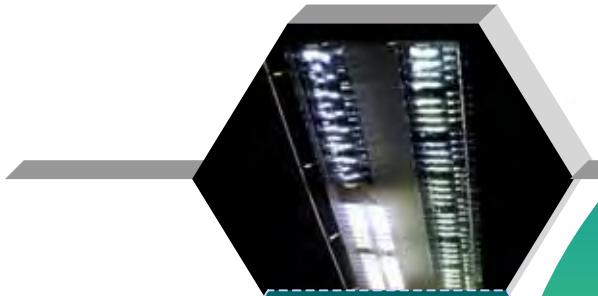
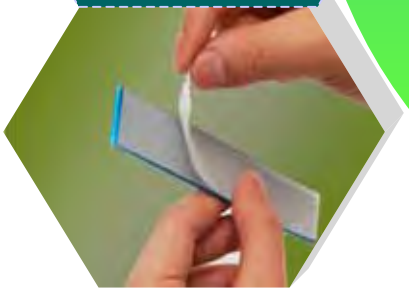
COOLTTM

THE EPOCHAL THERMAL SOLUTION PROVIDER



TTM Co., Ltd.



COMPANY INTRODUCTION

OVERVIEW

PRODUCTS

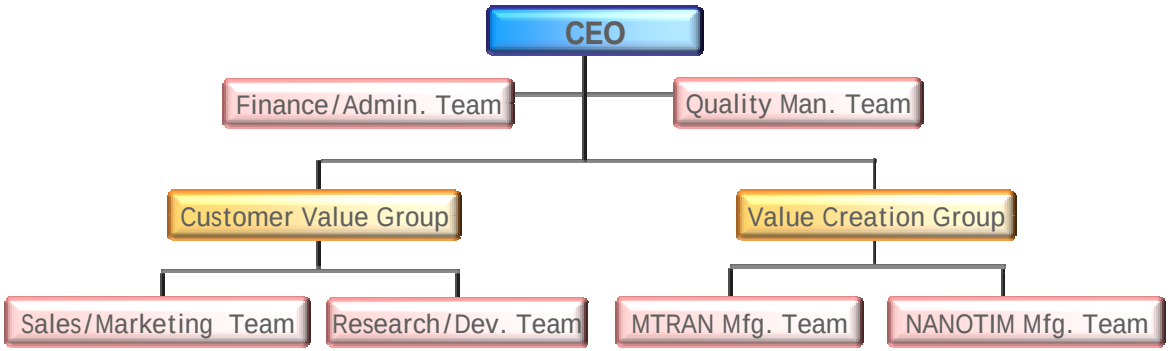
LED APPLICATIONS

Corporate Overview

General Overview

Company Name	TTM Co., Ltd.
CEO/President	Eugene Choi
Established	November 14, 2003
Business Area	Thermal Solutions for Electronics
Research Area	Thermal Interface Material based on Nano Technology Thermal Management Device based on Micro technology
Address	43-5 Sameun-Ri Jiksan-Eup Seobook-Gu Chunan-Si Chungnam, Korea
Phone & FAX	HQ : 041-585-3755, FAX : 041-585-3756
E-Mail	ttm@coolttm.com
Web	www.coolttm.com

Organization Structure



Corporate History

YEAR 2009	Awarded The Entrepreneur Festival Korea 2009 Authenticated INNO-BIZ company by Korean Government Authenticated Patent Star Company by local Government Acquired Intel Validation (NANOTIM PCM/NANOTIM SPS)
YEAR 2008	Designated as The Materials & Components Specialty Company by Korean Government
YEAR 2007	Certified partner of OSRAM's LLFY Awarded Korea Venture Design Contest
YEAR 2006	Certified as The Clean Factory by Korean Government
YEAR 2005	Acquired ISO9001/ISO14001 Acquired Korea Good Technology Mark by Korean Government (KT Mark/Now NET)
YEAR 2004	Designated as The Center of Excellence by UGS (Acquired by Siemens) Authenticated Venture Company by Korean Government Foundation of TTM Co., Ltd. Research Center
YEAR 2003	TTM Co., Ltd. Foundation

Core Technologies & Products

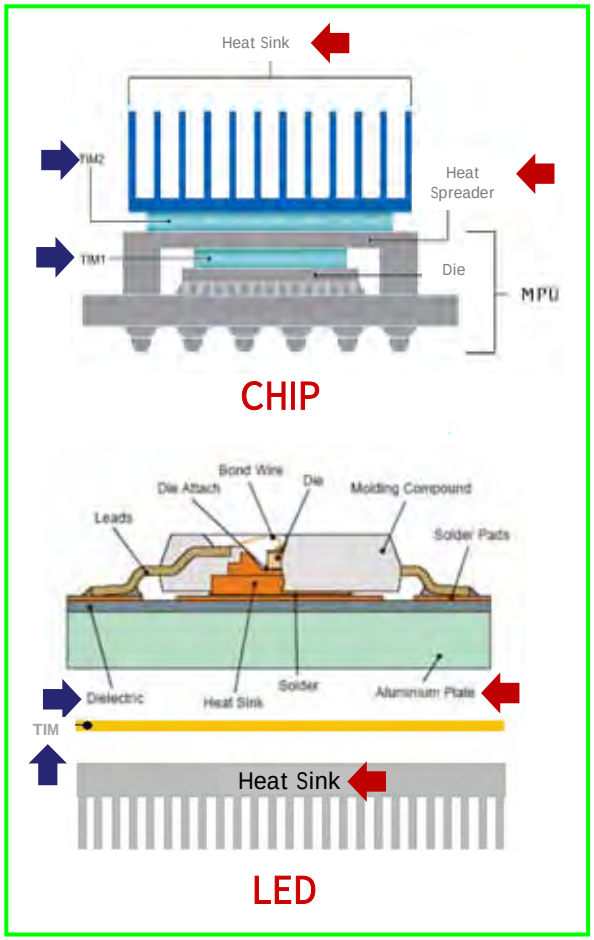
Micro Technology

Flat Heat Transmitter

- Micro Channel Technology
- Vacuum Technology
- Cold Welding Technology

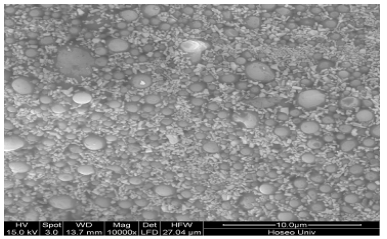
MTRAN®

- MTRAN® BASIC
- MTRAN® MEMORY
- MTRAN® CPU
- MTRAN® PCB
- MTRAN® RHP (TBL,1Q 2010)
- MTRAN® HBS (TBL,2Q 2010)



MTRAN ➡ NANOTIM ➡

Nano Technology



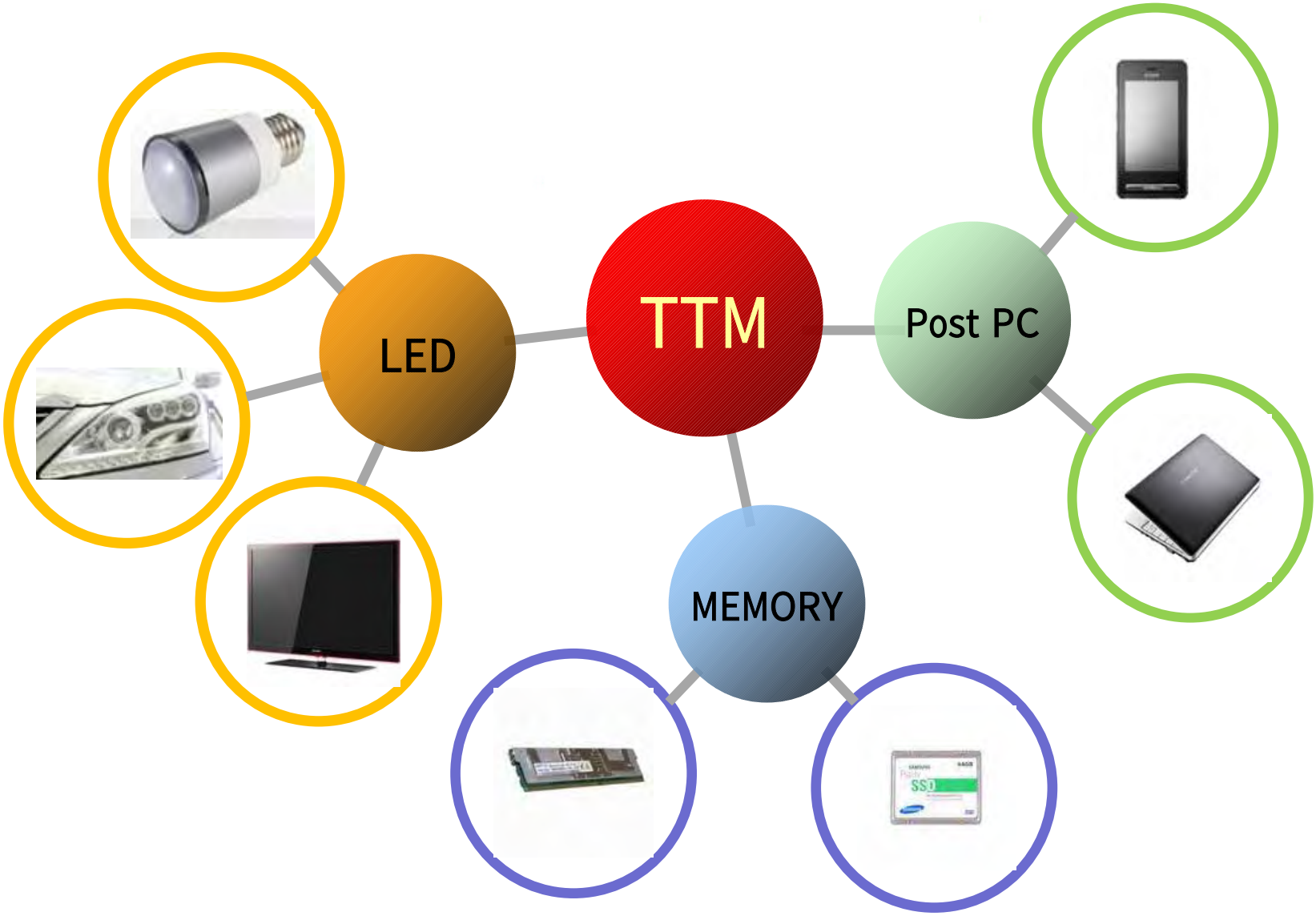
Thermal Interface Material

- Nano Dispersion Technology
- Sheet Forming Technology

NANOTIM®

- NANOTIM® TGS
- NANOTIM® SPS
- NANOTIM® PCM
- NANOTIM® APS
- NANOTIM® DLS (TBL,1Q 2010)
- NANOTIM® HIM (TBL,2Q 2010)

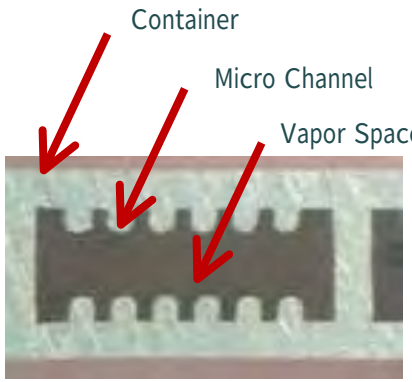
Target Markets & Current Applications



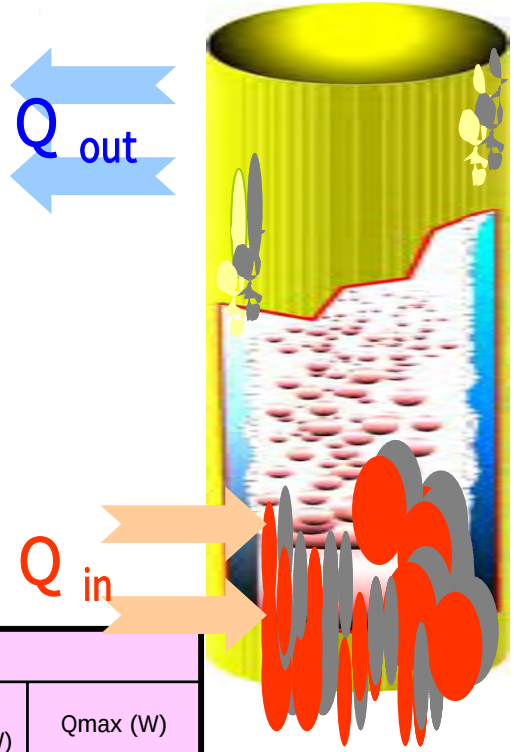
COOLTTM

Feature

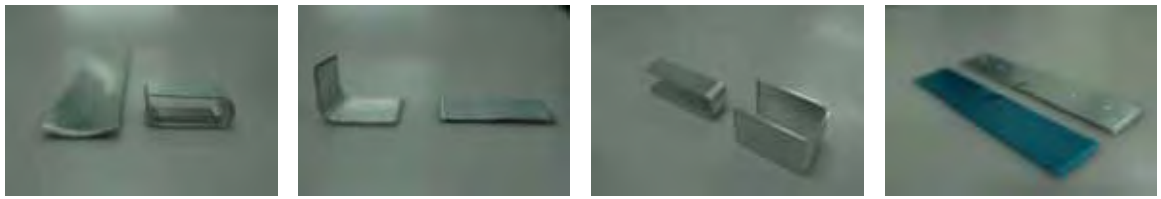
- -Flat Heat Transmitter
- -Very common Al Container
- -Micro Channels as Wick
- -Phase Change of Working Fluid
- -20X Thermal Conductivity of Cu
- -1/3 Weight of Al



[Cross Section of MTRAN]



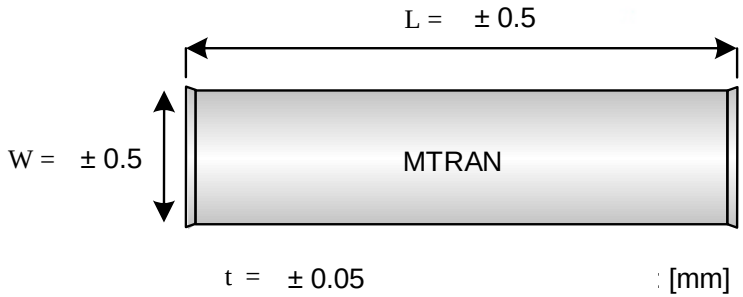
	Cu Heat Pipe			MTRAN		
Diameter D: (mm)	Flat t: (mm)	Thermal Resistance (°C/W)	Qmax (W)	Thickness t: (mm)	Thermal Resistance (°C/W)	Qmax (W)
ϕ6	2.0t	0.1~0.32	5	2.0t	0.1	50



[Examples of Easy Fabrication]

[1] MTRAN General Spec. Table

ITEM	Description
Material of Container	Aluminum
Wick Structure	Grooved Wick
Working Fluids	Acetone
Typical Thermal Resistance	< 0.4℃/W
Operating Inclination(θ)	0 ~ 90°
Leakage Temperature	170℃

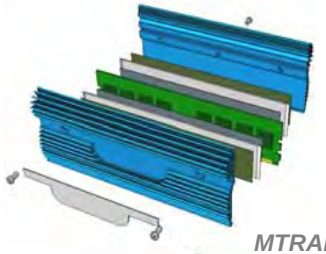


[Dimmension]

[2] MTRAN Model Dimension

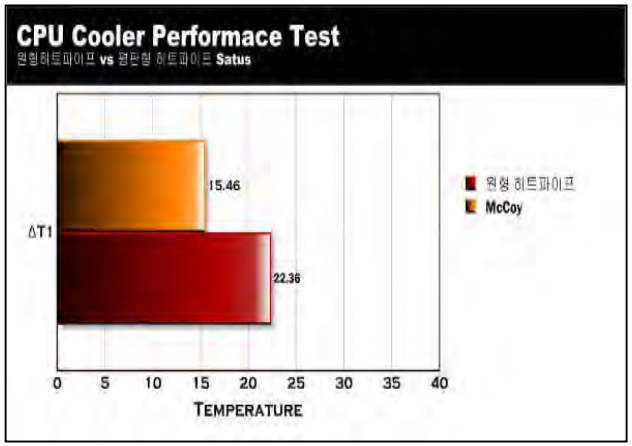
Part Number	Thickness [mm]	Width [mm]	Length [mm]		Maximun Heat Trasfer Rate [Watt]
			Min.	Max.	
TMT-1220B Series	1.2	20	60	200	5 ~ 18
TMT-1223A Series	1.2	23			5 ~ 18
TMT-1550A Series	1.5	50			18 ~ 80
TMT-1630C Series	1.6	30			11 ~ 50
TMT-2040A Series	2.0	40		300	40 ~ 170
TMT-2550A Series	2.5	50			75 ~ 300
TMR-0060A Series	6.0	6.0			25 ~ 90

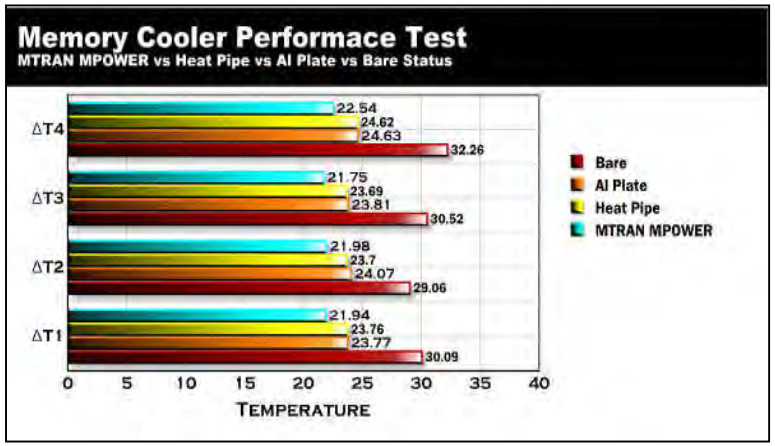
MTRAN® CPU / MTRAN® MEMORY



MTRAN MPOWER

"CPU/MEMORY Cooler"

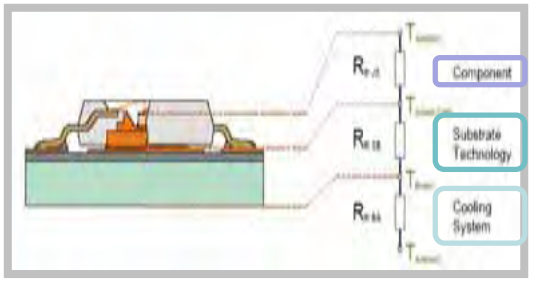




Feature

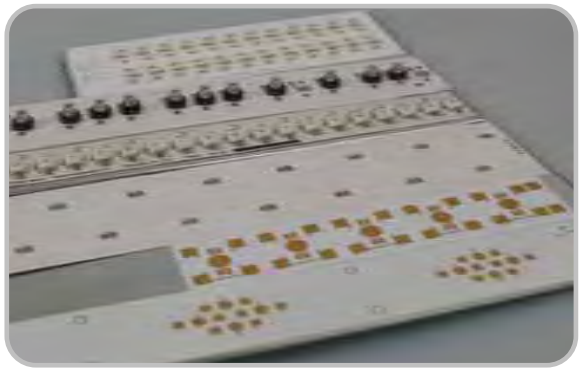
-MTRAN based MCPCB (Metal Core Printed Circuit Board)

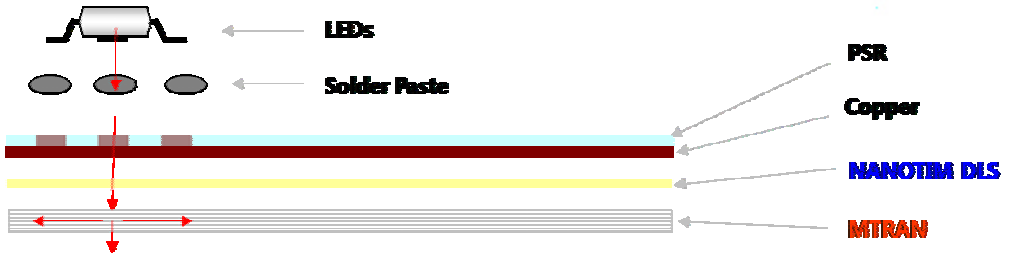
-1/10 of Thermal Resistance



[Analysis of LED]

Substrate Technology	Thermal Resistance R_{thSB}
Al MPCB with Enhanced dielectric	3.4 K/W (OSRAM)
MTRAN PCB with Enhanced dielectric	**2.1 K/W (TTM)**





[Basic Structure of MTRAN PCB]

Feature

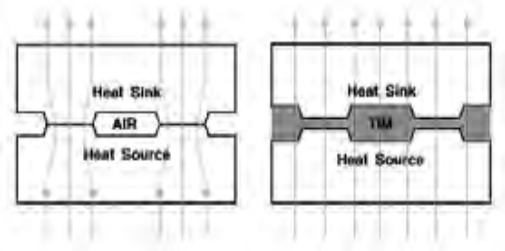
-Various Type of Thermal Interface Material

-Thermal Grease (NANOTIM TGS, Paste)

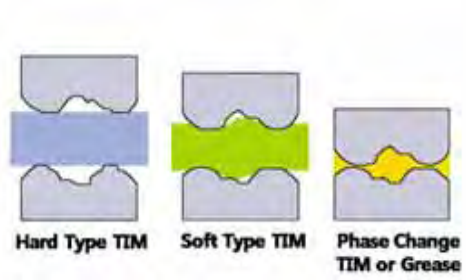
-Phase Change Material (NANOTIM PCM, PAD/Paste)

-Solid PAD/Sheet (NANOTIM SPS, Various Peel Strength)

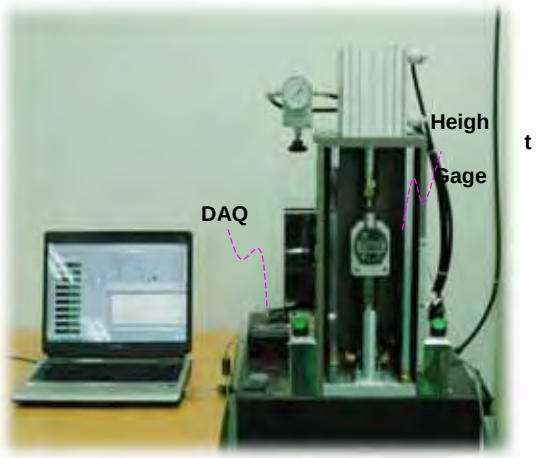
-Adhesive PAD/Sheet (NANOTIM APS, No Coating Layer)



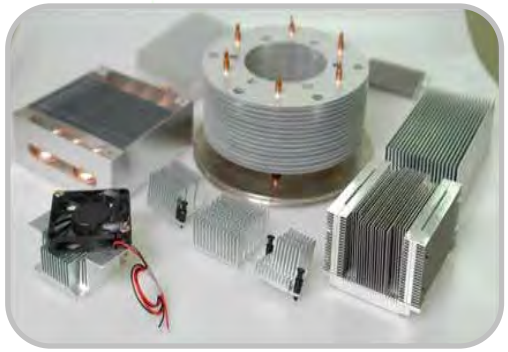
[Function of TIM]



[Schematic of functionality TIM]



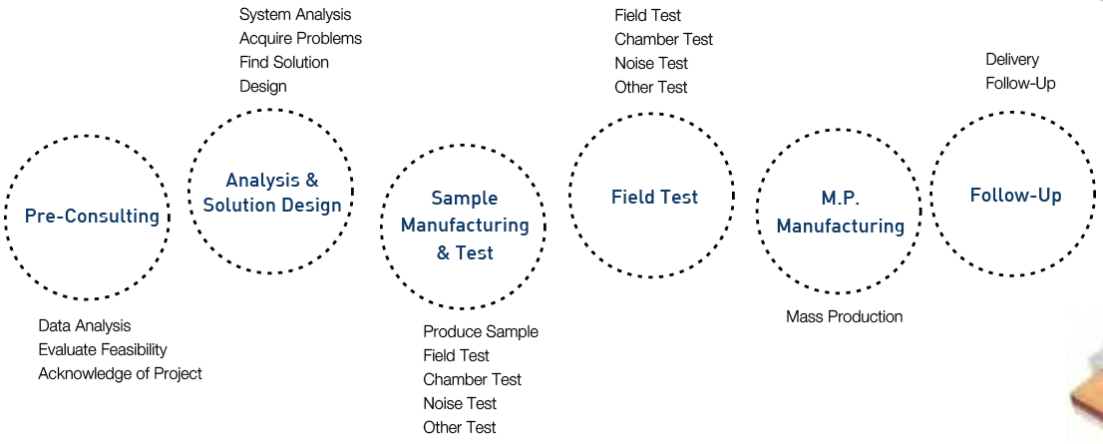
[T-Thermo 200 based on ASTM D5470]

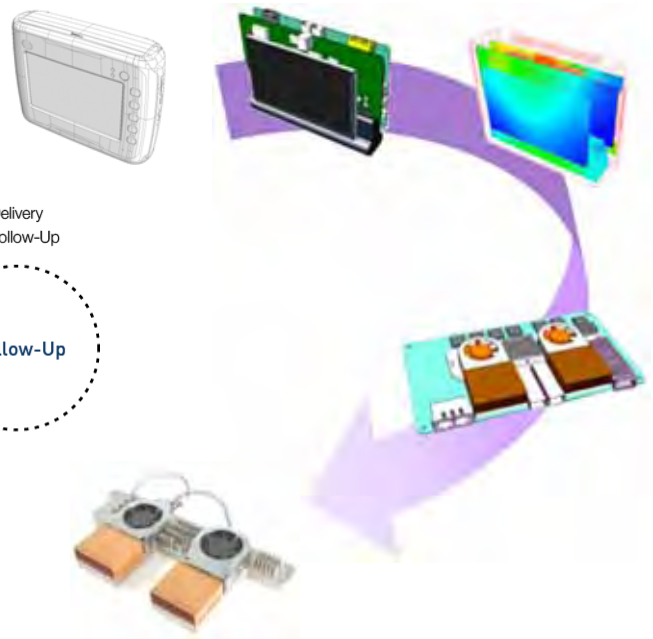


“Conventional Technology Based Products”

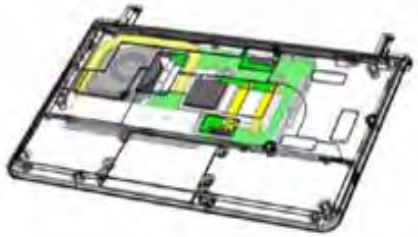
“Thermal Analysis & Design Consulting Service”

Process



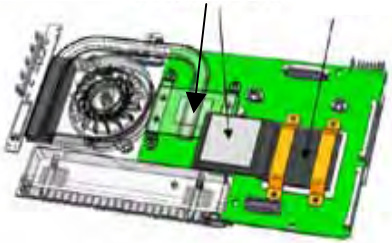


Applications & Products



NANOTIM PCM for CPU

MTRAN



NANOTIM PCM/NANOTIM
SPS
for Control IC & Memory Chip

NANOTIM SPS
for Control IC & Memory Chip

MTRAN /NANOTIM
for RFIC, PAM

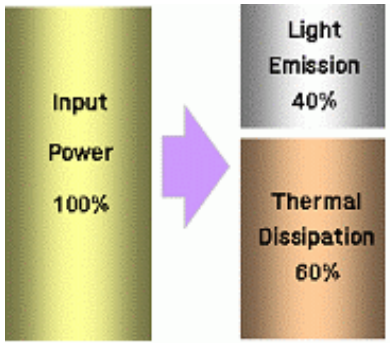
MTRAN /NANOTIM for
LED

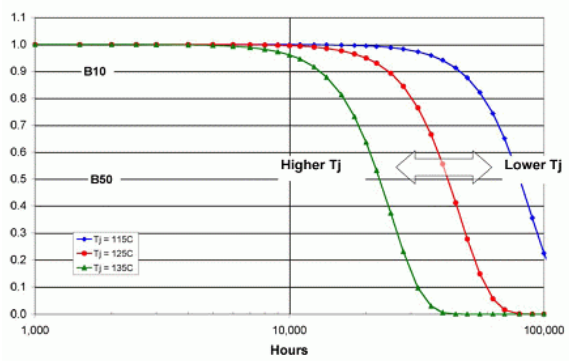
MTRAN /NANOTIM PCM for
LED

NANOTIM
SPS
for Driver IC

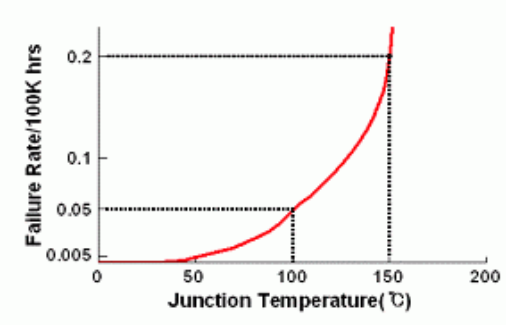
NANOTIM SPS/T-SET
for Power TR

Thermal Problem in LED

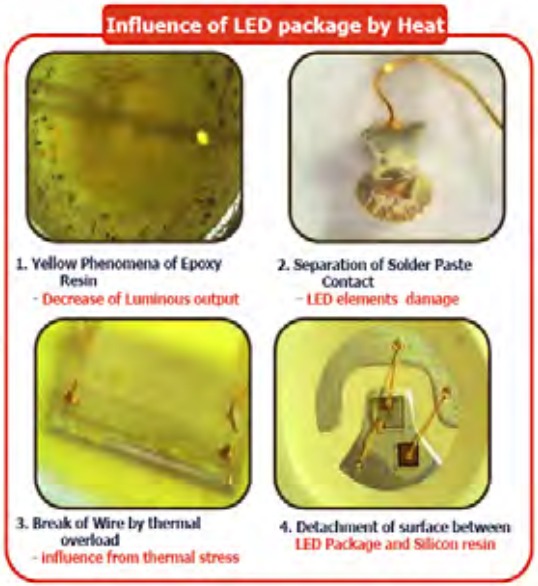




SOURCE [Lumileds]



SOURCE [KOPTI]

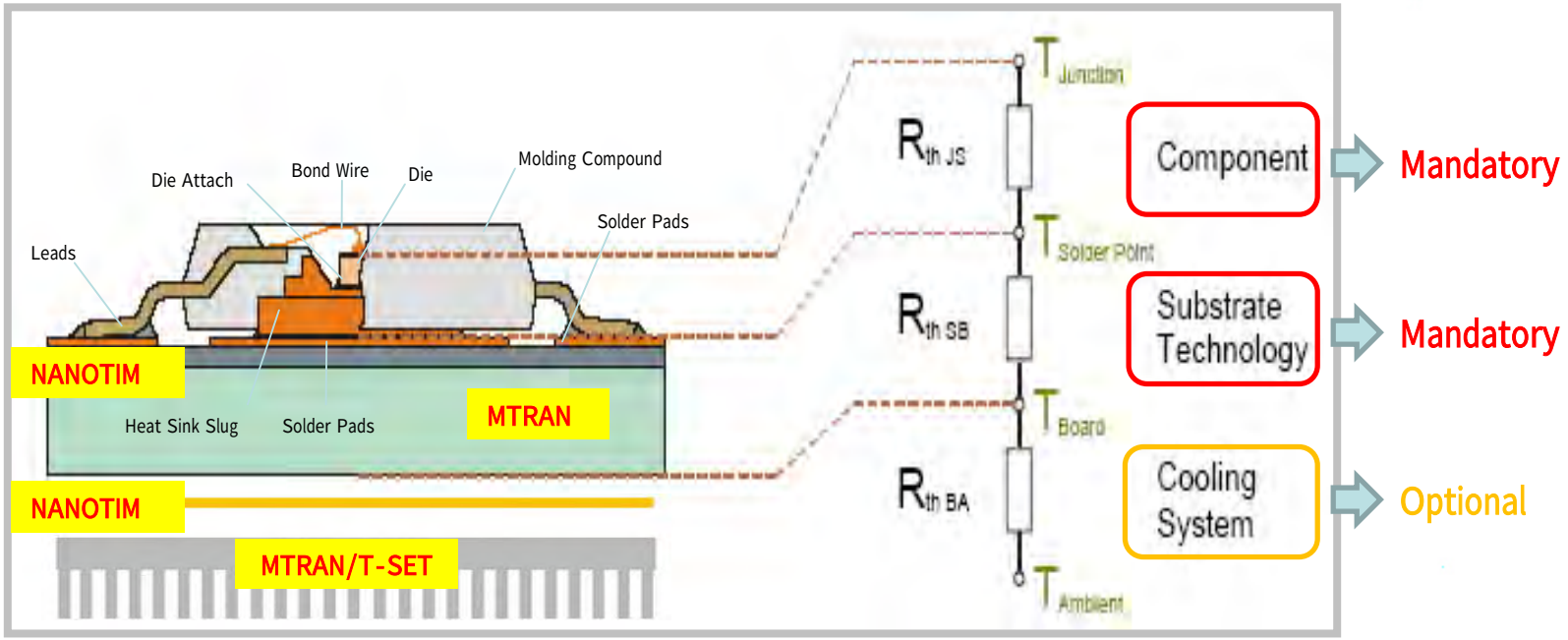


Average Lumen Maintenance Characteristics

Heat sink temperature	Drive Current	Average Lumen Maintenance after 500 hours of operation
35° C	700 mA	90%
75° C	700 mA	75%
85°C	600 mA	65%

SOURCE [Lumileds]

Analysis of LED Module



[Resistance Series Configuration, Courtesy of OSRAM]

4 Basics of COOLTTM

- **Conduction**

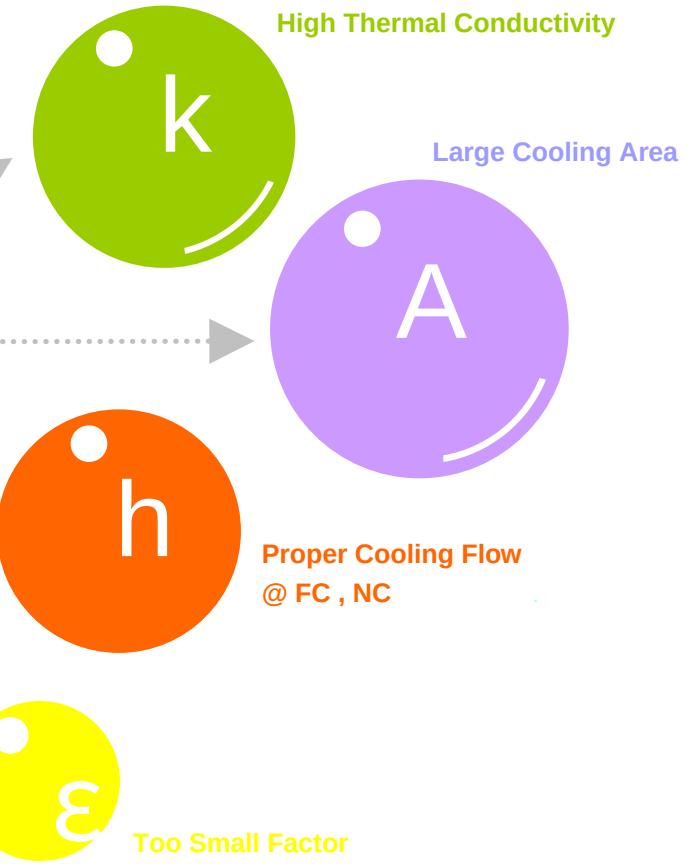
  Fourier's law $Q = -kA(\triangle T / \triangle x)$

- **Convection**

  Newton's law $Q = hA(T_s - T_\infty)$

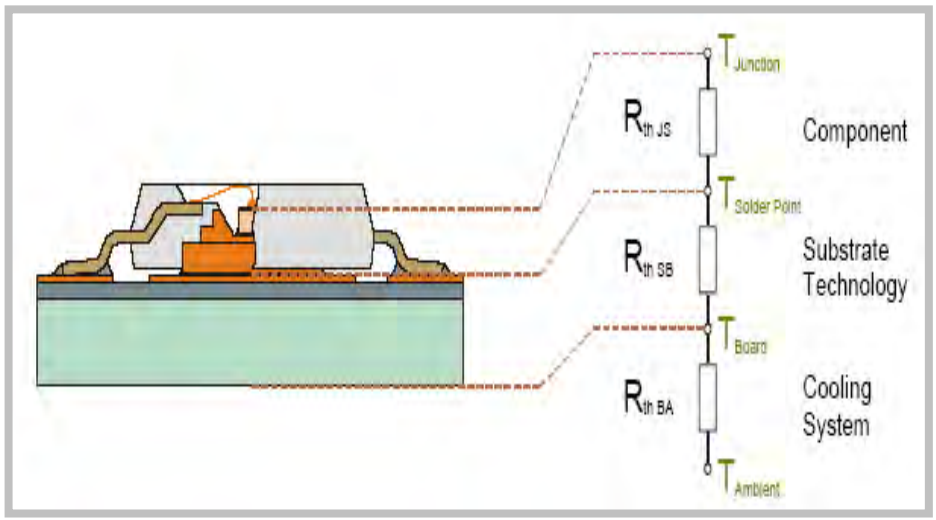
- **Radiation**

  Stefan-Boltzmann's law $\dot{Q} = \varepsilon\sigma(T_s^4 - T_{surr}^4)$



COOLTTM

Too many Layers



- p-GaN
- n-GaN
- Sapphire
- Epoxy
- HS Slug

- Solder
- Circuit
- Copper
- Dielectric
- PCB

- TIM
- Heat Sink
- Fan

High Thermal Resistance

COOLTTM

Properties of Light Source

Light source	Luminous Efficacy (lm/W)	Heat Lost (%)	Cost Efficiency ($/lm)
Incandescent	10-20	90 / 5 / 5	.0003
Fluorescent	75-90	40 / 40 / 20	.0005
Cold Cathode Fluorescent	55-65	40 / 40 / 20	.02
High Intensity Discharge	100-120	90 / 5 / 5	.03
LED	45-50 to 100+	5 / 5 / 90	.06~.10

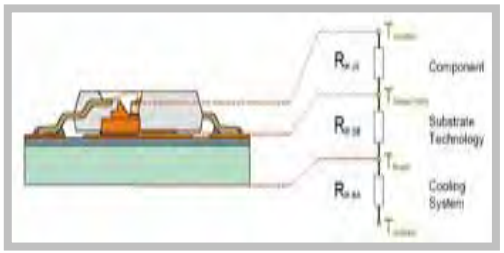
∴ In case of LED, Management from conduction loss is the most important

Solutions

COOLTTM

p-GaN
n-GaN
Sapphire
Epoxy
HS Slug

- COB/COF
- Hybrid LED etc.



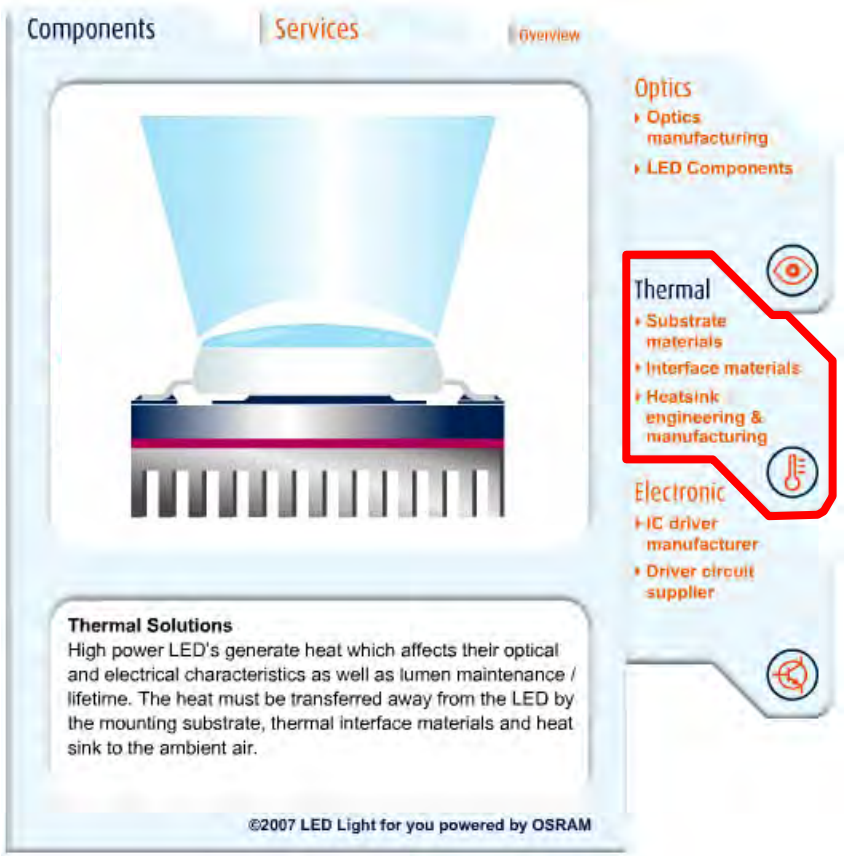
Solder
Circuit
Copper
Dielectric
PCB

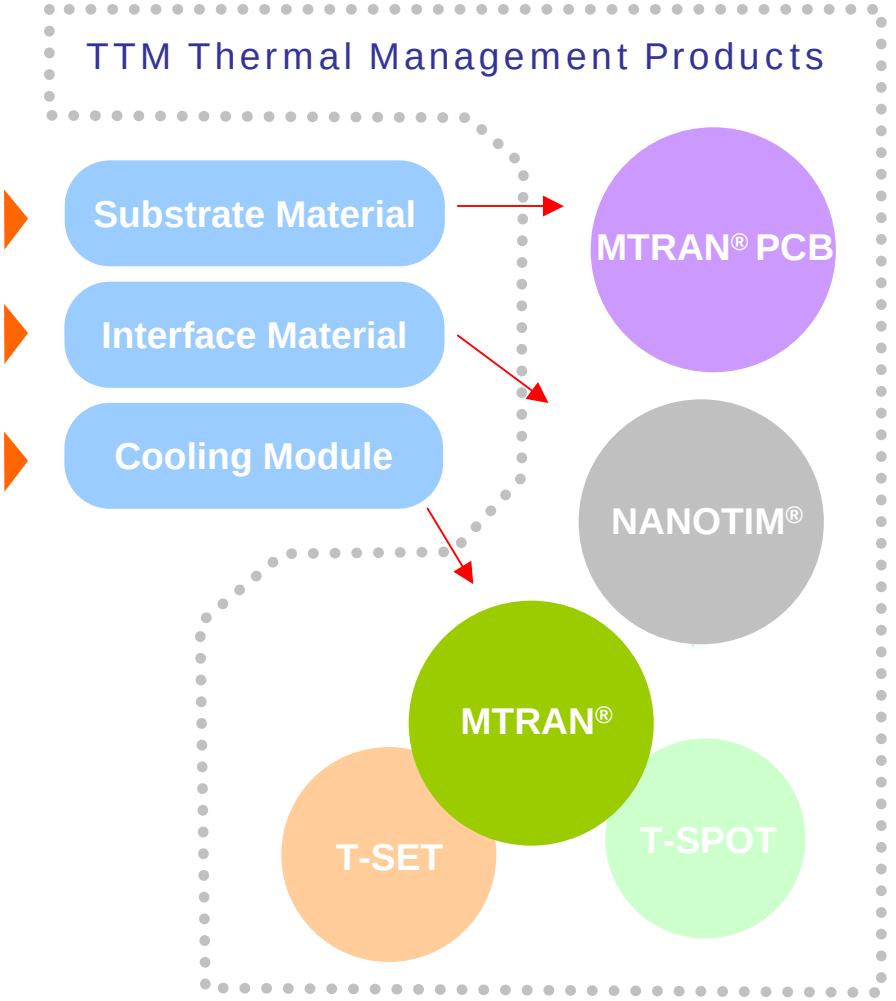
- High k Dielectric
- High k PCB

TIM
Heat Sink
Fan

- High k, Low R TIM
- High k HS Module
- No FAN

TTM Product Lines for LED

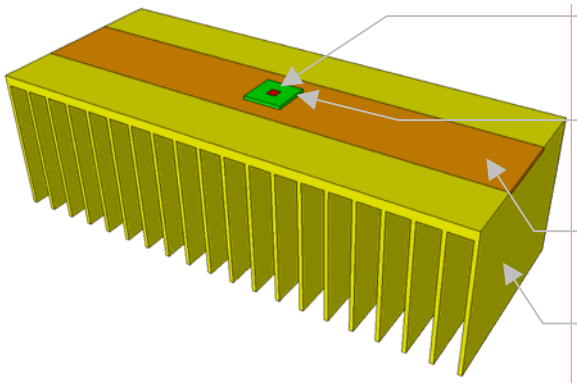




Cooling Performance Effect Check (@ Heat sink+ MTRAN)

[Geometry Check]

<Case 1>



LED : 5×5 (15W)

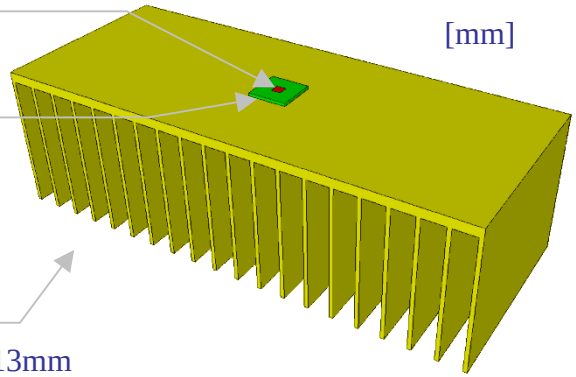
Metal PCB : 20×20×1.6t

MTRAN : 40×249×2.0t

Heat Sink : 249×100×75
< Base : 5t, Fin thickness : 2t, pitch : 13mm

<Case 2>

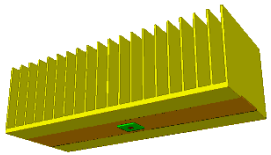
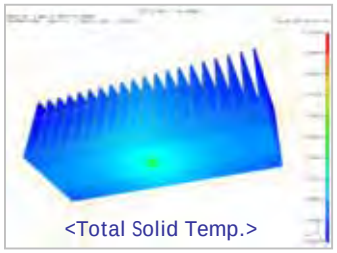
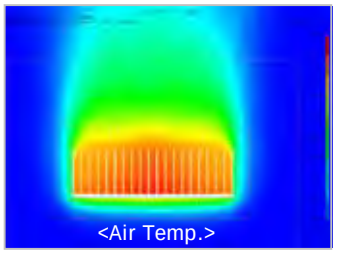
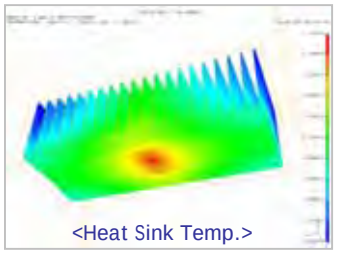
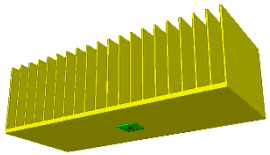
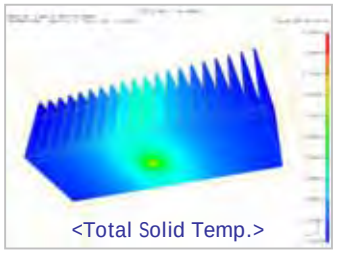
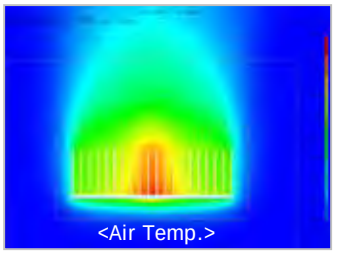
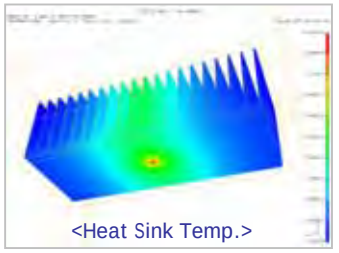
[mm]



	H/S Weight[g]	MTRAN Weight[g]	Sum of Weight[g]	Cooling Area [㎡]	Remarks
Case 1	1,042	29	1,071	0.3397	Groove for MTRAN
Case 2	1,096	0	1,096	0.3397	

Heat Sink Analysis 2

[Simulation Results (@ Ambient 20℃)]

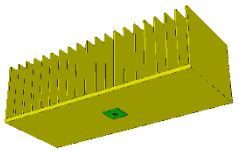
Sort	Case 1 (MTRAN Embedded Heat Sink)	Case 2 (Heat Sink only)
Simulation Results	   	   
Weigh [g]	1,071	1,096
Area [m^2]	0.3397	0.3397
LED T_J [℃]	36.3	44.0
Heat Sink T [℃]	28.9 ~ 31.2 [2.3℃]	27.7 ~ 39.5 [11.8℃]

Heat Sink Analysis 3

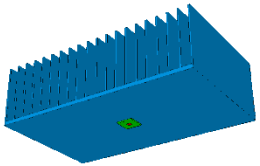
Heat Sink Size Check as replacement for MTRAN

[Geometry Check]

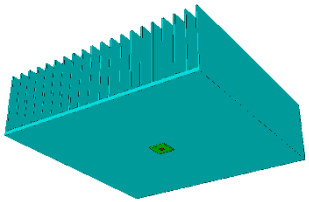
		Size [mm]	H/S Weight [g]	Cooling Area [m^2]	Remarks
Basic Heat Sink (5t Base)	Heat Sink 1	249 × **100** × 75	1,096	0.3397	MTRAN vs Heat Sink
	Heat Sink 2	249 × **150** × 75	1,644	0.5043	50mm increase (to Heat Sink Extruding Direction)
	Heat Sink 3	249 × **250** × 75	2,741	0.8351	150mm increase (to Heat Sink Extruding Direction)
High Capacity Heat Sink	Heat Sink 4	249 × **250** × 75	**5,782**	0.6291	Heat Sink of 15t Base (Fin Height : 60mm)
	Heat Sink 5	249 × **250** × **105**	**6,138**	0.8326	Heat Sink of 20t Base (Fin Height : 85mm)



Heat Sink 1

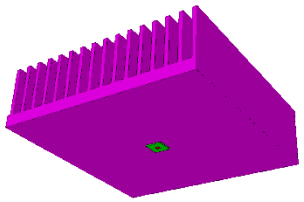


Heat Sink 2

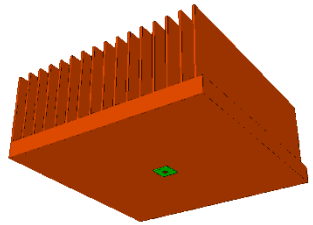


Heat Sink 3

<Basic Heat Sink (5t Base, Fin Height : 70mm)>



Heat Sink 4

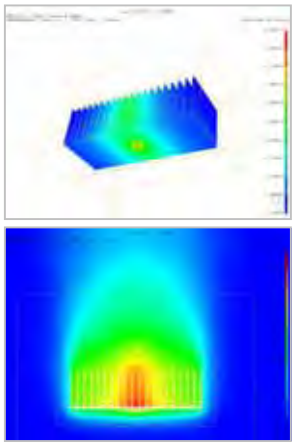
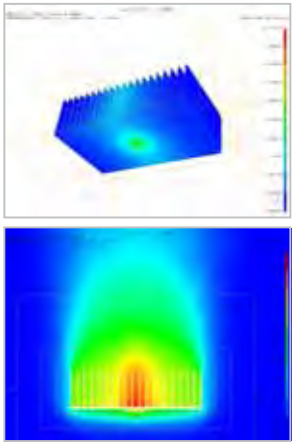
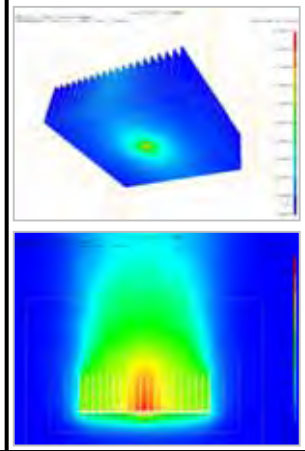
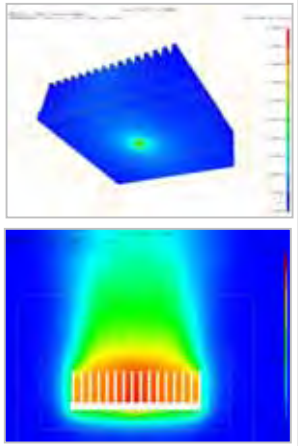
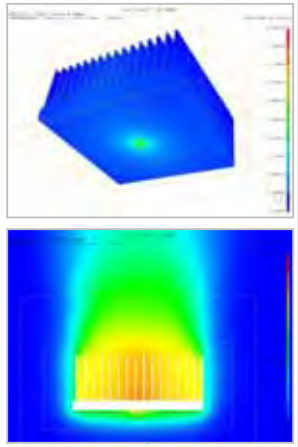


Heat Sink 5

<High Capacity Heat Sink>

Heat Sink Analysis 4

[Simulation Results (@ Ambient 20℃)]

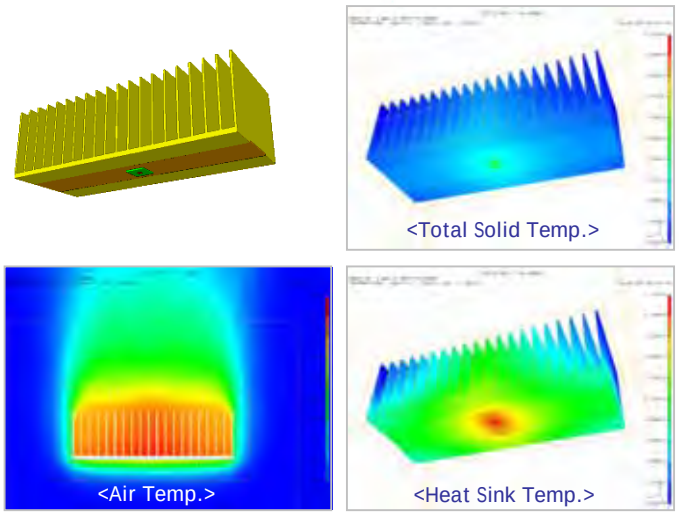
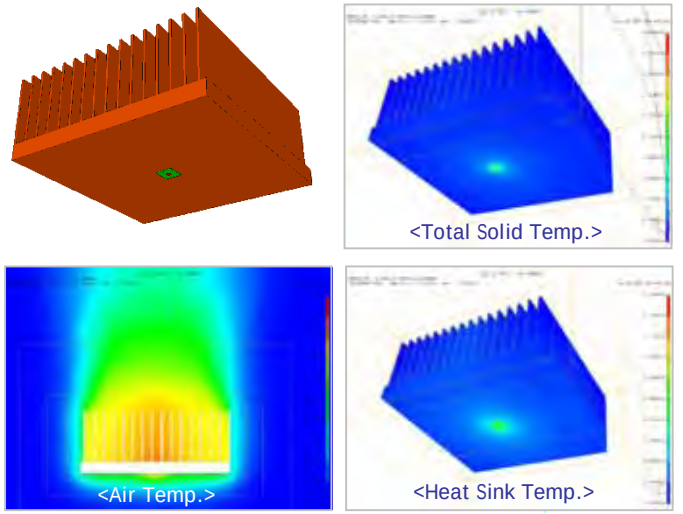
Sort	Basic Heat Sink (5t Base)			High-Capacity Heat Sink	
	Heat Sink 1	Heat Sink 2	Heat Sink 3	Heat Sink 4	Heat Sink 5
Simulation Results					
weight [g]	1,096	1,644	2,741	5,782	6,138
Area [m^2]	0.3397	0.5043	0.8351	0.6291	0.8326
LED T_J [℃]	44.0	41.7	40.0	38.3	36.9

a. When High capacity Heat Sink is applied, the cooling performance of it is similar to Case 1 (MTRAN Embedded Heat Sink)
b. A small size(5X)5mm) heat source is effective to cooling as thickness of the Heat Sink Base is more thicker .
(But the weight is increased)

Heat Sink Analysis 5

COOLTTM

Summary

Sort	Case 1 (MTRAN Embedded Heat Sink)	Heat Sink 5 (High Capacity Heat Sink)
Simulation Results		
Weight [g]	1,071	6,138
Area [m^2]	0.3397	0.8326
LED T_J [℃]	**36.3**	36.9
Heat Sink T [℃]	28.9 ~ 31.2 [2.3℃]	25.1 ~ 32.6 [7.5℃]

※ Consideration : By application of MTRAN, weigh of Heat Sink reduces by 5.1kg

※ This result of simulation is available at the special Size , if LED Thermal Spec. change & Heat Sink size is limited , the result of simulation is possible to change.

Performance Test of MTRAN

[10W LED]

69.3℃

17.2℃ Drop

52.1℃

8.8℃ Drop

43.3℃

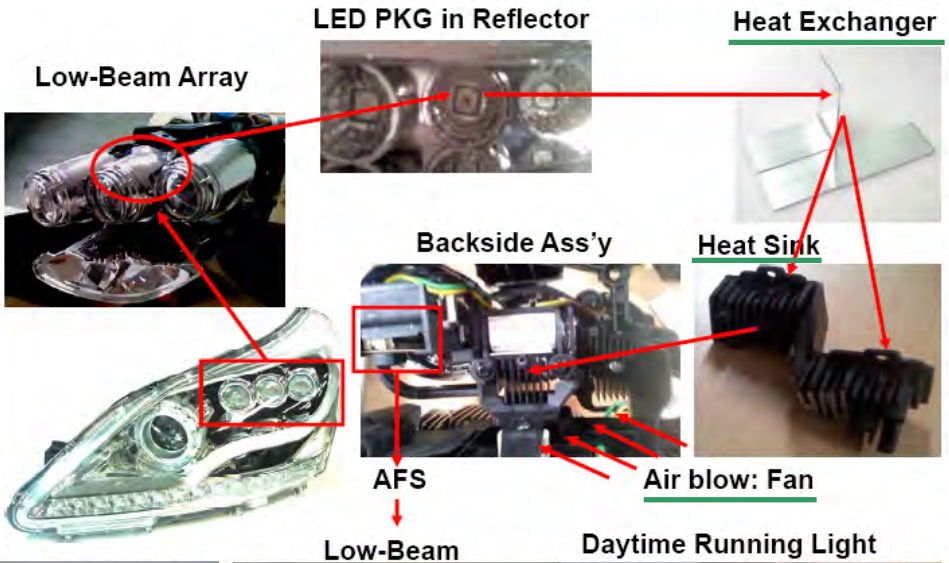
Total 26℃ Drop

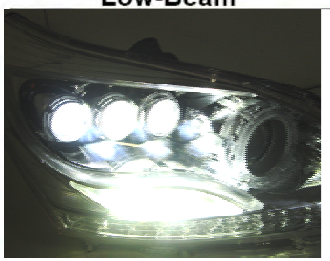
Thermal key point is MTRAN ➔ 17℃ Cooling

MTRAN + Heat Sink ➔ 26℃ Cooling

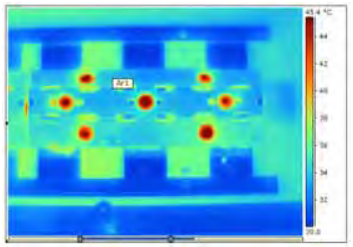
LED Applications

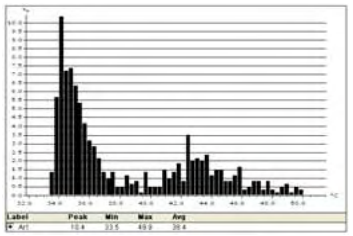
HYUNDAI – EQUUS VI Limousine

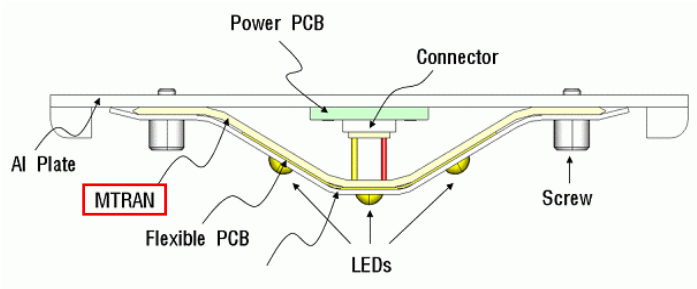


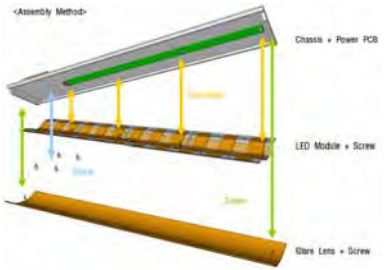


Bar Type LED Lighting









3W LED Lighting

Concept -1

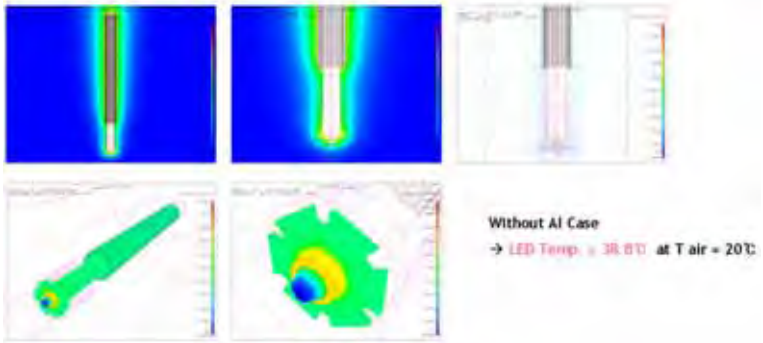
- Fanless Cooling.
- Heat Pipe 를 이용하여 LED Chip 에 집중된 열을 상부로 이송.
- Heat Pipe 끝 단에 Sink 를 결합하여 방열 면적 확보.
- Al Case 를 제거하여 주위 공기와의 대류 열 전달 촉진.

Concept -2

- 제품 보호를 위한 Al Case 결합.
- Al Case 의 하부에 Vent Hole을 가공하여 외부 공기 유입

< Concept 1,2 >

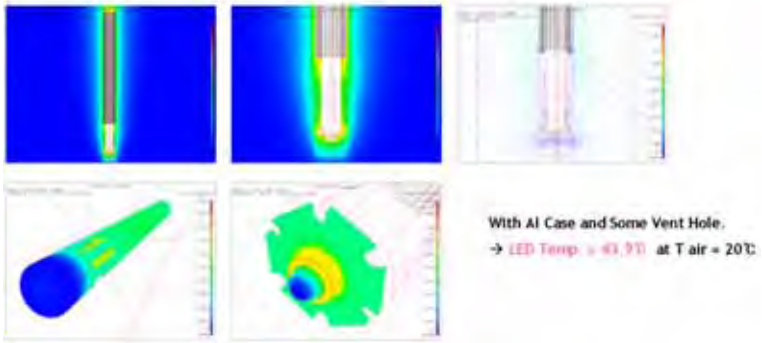
< Concept 1- w/o Case >



Without Al Case

→ LED Temp. : 38.6℃ at T air = 20℃

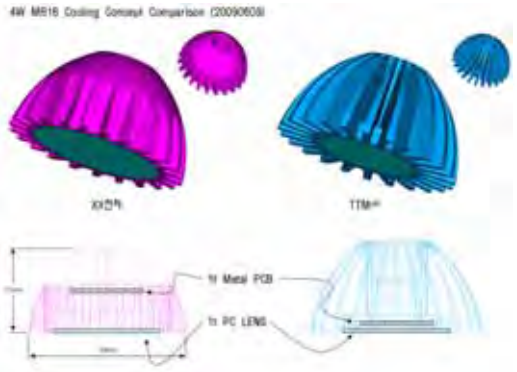
< Concept 2- w/ Case >



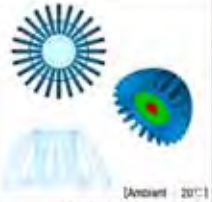
With Al Case and Some Vent Hole.

→ LED Temp. : 43.9℃ at T air = 20℃

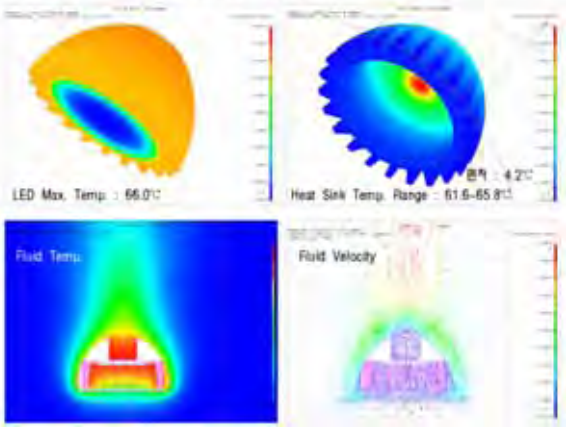
4W LED Lighting



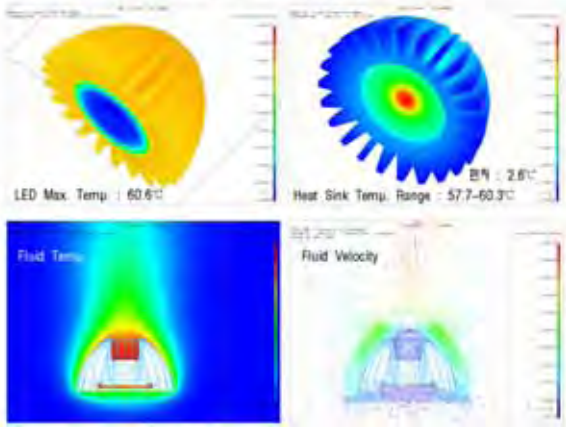
1. 4W MR16 Cooling Concept Comparison (20090609)

검체	LG 전자	TTM㈜
구분		 [Ambient : 20℃]
무게 [g]	41.0	41.0 [동일함]
표면적 [㎡]	0.0092	0.0164 [약 2배 증가]
HS 재질	AlDC10 (96 W/mK)	AlDC10 (96 W/mK)
LED T_j [℃]	66.0	60.6
Cooling [℃]	0	5.4℃
고찰		[illegible]

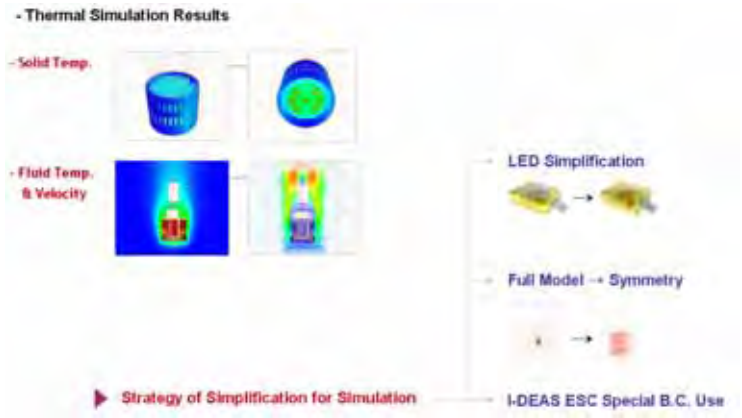
2. Simulation Results – XX (Heat Sink 재질 : AlDC10 [96W/mK])

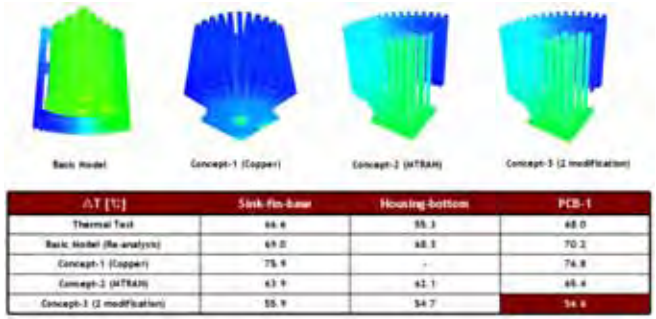


3. Simulation Results – TTM㈜ (Heat Sink 재질 : AlDC10 [96W/mK])

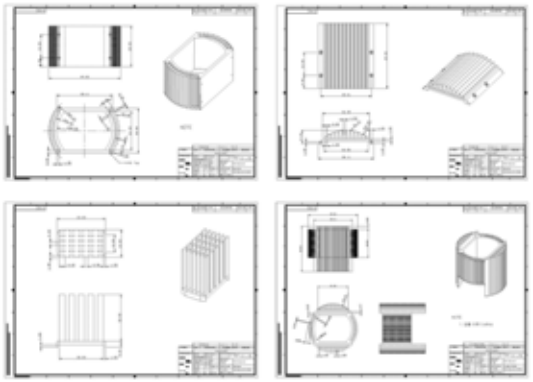


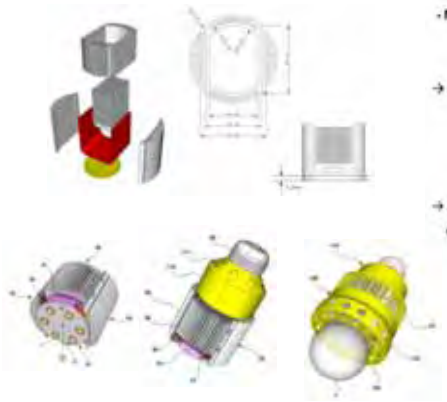
6W LED Lighting

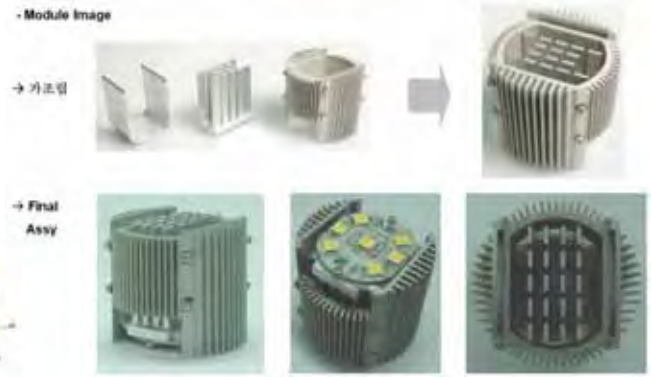




ΔT [℃]	Sink-fin-base	Housing-bottom	PCB-1
Thermal Test	66.6	55.3	68.0
Basic Model (Re-analysis)	69.0	68.3	70.3
Concept-1 (Copper)	75.9	-	74.8
Concept-2 (ATTAN)	63.9	61.1	65.4
Concept-3 (2 modification)	55.9	54.7	56.6

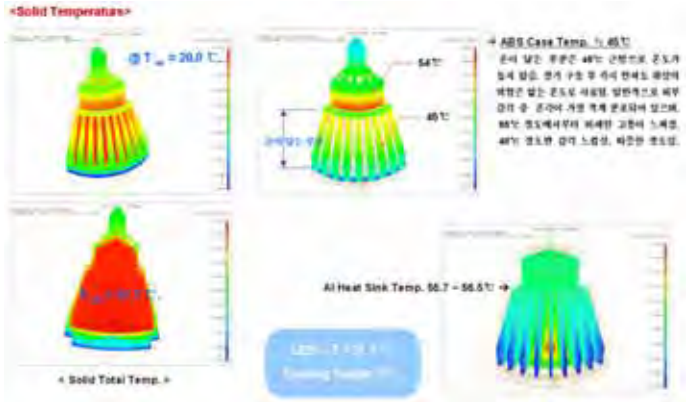


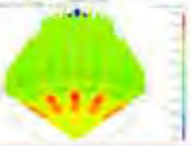
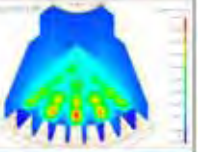




<COOLING MODULE>

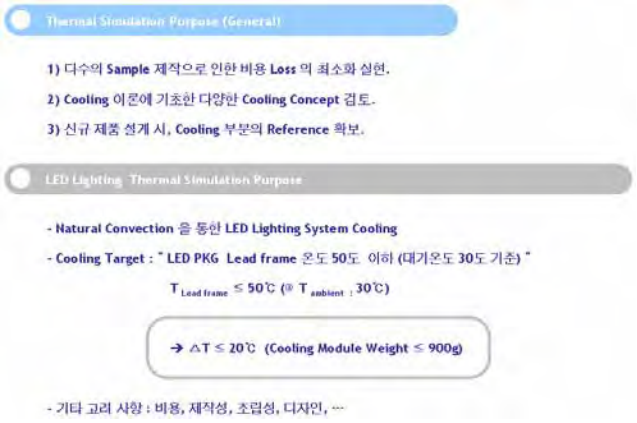
10W LED Lighting

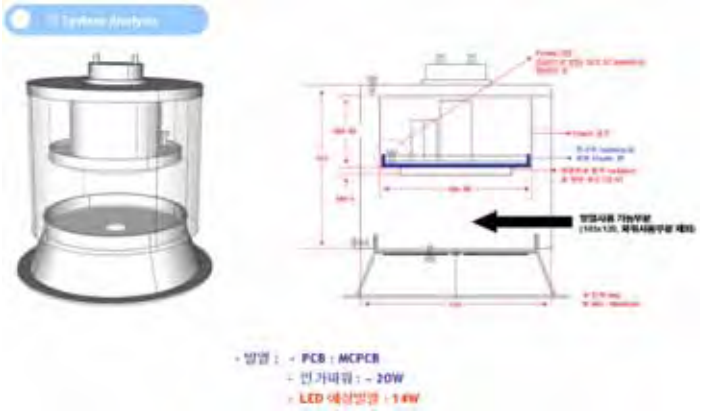


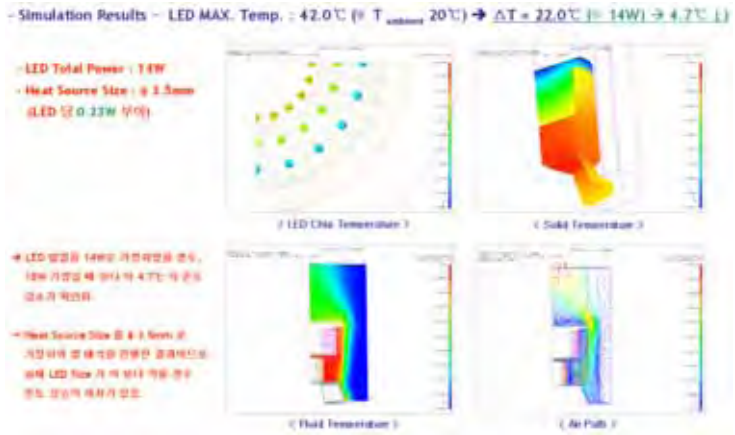
	FR4 PCB + Housing Contact + H/S no hole	FR4 PCB + Housing no Contact + H/S no hole	FR4 PCB + Housing no Contact + H/S with hole
Solid Temp. [℃]			
LED T_j	57.1	46.1	46.3
T_{air}	20.0	20.0	20.0
△T	37.1	46.1	46.3
T_{case}	56.7 ~ 57.1	56.5 ~ 64.0	61.0 ~ 64.1

※ Case 2 와 3의 경우, 방열 차이 가 없음.
Case 2는, Hole 이 없는 경우이며, 당연히 Power 부 PCB 가 온도하이어 부품 탈락 요인으로 인하여 양산 출가가 없는 조건으로 판단됨.
기존 대비 Vent 추가로 인하여 0.5℃, 15mm 증가된 Heat Sink 로 인하여 0.9℃ 냉각 개선됨.
Case 1의 경우, Housing의 용기와 기업한 접촉을 통하여 열 교환하므로, 다른 2안 과 냉각 조건이 같음.

14W LED Lighting

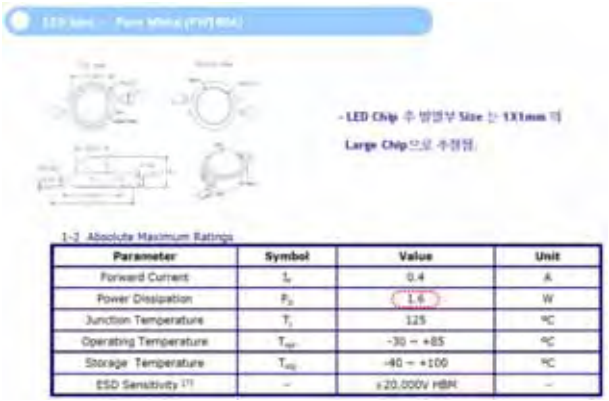






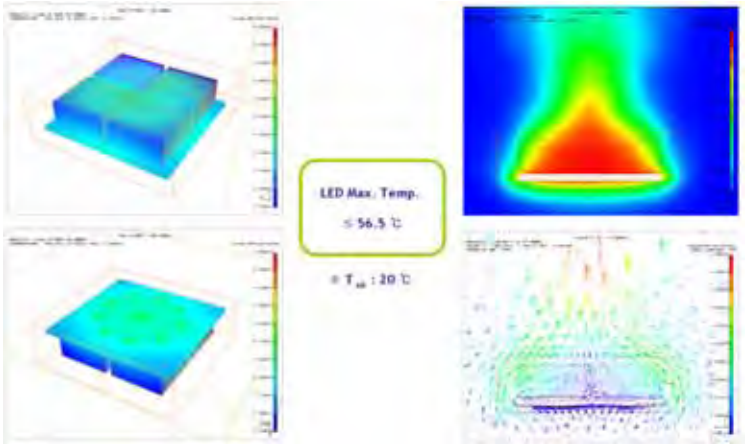
<COOLING MODULE>

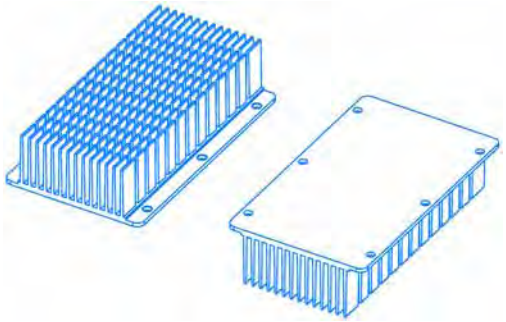
16W LED Lighting



1-2. Absolute Maximum Ratings

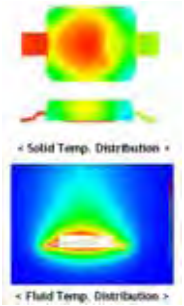
Parameter	Symbol	Value	Unit
Forward Current	I_F	0.4	A
Power Dissipation	P_D	1.6	W
Junction Temperature	T_J	125	℃
Operating Temperature	T_{OP}	-30 ~ +85	℃
Storage Temperature	T_{STG}	-40 ~ +100	℃
ESD Sensitivity [1]	-	±20,000V HBM	-

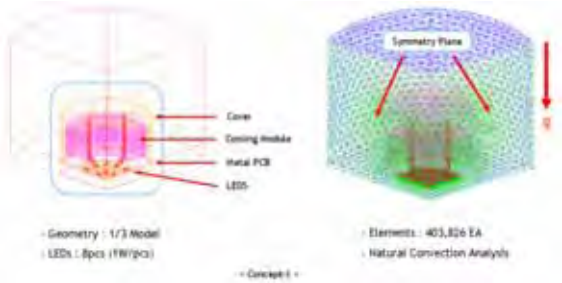


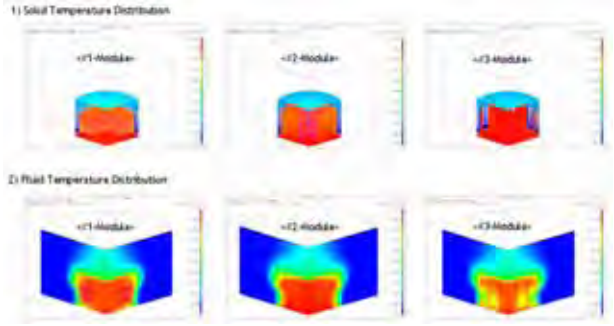


<COOLING MODULE>

24W LED Lighting

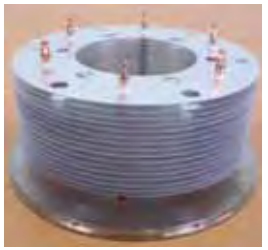


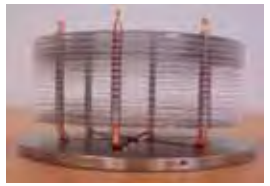




Simulation Model	Concept-1	Concept-2	Concept-3
Module Geometry			
Fin Dim.	O.D.(ϕ160mm) , I.D.(ϕ80mm) , 0.4t , 16EA	55mm X 89mm X 0.4t , 75EA	203mm X 20mm X 1.2t , 18EA
Surface Area [㎡]	0.499	0.759	0.144
Cooling Tech.	- [illegible] + Fins - Module Base	- Flat Fin - Module Base	- [illegible] - Module Base
Max. Temp.[℃]	58.4	56.6	54.7

※ HPLED Cooling Module
→ Recommendation Module : #1 Module (Cooling Performance & Manufacturing Cost & time...)
- Circular type Fin Shape Optimization → Performance ↑
- Module Base & Heat Pipe Assy (Soldering) → Contact Resistance ↓





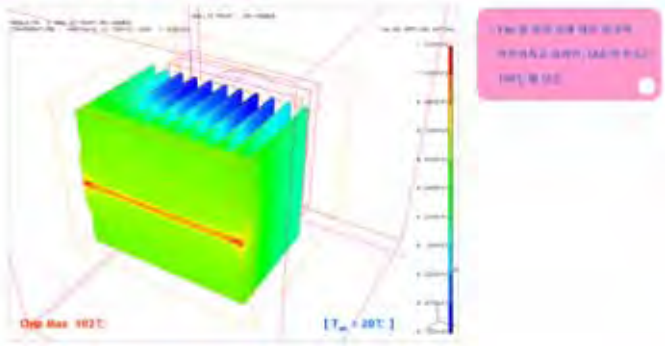
<COOLING MODULE>

54W LED Lighting for Tester

- Heat Sink Size : 70 X 60 X 45mm
- Base Thickness : 5mm
- Fin & Pitch : 1.5 & 7mm
- Fan : 60 X 60 X 15mm (DC Fan)

❖ LED 발열량 : 2.7W X 20 ea = 54 W (※ 35 X 25 X 1.6 mm Metal PCB X 2ea)
Metal PCB 2 개를 1 set로 Cooling 하도록 Heat Sink 설계함 (Heat Sink + MTRAN + Fan)

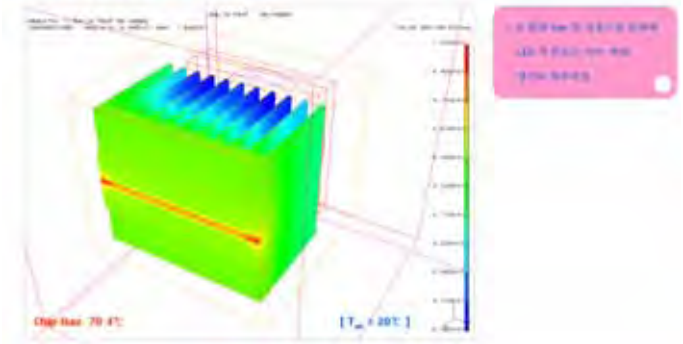
Case1 [A 소음 Fan (20 dBA)] - Solid Data



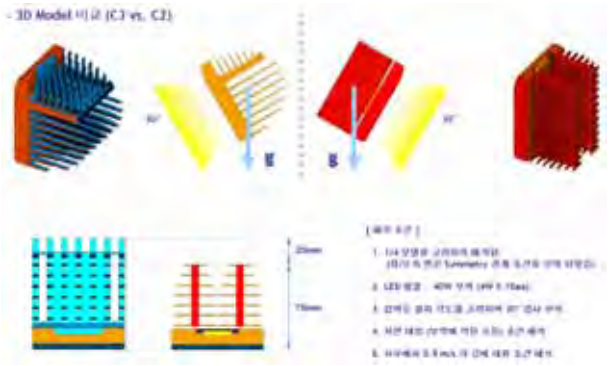
Cooling Concepts - Simulation Case

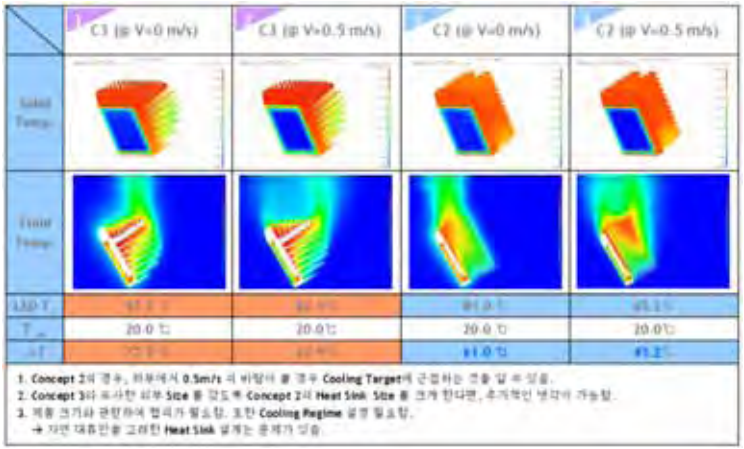
Case	Heat Sink	MTRAN	Fan	Remarks
1 	적용		11.53 CFM	저 소음 Fan (20 dBA)
2 	적용		26.20 CFM	고 풍량 Fan (38 dBA)

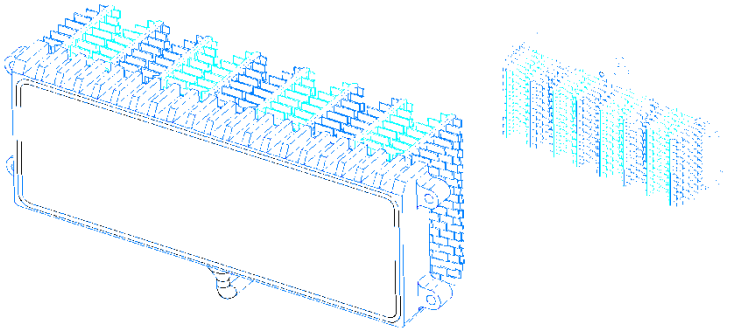
Case2 [고 풍량 Fan (38 dBA)] - Solid Data



160W LED Lighting



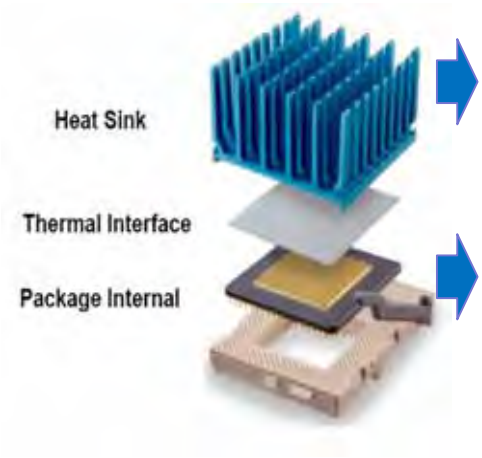


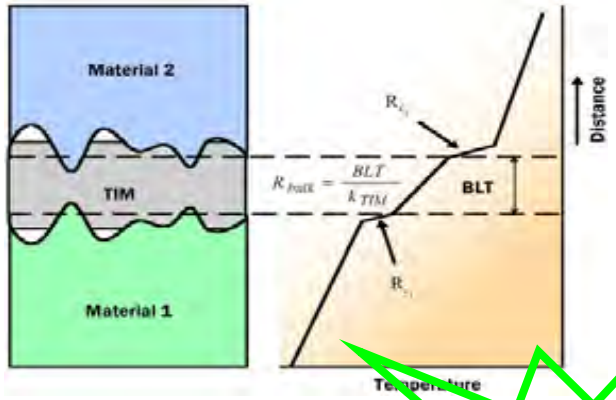


<COOLING MODULE>

Importance of NANOTIM®

Thermal Interface Material (TIM) is used to fill the gaps between thermal surfaces, such as between micro-processor & heat sinks, in order to increase thermal transfer efficiency.





Low Thermal Resistance

NANOTIM® Series Spec.

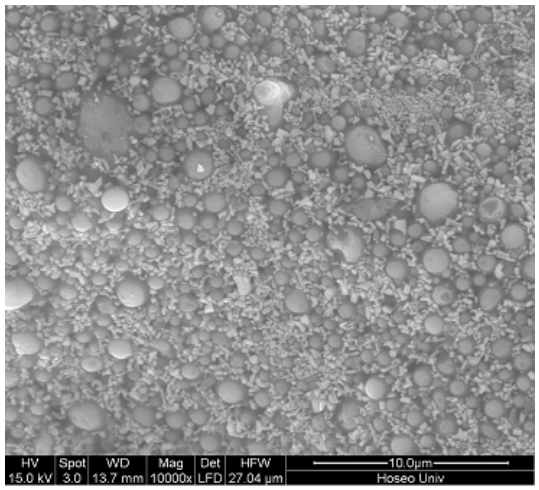
Items	Unit	PCM25			TGS		SPS		APS	
		PCM25	PCM25-SP	PCM-L	A300	C200	SPS	SPS025	APS-S	APS-T
Color	-	Gray	Gray	Gray	Gray	White	Gray	Gray	Gray	Gray
Thickness	mm	0.25	-	0.25	-	-	0.3~10	0.25	0.25	0.15, 0.25
Density	-	3.2	2.2	2.8	2.6	2.4	2.5	2.4		
Thermal Conductivity	W/m·K	4.0	3.0	2.0	4.0	1.7	1.55	1.55	1.0	1.8

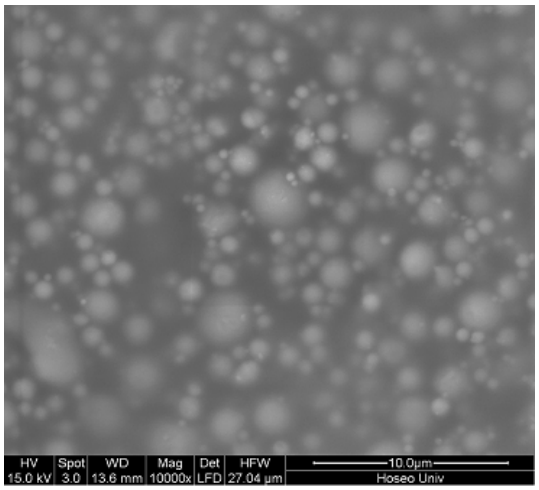
COOLTTM

$$q = kA\frac{\Delta T}{t}(w)$$: Thermal Conductivity

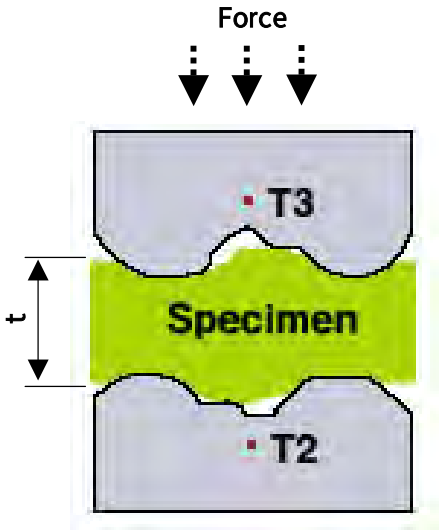
$$R = \frac{\Delta T \times A}{q} = \frac{t}{k}(^{o}Cm^{2}/w)$$: Thermal Resistance

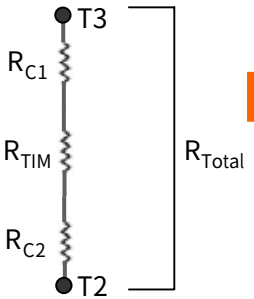
$$R_t(^{o}Cm^{2}/w) = R_{C1} + R_{TIM} + R_{C2} = R_{TIM} + R_C = \frac{t}{k} + R_C$$: Thermal Impedance

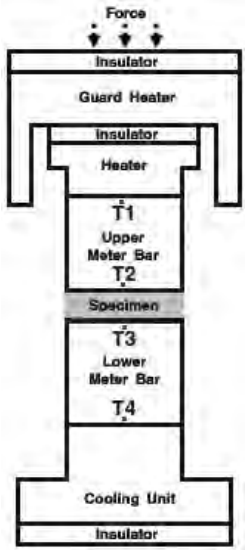




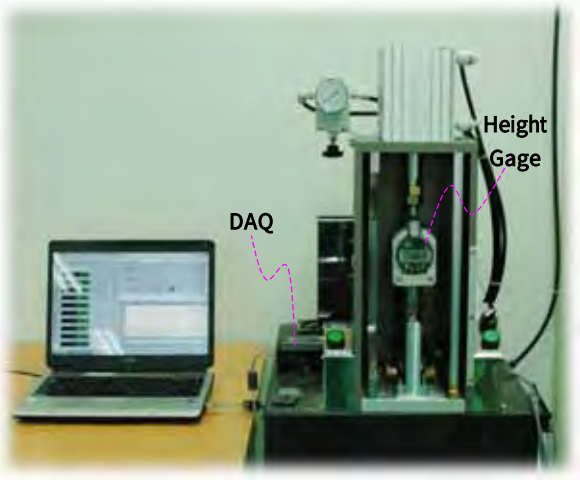
Test of NANOTIM®





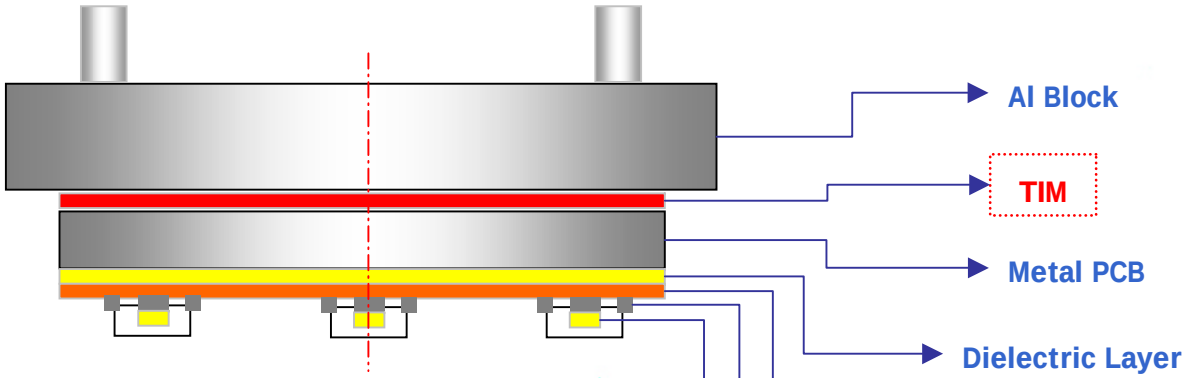


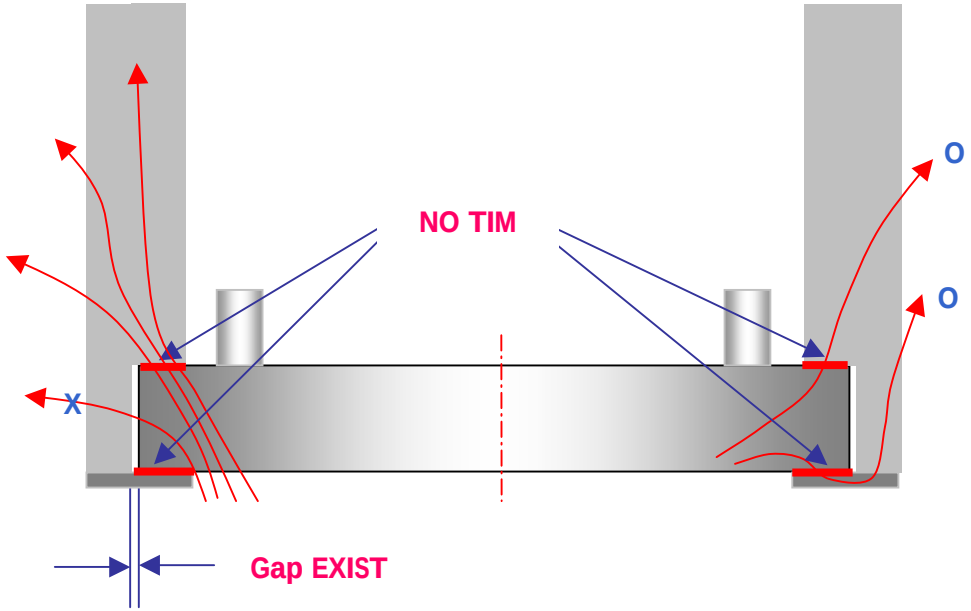
ASTM D5470



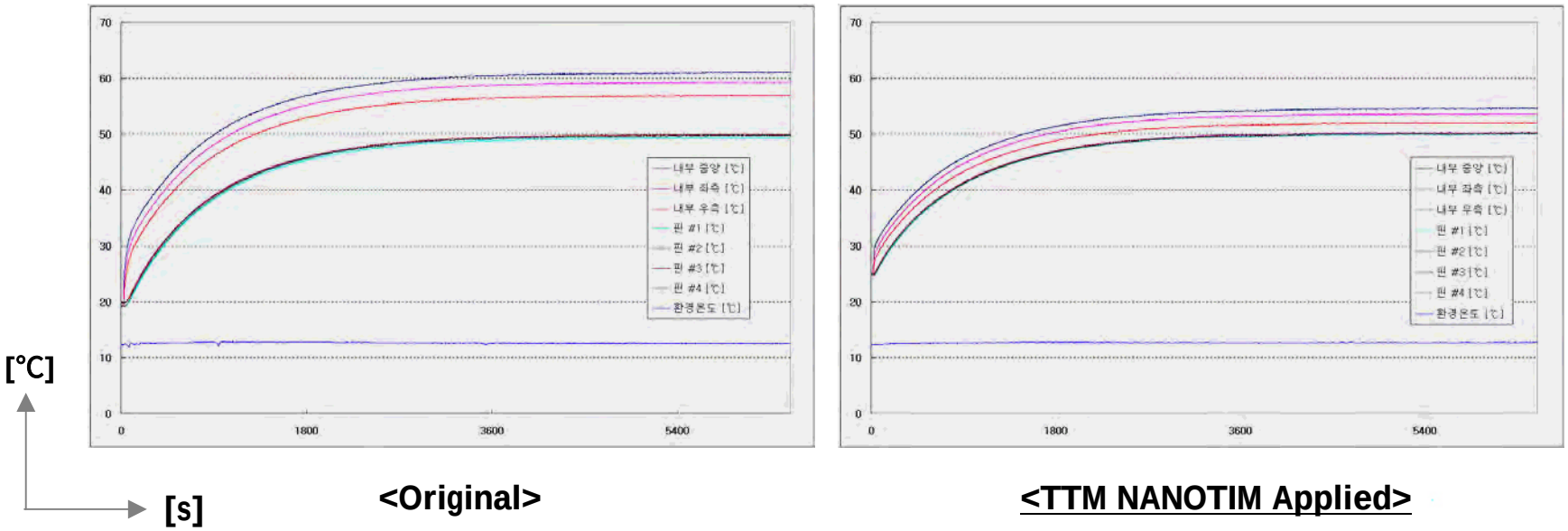
T-Thermo200

Performance of NANOTIM®





Performance of NANOTIM®



<Original>

<TTM NANOTIM Applied>

6℃ Drop just by changing TIM !

EPOCHAL **THERMAL SOLUTION** PROVIDER

MTRAN®	• MTRAN BASIC • MTRAN PCB – MTRAN Embedded PCB • MTRAN MEMORY – TANK, WINE, TECHNO • MTRAN CPU – CPU Cooler
NANOTIM®	• NANOTIM TGS – Thermal Grease • NANOTIM PCM – Phase Change Material • NANOTIM SPS – Silicon Thermal PAD • NANOTIM APS – Adhesive Thermal PAD
T-SET	• Customized Design Module • Heat sink Module, Heat pipe applied Module, Fan
T-SPOT	• Thermal Consulting Service • Thermal and Fluid Flow Analysis