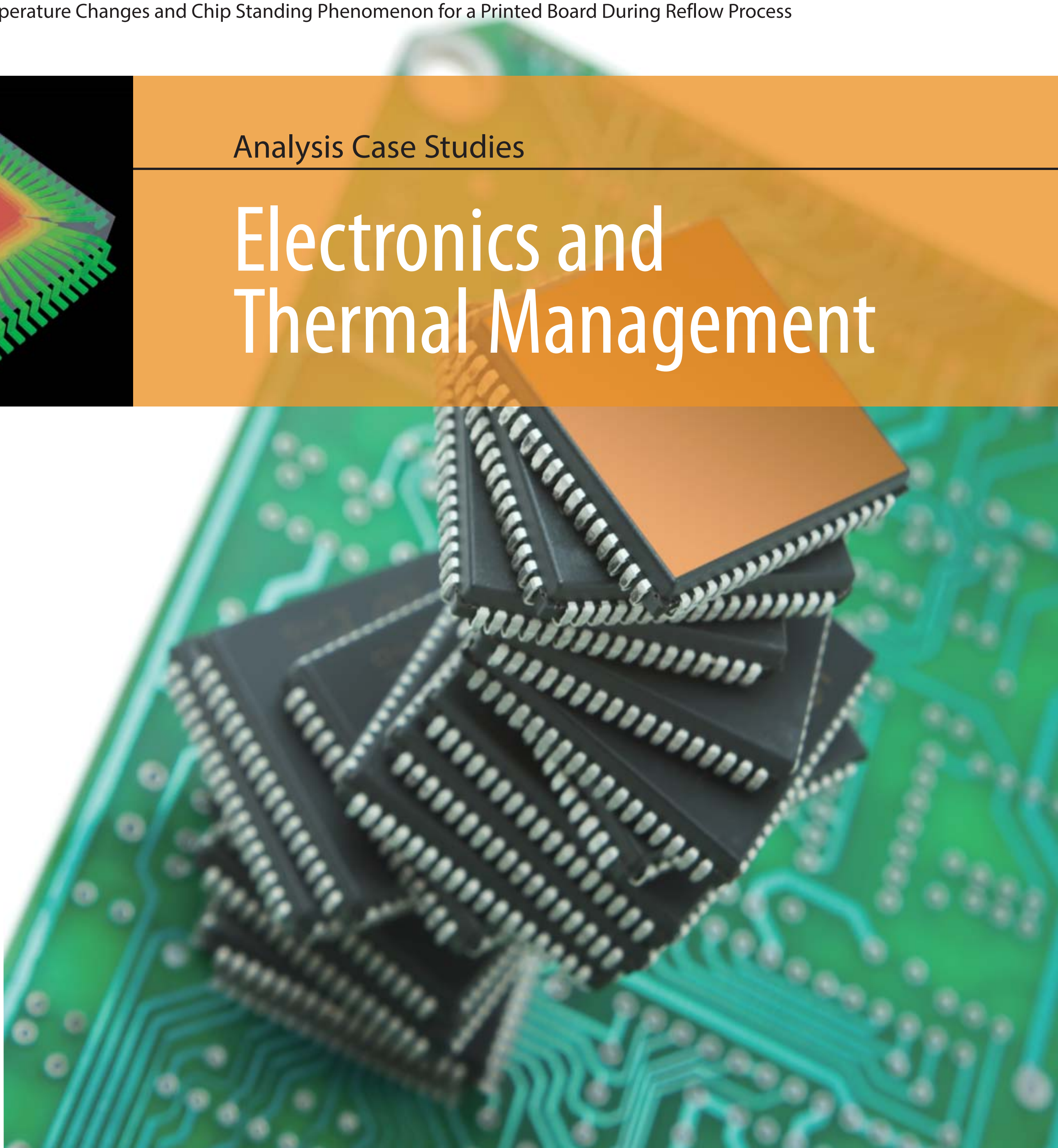
- Temperature Prediction of an LED Bicycle Headlight
- Cooling System for Hybrid and Electric Vehicles (HEV/EV)
- Application Example of HEATLANE®
- Water-Cooled Plate Development
- Heat Release Design for Printed Circuit Board
- Gerber Data Import and Other Functions
- PICLS: Tool for Real-Time Thermal Simulation of Printed Circuit Boards
- Changing Printed Board Layout to Lower Device Temperature: Prediction and Measurements
- Heat Release of LED Device
- Thermal Fluid Analysis on LED Bulb
- Heat Dissipation of Lighting Equipment and Optimization
- Heat Release Analysis of Lighting Equipment
- Predicting Durability of Junctions for Mounted Parts
- Predicting Temperature Changes and Chip Standing Phenomenon for a Printed Board During Reflow Process



Analysis Case Studies

Electronics and Thermal Management



HeatDesigner

Temperature Prediction of an LED Bicycle Headlight

CATEYE Co., Ltd. Case Study HeatDesigner Function

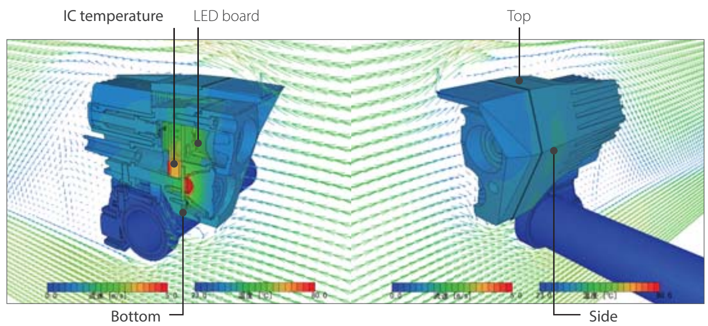
Temperature predictions of an LED bicycle headlight using HeatDesigner compare favorably with measured values

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.

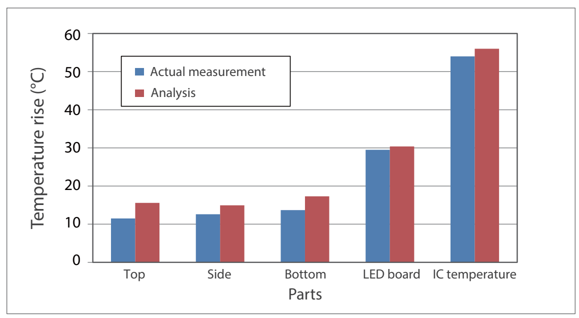
CFD analysis was used to calculate the temperature rise in the Cateye HL-EL930RC bicycle headlight and identify thermal paths. The temperature predictions were compared to measured values, and the thermal paths showed the amount of heat release from each section of the light. This methodology can be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

Measurement and simulation



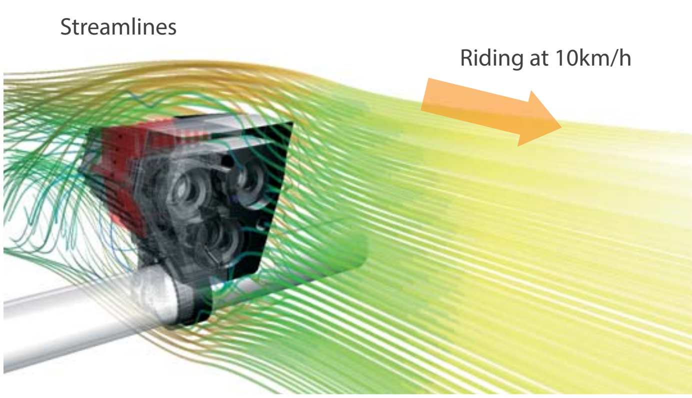
Simulated velocity vectors and temperature distribution

LED bicycle headlight (HL-EL930RC)



Temperature rise of each part

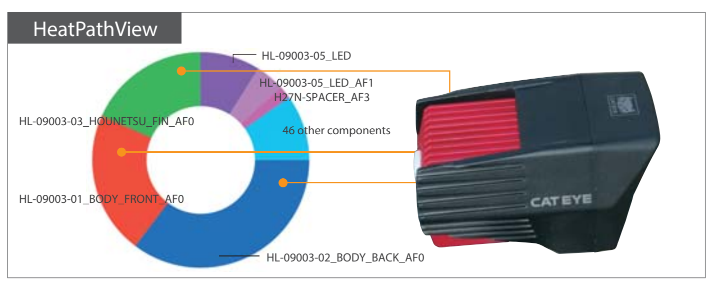
Benefits of simulation



Streamlines of air flow around the bike light

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

Identifies which sections of the light contribute the most heat release

This information can be used to improve and optimize the design

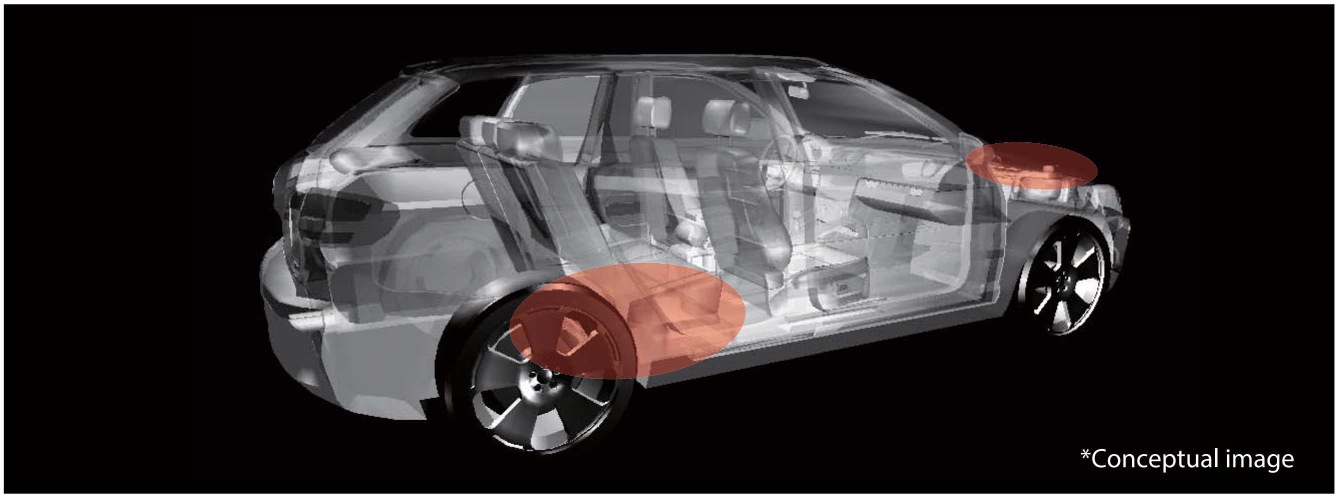
Customer Comments

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 different headlight shapes and materials. HeatDesigner is an excellent design simulation tool for products subject to demanding thermal challenges.

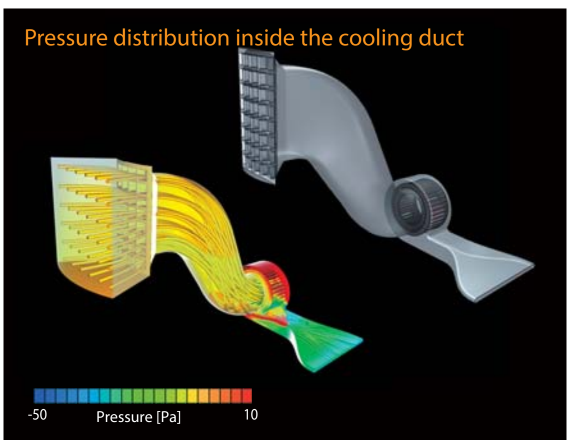
SC/Tetra

Cooling System for Hybrid and Electric Vehicles (HEV/EV)

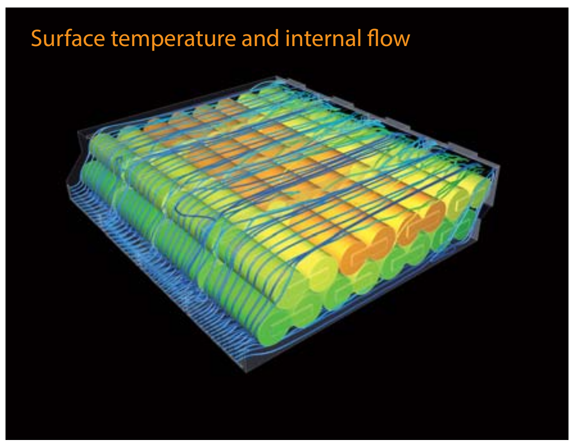
SC/Tetra Application Example



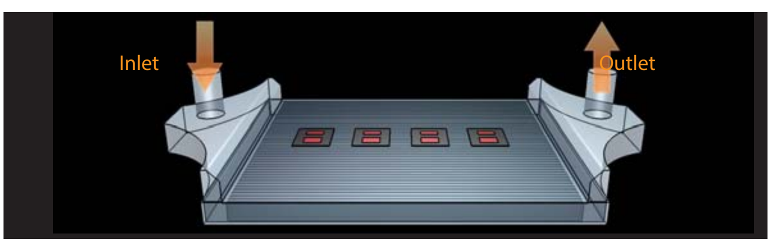
Battery Cooling Fan Module

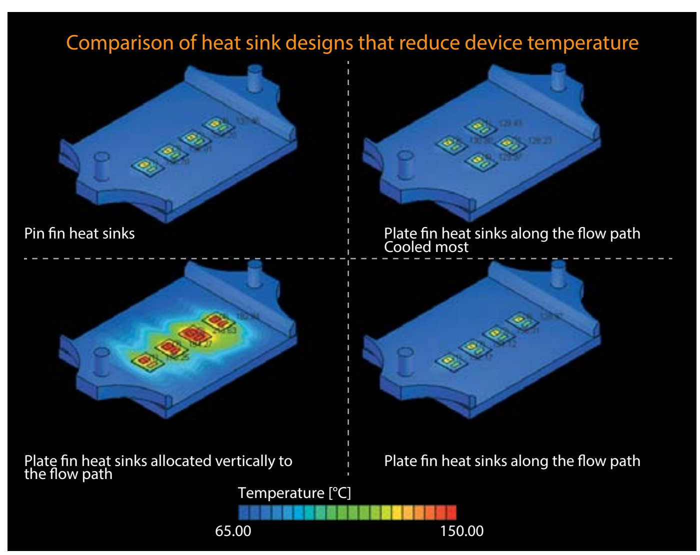


Battery Packs



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 identify the optimal design.

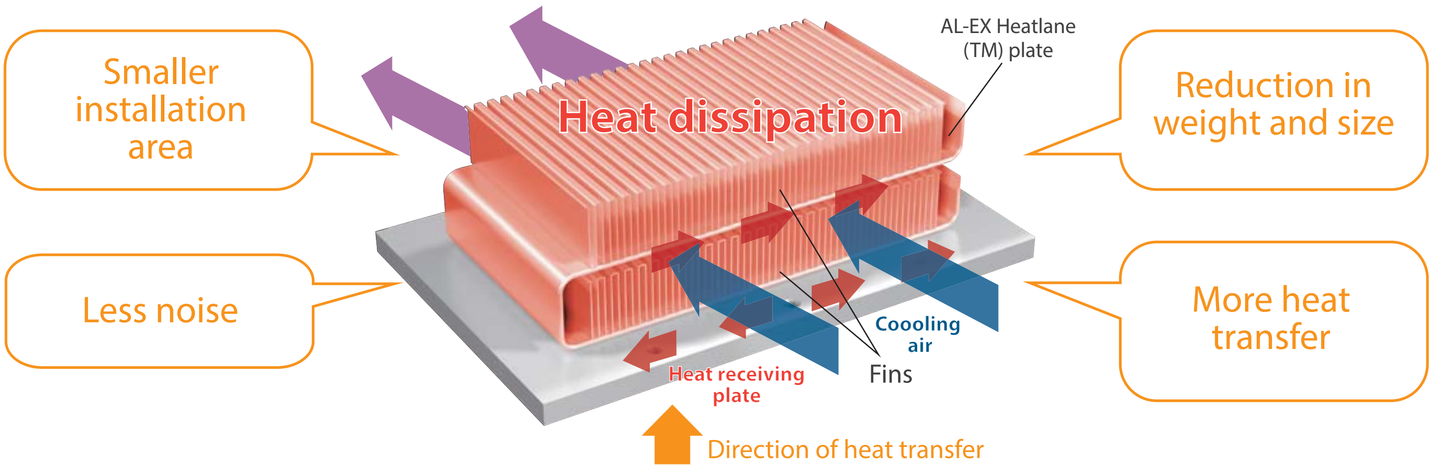
HeatDesigner

Application Example of HEATLANE®

Case Study for Mizutani Electric Ind. Co., Ltd.

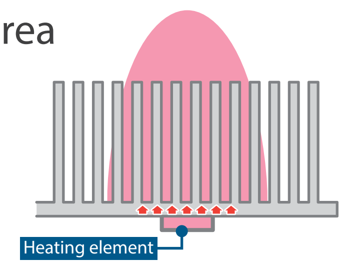
Patent, trademark registered

Designed to offer the best performance in the limited space

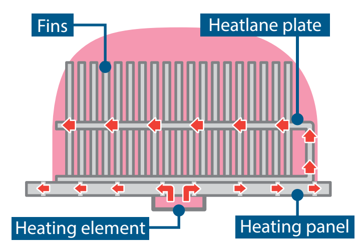


Expand the Heat Dissipation Area

- Quickly dissipates heat and extends heat dissipation area
- Extremely effective when cooling down devices with high thermal density
- Thermal characteristics are reinforced by heat transfer through accumulated low-height fins on Heatlane



Regular heat sink



Heatlane

Evaluation example

Model shape used:
200 width x 130 length x 70 height, 8.2 base thickness (mm)

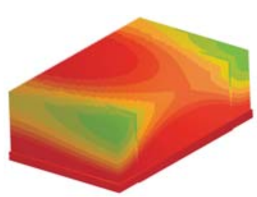
Conditions
- Heating element: 140 x 130 (mm), 500 (W)
- 2 m/s front velocity

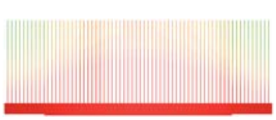
Types	Modeling of fins (mm)	Thermal resistance (ºC/W)	Mass (g)
Heatlane	0.5 (thickness) x 110 (length) x 28 (height), 56 fins x 2 layers	0.064	1130
Regular heat sink	0.5 (thickness) x 130L (length) x 61.8 (height) x 66 fins	0.088	1300

CFD analysis application

Regular heat sink

Heat centers near the heating element. The degree of Fin effectiveness remains low as the heat dissipating area is small.



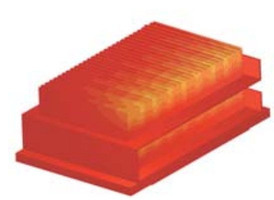


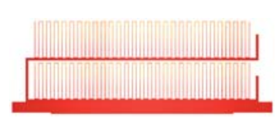
Heatlane

Heat is transferred to the entire fin through Heatlane plates.
Functioning performance is optimized by high fin effectiveness and dissipated base heat.

	Thermal resistance (ºc/W)
Measured value	0.065
Analysis value	0.064

Analysis and test values are virtually equal





Customer Comments

Accurate thermal analysis is crucial for satisfying engineers' various needs today. scSTREAM and HeatDesigner are the very rare tools that enable us to simulate our designs in a way as close to actual measurements as possible. We are happy with Cradle's software and hope to continuously use it for more thermal analyses.

scSTREAM

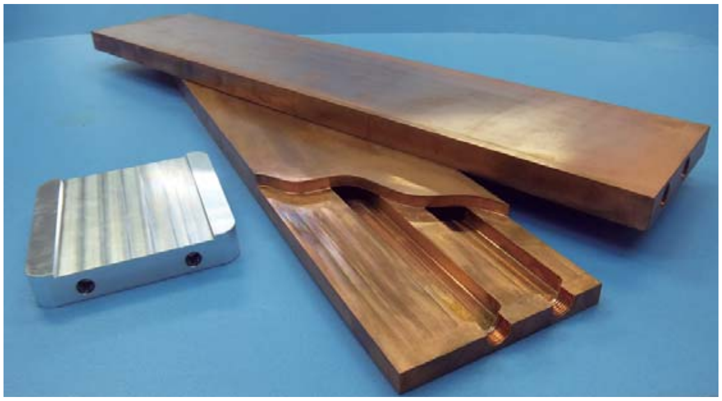
Water-Cooled Plate Development

Case Study for Mizutani Electric Ind. Co., Ltd.

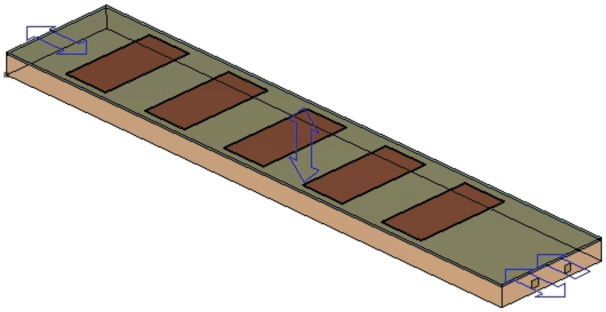
Application Example of scSTREAM for Water-cooled Plate Analysis

Designing the Optimized Flow Path Using Thermal Fluid Analysis

Effective heat dissipation for home and office electronic devices is essential for ensuring product quality and durability. A water-cooled plate is often used to dissipate large quantities of heat when air cooling effect is not sufficient. By applying thermal fluid analysis, the flow path of a water-cooled plate can be designed in a short amount of time, often fast enough to support production orders. Visual analysis results also helped Mizutani Electric present the performance results to their clients and explain the effectiveness.



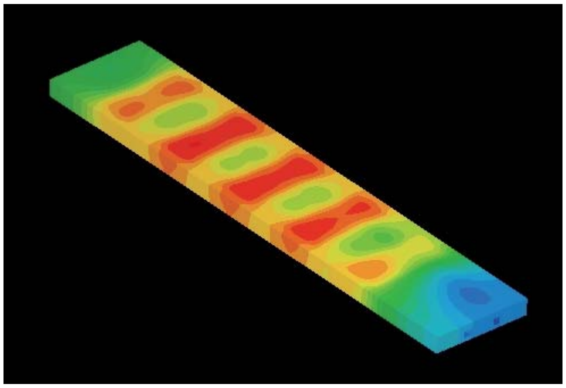
Cross section of a water-cooled plate



Water-cooled plate analysis model

Thermal analysis example

Plate dimensions	100 x 550 x 18 (mm)
Material	C1020
Heat element size	5 pieces @ 45 x 90 (mm)
Thermal load	1 (kW)
Flow rate	10 (L/min)
Predicted thermal resistance	0.0092 (ºC/W)
Measured thermal resistance	0.0095 (ºC/W)



Water-cooled plate analysis results

Customer Comments

The simulation and analysis capabilities of scSTREAM have helped us develop better products faster. We can customize the software for our purposes. The analysis results match well with theoretical and measured values, keeping the post production refinement tasks to a minimum.

MIZUDEN MIZUTANI

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.

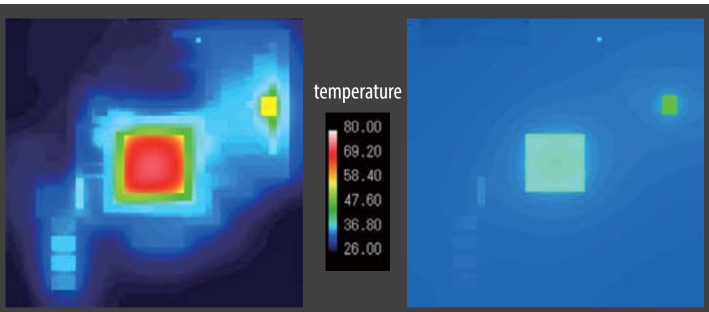
If the heat release could be mainly through natural convectioninstead of forced convection, it is possible to;

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

Design Changes

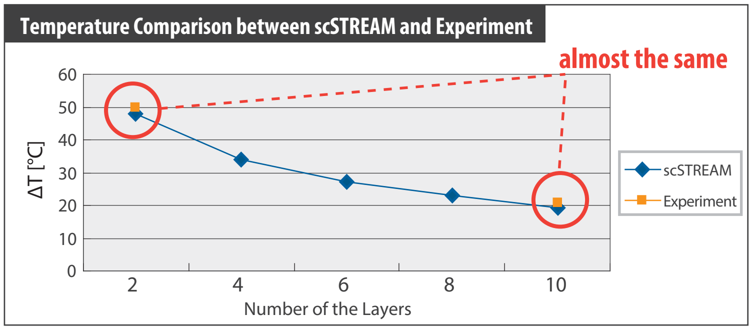
- For increasing the thermal conductivity of PCB
  The number of layers; 2 layers -->10 layers
  Halogen-free insulation
  Increase the residual copper area ratio
- For improving thermal conductivity of Board in PKG
  Ground connection of Chip NC pins
- For improving thermal heat transfer in PCB
  Additional aluminum fin at the back and at the edge of PCB
  Additional pin-fin at the dead space of PCB

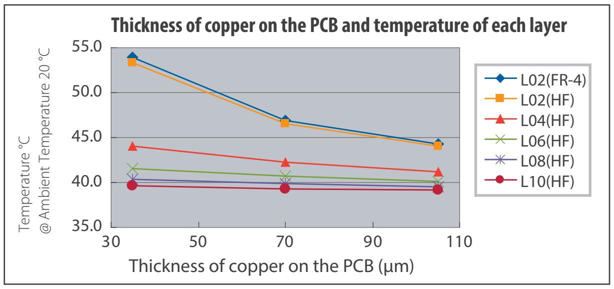
Analysis Results

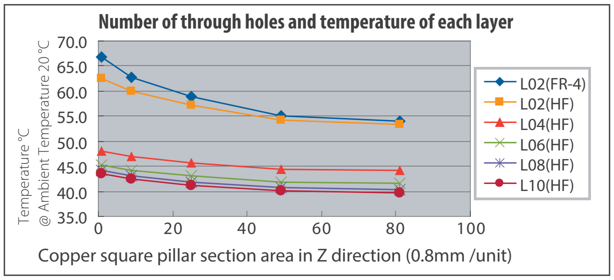


Only with the design changes on PCB, temperature goes down by more than 30 [°C]!

2 Layers(Before) 10 Layers (After)







Temperature for various different 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 **HeatDesigner**

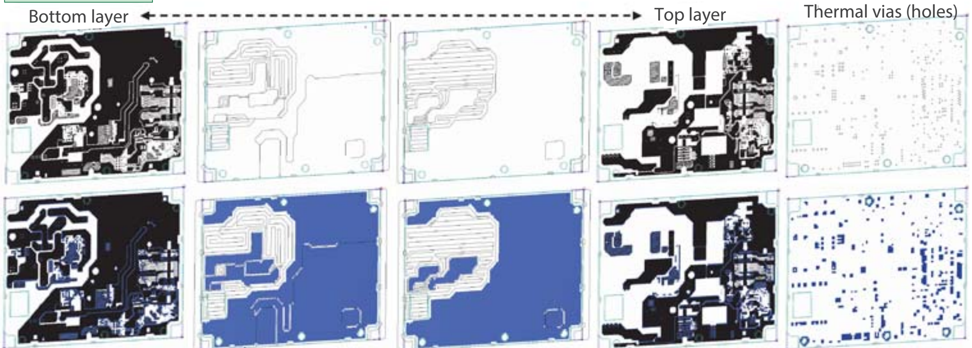
Gerber Data Import and Other Functions

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 effects of the wiring distribution.

Gerber data imported



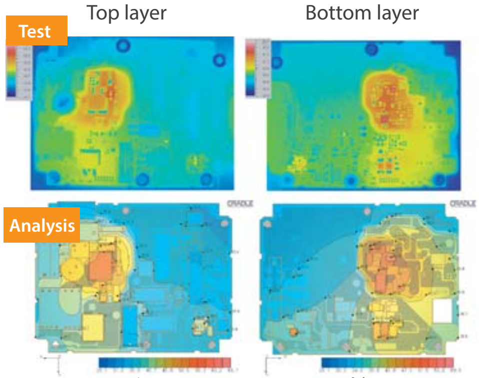
Meshes generated (thermal conductivity of copper applied to the area in blue)

Reversing the inner plane layer

Accounts for:

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

Simulate more accurate board temperature distribution



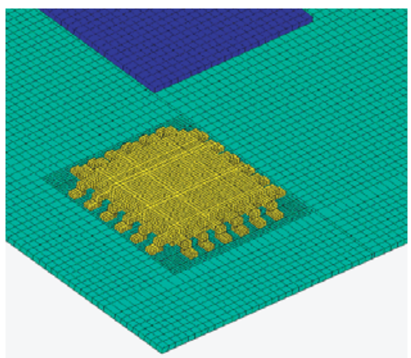
Comparison between standard procedure and Gerber data application

	Standard procedure	Gerber application
Number of mesh elements	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.

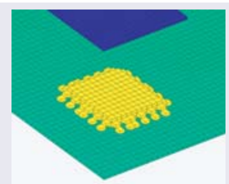


- Controls calculation time and memory share
- Improves calculation accuracy

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

Without multi-blocks

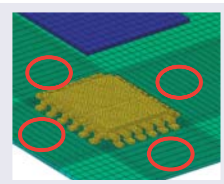
Meshes are coarsely generated. Intricate parts are not precisely represented.



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

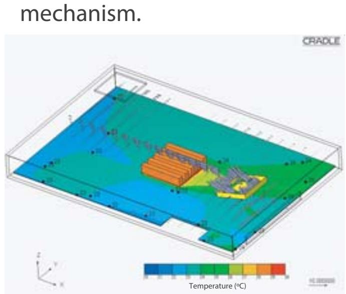
Without multi-blocks

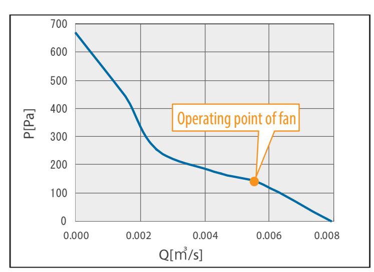
Due to fragmentation, meshes are unnecessarily generated, and can be overly assembled in some places.



Effect 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

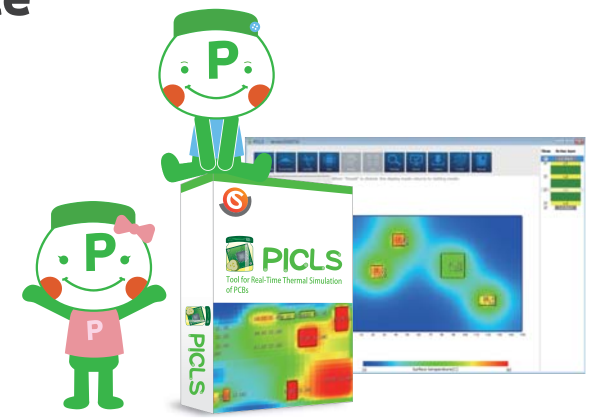
Wow! Was it this easy?!

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

PICLS PICLS Lite

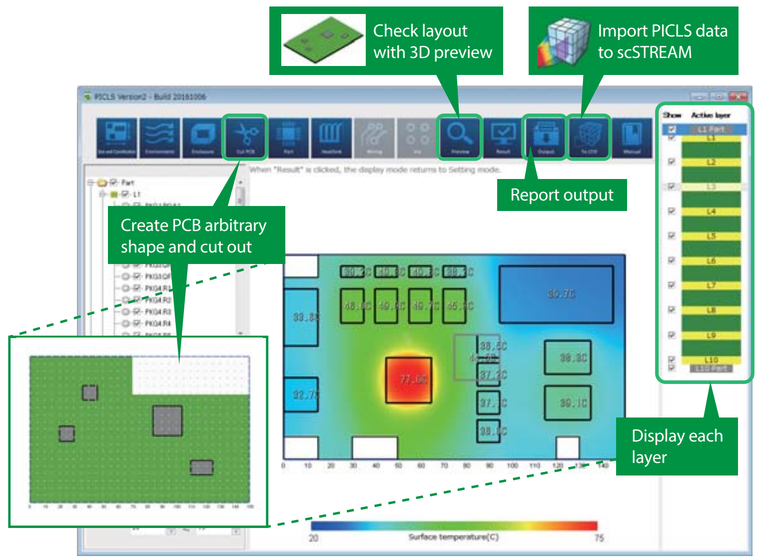
http://www.cradle-cfd.com/picls/

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.



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 fins, 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

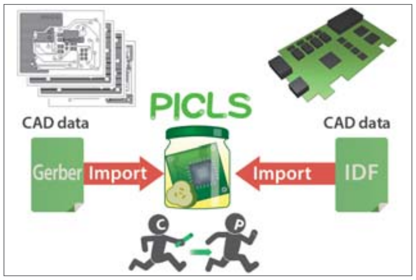
○ …PICLS and PICLS Lite ● …PICLS only

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

PICLS

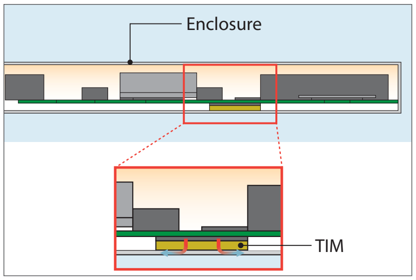
Main features of PICLS and PICLS Lite

Modeling



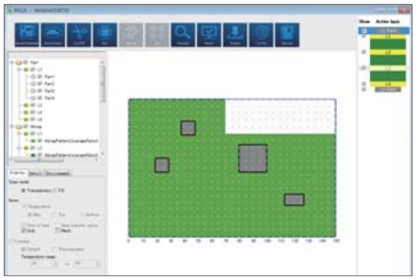
External file interface PICLS

You can import IDF 3.0 and Gerber data



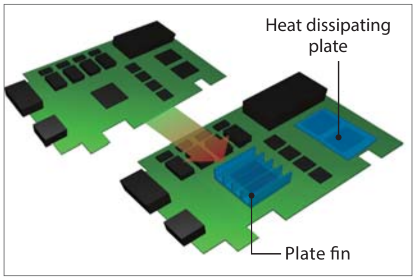
Consideration of simple enclosure PICLS

You can consider heat dissipation by connection to enclosure



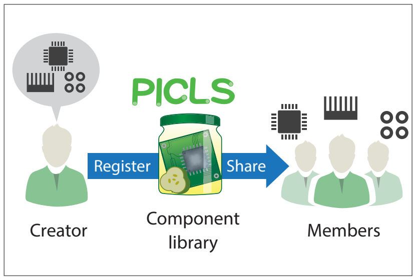
Cutting out a PCB PICLS PICLS Lite

You can create PCB of arbitrary shape using cut-put function



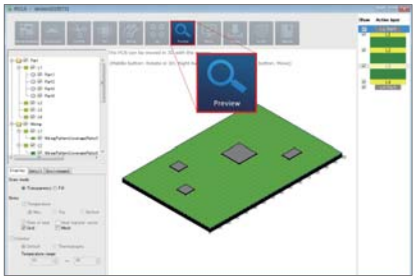
Heatsink PICLS

You can allocate and display parts such as plate fins and heat dissipation plates



Library PICLS

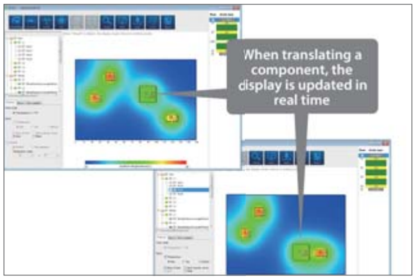
You can register and reuse created parts to the library



Preview PICLS PICLS Lite

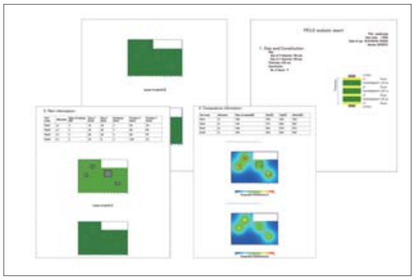
You can check the layout of components in the 3D image

Calculation and Post-Processing



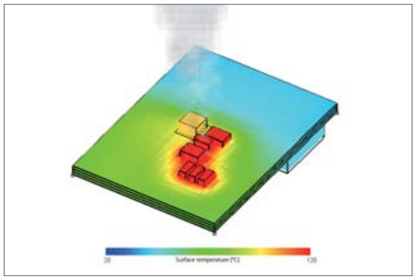
Real-time display PICLS PICLS Lite

The translation of components is displayed in real time



Report output PICLS PICLS Lite

You can output analysis results as reports



Alert function PICLS PICLS Lite

You can check parts whose temperature is higher than threshold

System Configuration

Compliant OS	Recommended environment
Windows 10 Windows 8.1 Pro (32bit) Windows 8.1 Pro (64bit) Windows 7 (Professional / Ultimate / Enterprise) (32bit) Windows 7 (Professional / Ultimate / Enterprise) (64bit) Windows Vista*1 (Business / Ultimate / Enterprise) (32bit) Windows Vista*1 (Business / Ultimate / Enterprise) (64bit) RedHat Enterprise Linux5*2, 6 (64 bit) *3 SUSE Linux Enterprise Server 11 (64 bit) *3	[Memory] 2.0 GB or more [Hard disk] 0.5 GB or more free capacity recommended [Display resolution] 1920 x 1080 or more

*1 Will not support after April 12, 2017.
*2 Will not support after March 31, 2017.
*3 Supports license manager only.

PICLS

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

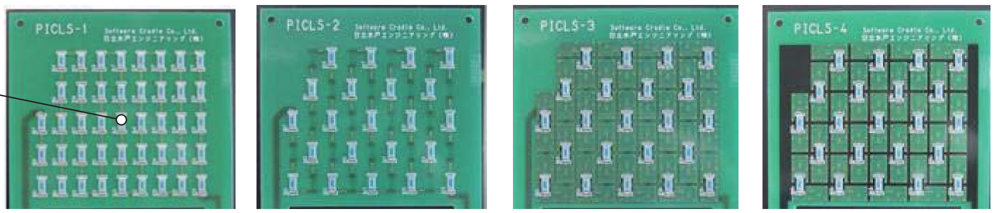
Using PICLS to perform thermal analyses and predict temperatures of chip resistors

Thermal Analyses of Printed Boards

Analysis targets

Model 1 | Model 2 | Model 3 | Model 4

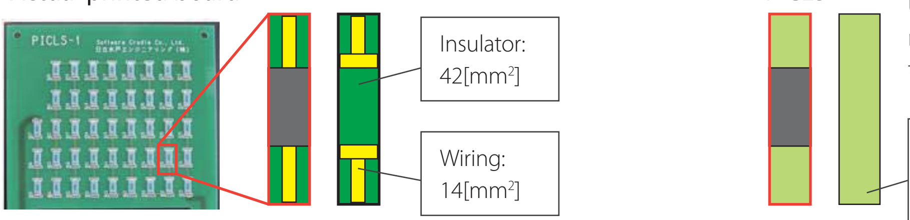
Subject of comparison: R45 chip resistor



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

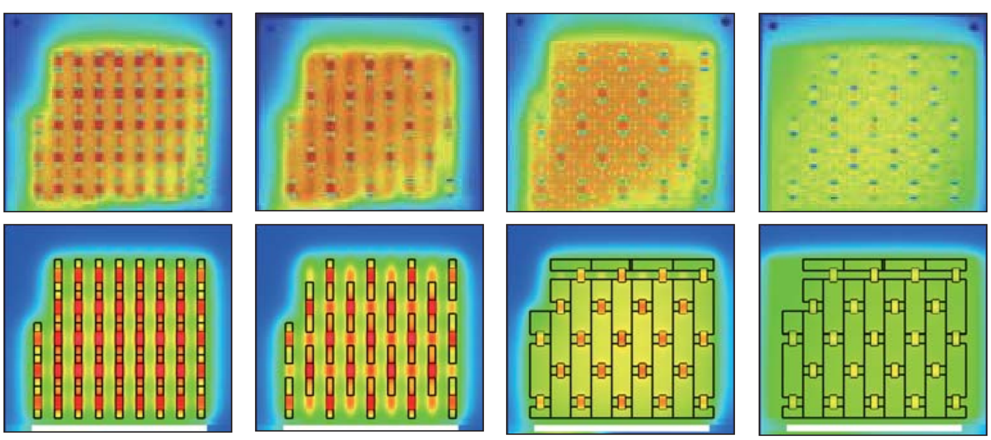
Time needed for calculation: Seconds

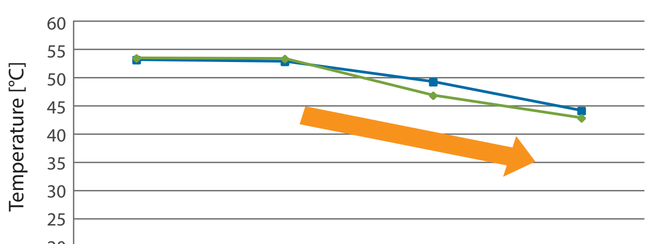
Analysis results

Model 1 | Model 2 | Model 3 | Model 4

Measured

PICLS





	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

Notes

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

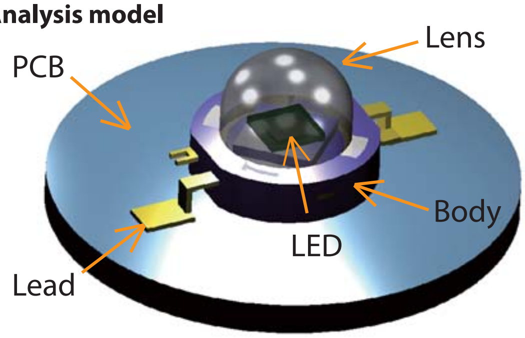
Heat Release of LED Device

Case study of SC/Tetra

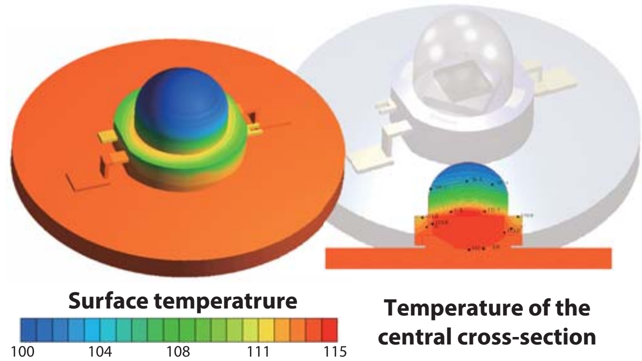
Comparison of SC/Tetra analysis result with experimental result for heat release of LED device

Heat release analysis of LED device

- **Analysis model**

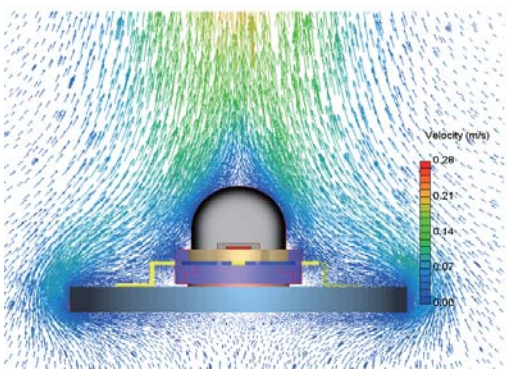


Surface and cross-section temperature distribution

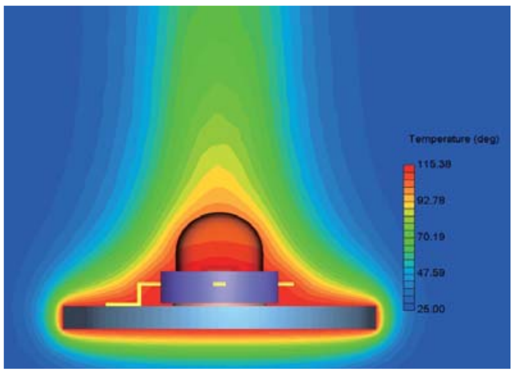


Heat of LED device is released mainly through PCB on which the device is installed and/or heat sink installed on the back of the PCB. SC/Tetra successfully simulates the phenomenon of heat release from the PCB.

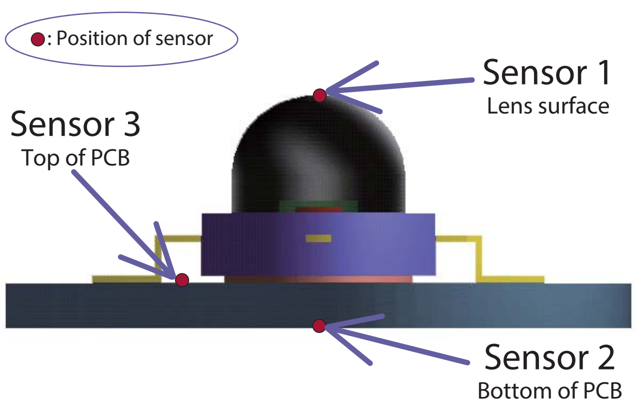
Flow pattern around the device (vector map)

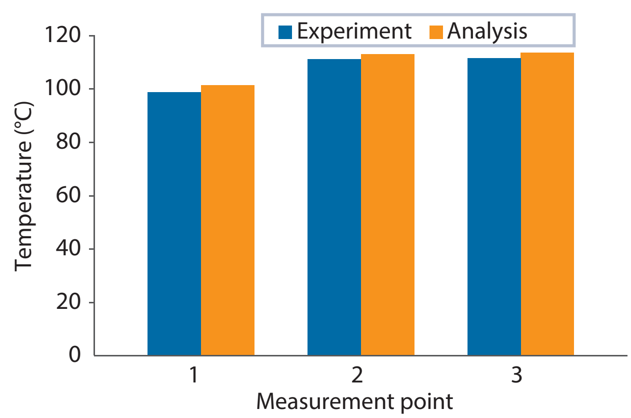


Fluid temperature distribution around the device (contour map)



Comparison between experimental and analysis values (temperature)





Notes

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 difference), which is adequate to simulate the tendency of the phenomenon.

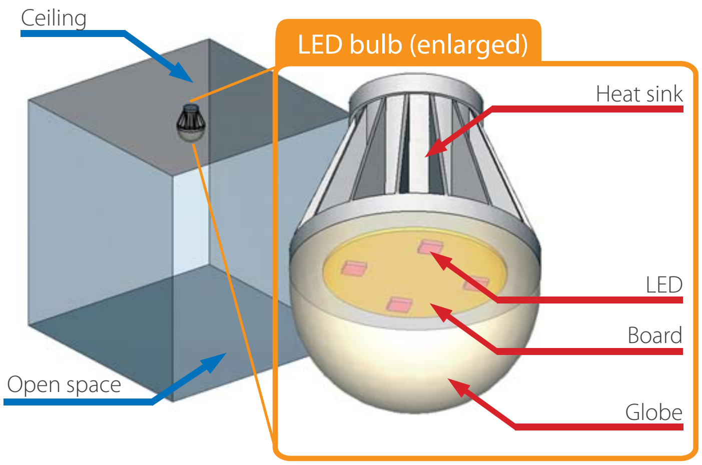
SC/Tetra

Thermal Fluid Analysis on LED Bulb

SC/Tetra Function

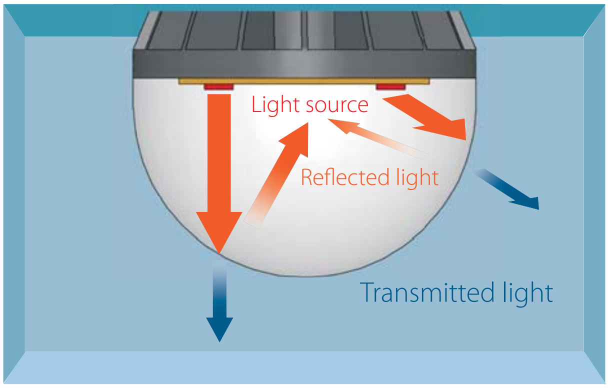
Investigating the Thermal Effect of Bulb Cover Transmittance using SC/Tetra

Details of Analysis Model

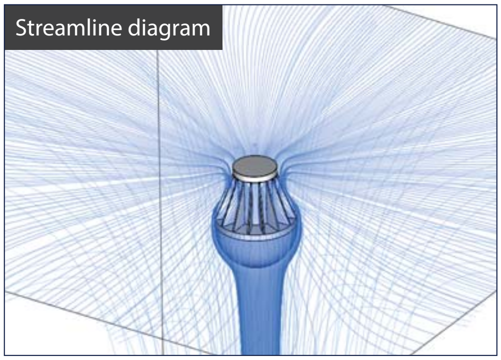


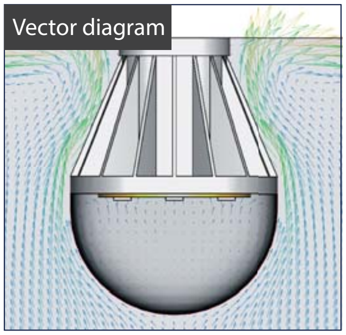
Effect of Bulb Cover Transmittance

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.



Visualizing the Flow





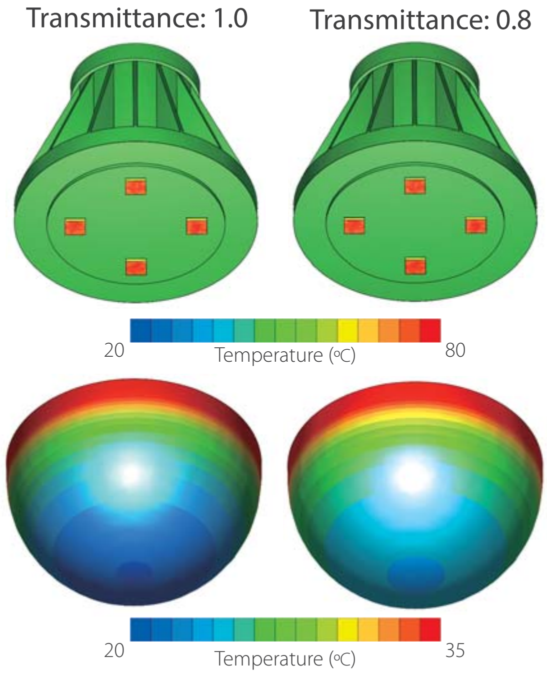
Displaying the streamline

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.

How Surface Temp. Distribution Changes by Different Transmittance



Globe surface temperature changes by approx. 3 degrees

Notes

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

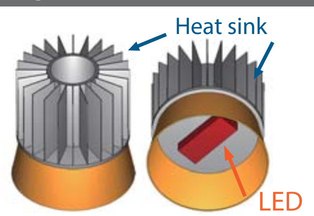
Effective Use of Optimization Tool for Heat Sink Design

Purpose of Optimization

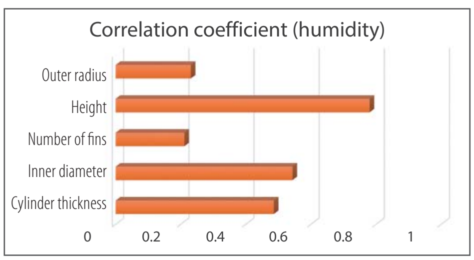
The modeling of heat sink needs to:

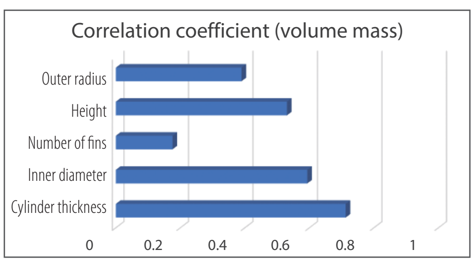
1. Reduce the LED temperature to the regulation
   Rising LED temperature [ΔT°C]:
   Minimized (ΔT: below 40°C)
2. Miniaturize itself
   Heat sink volume [weight]:
   Minimized (below 0.0005m³)

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.

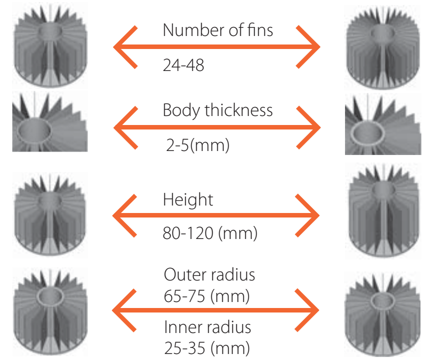
Optimization methods

■Experiment plan and sampling method
Central composite design ⇒43 samples

■Approximation of multiobjective optimization
Method of application ⇒RBG
Method of multiobjective optimization ⇒NSEA+

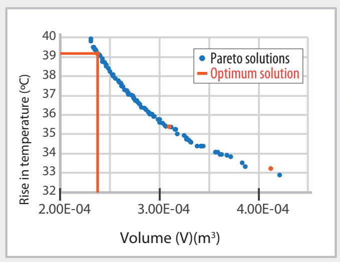
■Applications used
scSTREAM
Optimus® for Cradle

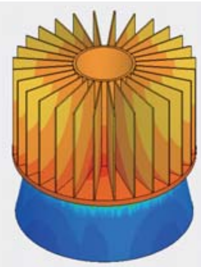
Design variables



Change design variables for sampling

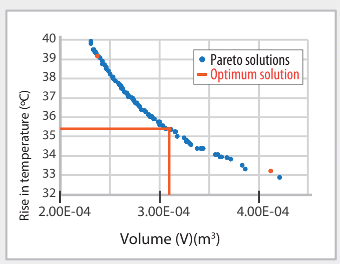
Optimum Designs Derived from Pareto Solutions

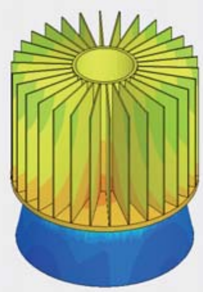




Priority on light weight

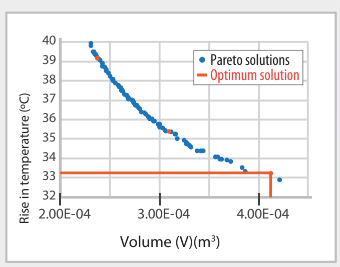
Volume	2.40×10-4 [m³]
Rise in temperature	39.1 [ºC]
Number of fins	28 [pieces]
Heat sink height	82.5 [mm]
Thickness of cylinder	2.4 [mm]
Outer radius	72.8 [mm]
Inner radius	25.0 [mm]

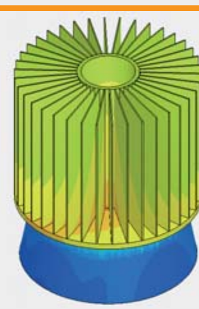




Priority on balance

Volume	3.11×10-4 [m³]
Rise in temperature	35.4 [ºC]
Number of fins	30 [pieces]
Heat sink height	104.9 [mm]
Thickness of cylinder	2.9 [mm]
Outer radius	74.4 [mm]
Inner radius	26 [mm]





Priority on heat dissipation

Volume	4.12×10-4 [m³]
Rise in temperature	33.3 [ºC]
Number of fins	38 [pieces]
Heat sink height	115.6 [mm]
Thickness of cylinder	3.5 [mm]
Outer radius	74.7 [mm]
Inner radius	25.1 [mm]

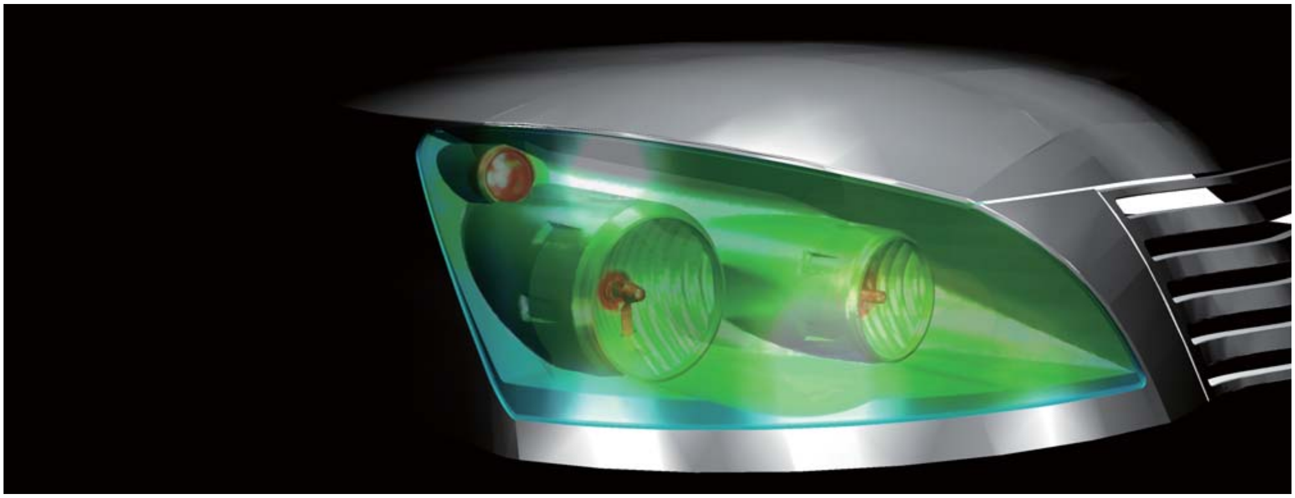
Notes

Optimization is effective to pinpoint design variables to the values that fulfill the objectives. Or, in many cases, it also plays an important role in the early stage of design process to identify that the proposed ranges of design variables cannot physically serve the intended purposes. On the other hand, optimization sampling requires a collection of analysis examples. Because of this, it is important to minimize the number of design variables as well as to choose the most appropriate analysis software with high computation performance.

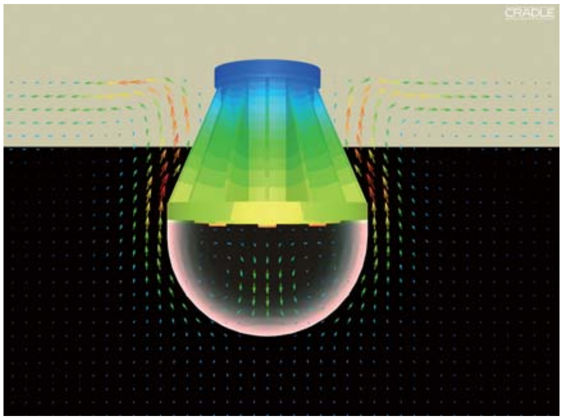
SC/Tetra HeatDesigner scSTREAM

Heat Release Analysis of Lighting Equipment

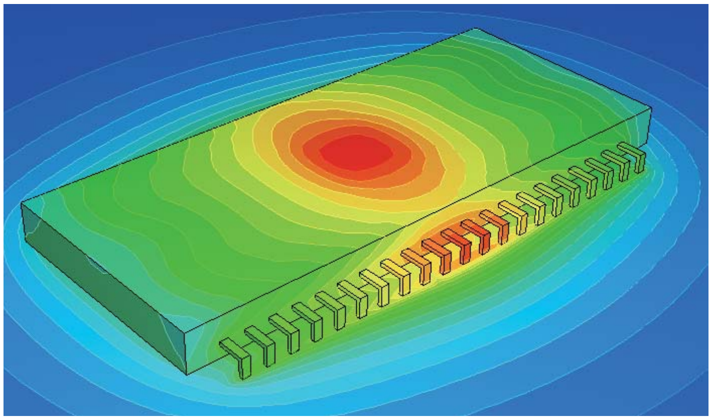
Case Studies of SC/Tetra, HeatDesigner, and scSTREAM



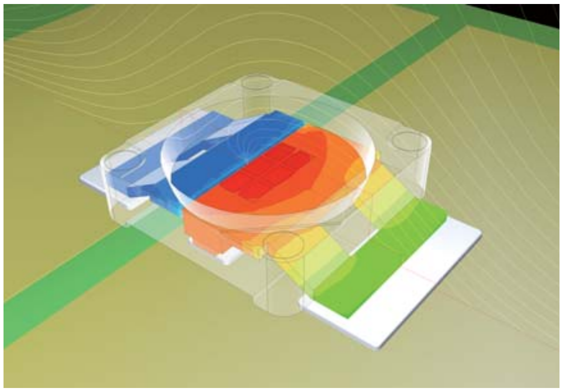
LED Bulb



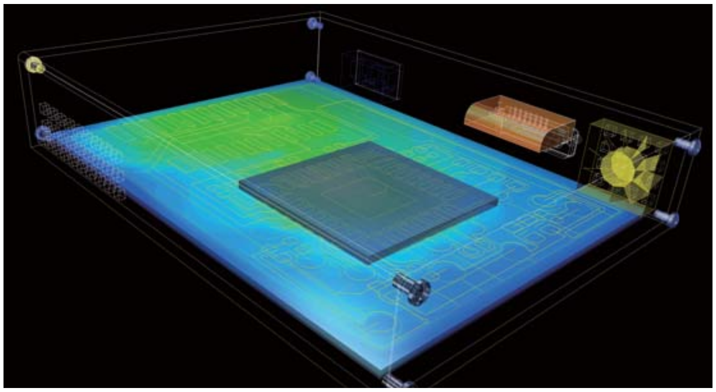
Semiconductor Devices



LED Devices



Heat Release Analysis Considering Gerber Data



Notes

It is a big challenge to effectively promote heat release from electronics components such as highly integrated LSI and LED, which is miniaturized further.
Thermal design is vital to develop high-quality products with more energy saving capability and longer duration.
Simulation helps examine new ideas for thermal design specifically and clearly with visual insights.

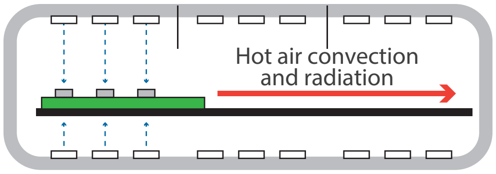
HeatDesigner SC/Tetra

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

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

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

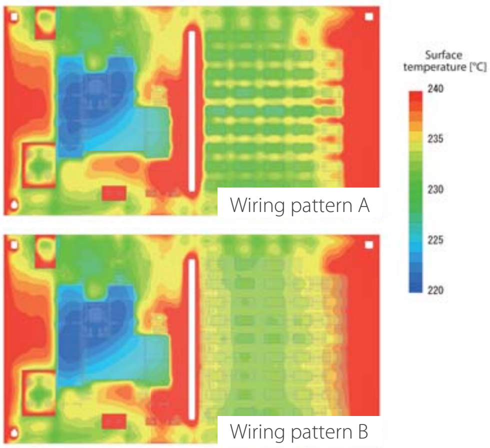
Analysis model



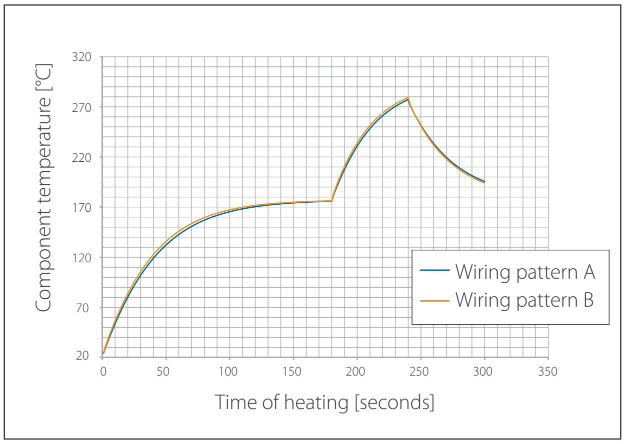
Reflow furnace

A transient thermal fluid analysis is conducted, simulating hot air convection, radiation and heating within the reflow furnace
Wiring patterns, component allocations, and material changes can be evaluated.

Analysis results



Temperature distribution on printed board after 200 seconds

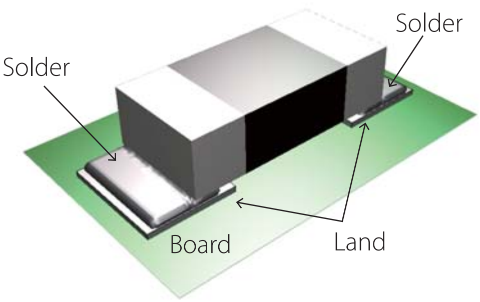


Chip resistor temperature changes as function of time

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

Simulating Chip Standing Phenomenon Using SC/Tetra

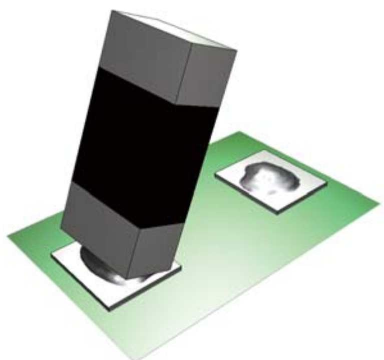
Analysis model



Chip resistor (0402 size)

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.

Analysis results



Notes

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.

About Software Cradle

Software Cradle Co., Ltd. is an innovative provider of computational fluid dynamics (CFD) simulation software. Established in 1984, the company has pursued to offer unique, innovation focused, and highly reliable CFD solutions that enhance customers' product quality and creativity. In 2016, the company joined MSC Software Corporation (headquartered in Newport Beach California, US), the worldwide leader in the field of multidiscipline simulation. As a truly global company, Software Cradle delivers all-inclusive multi-physics solutions.

For more information about MSC Software Corporation, please visit:
- MSC Software Corporation http://www.mscsoftware.com

Software Cradle Co., Ltd.

Address: Mainichi Intecio 3-4-5, Umeda,
Kita-ku, Osaka 530-0001 Japan
Phone: +81 (0)6 6343 5641
Fax: +81 (0)6 6343 5580
Email: info_en@cradle.co.jp
Web: www.cradle-cfd.com

Cradle
MSC Software Company

PART OF HEXAGON

Contact Details