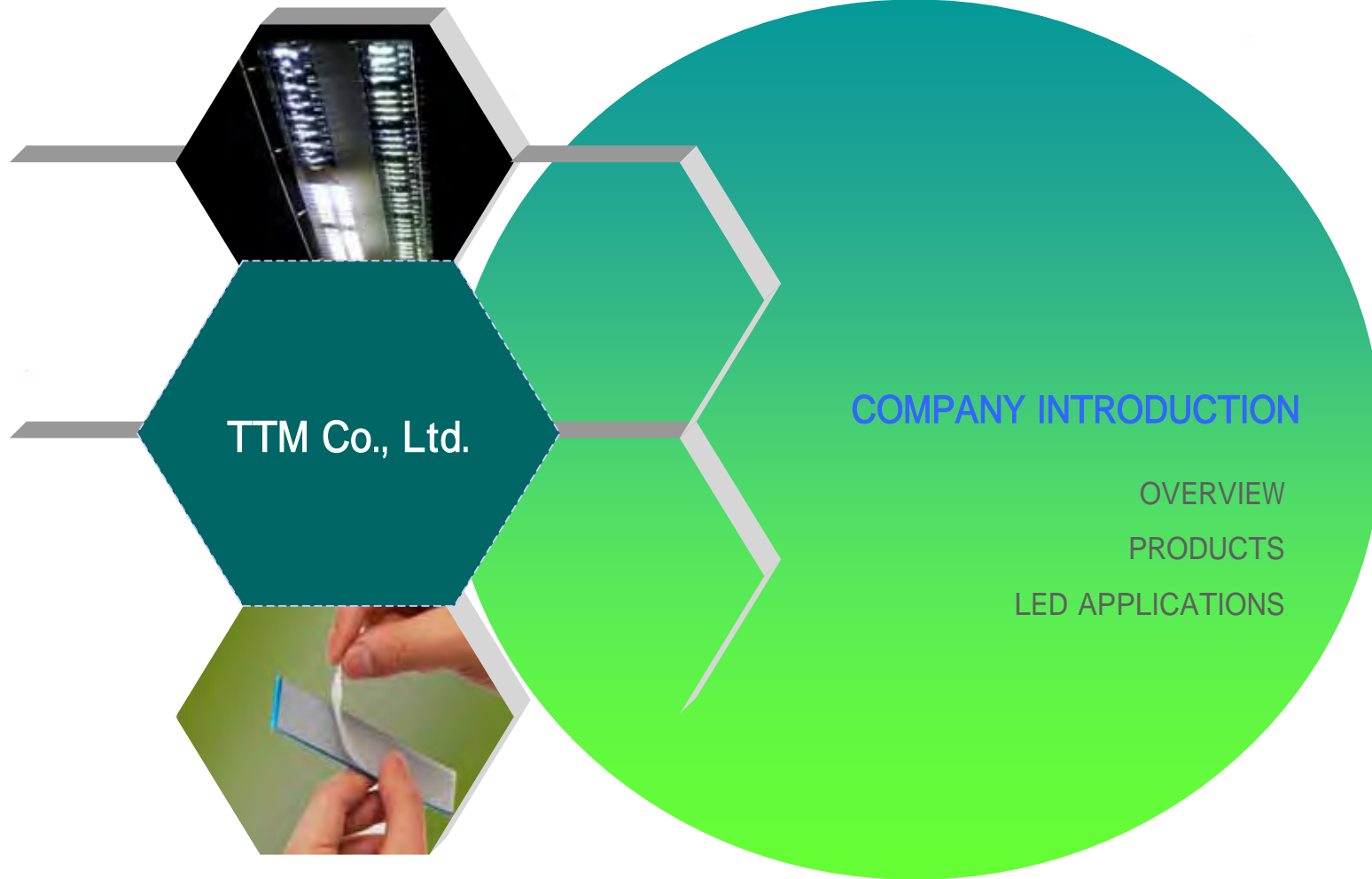


THE EPOCHAL **THERMAL SOLUTION** PROVIDER

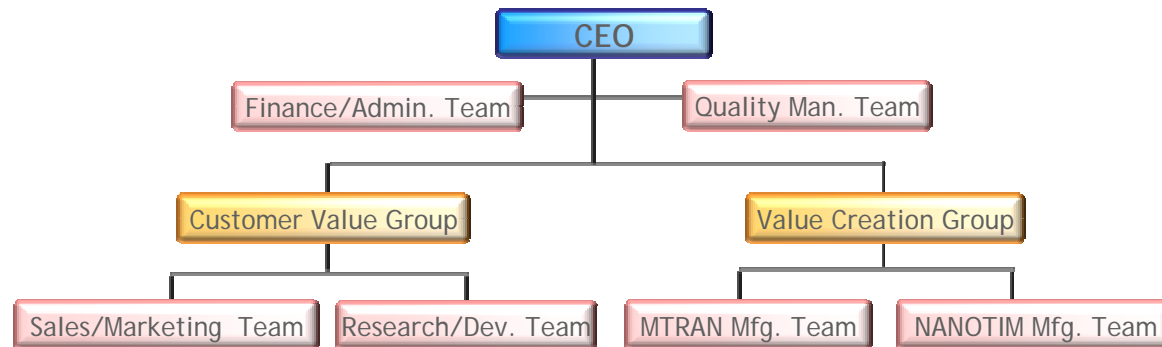




General Overview

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





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

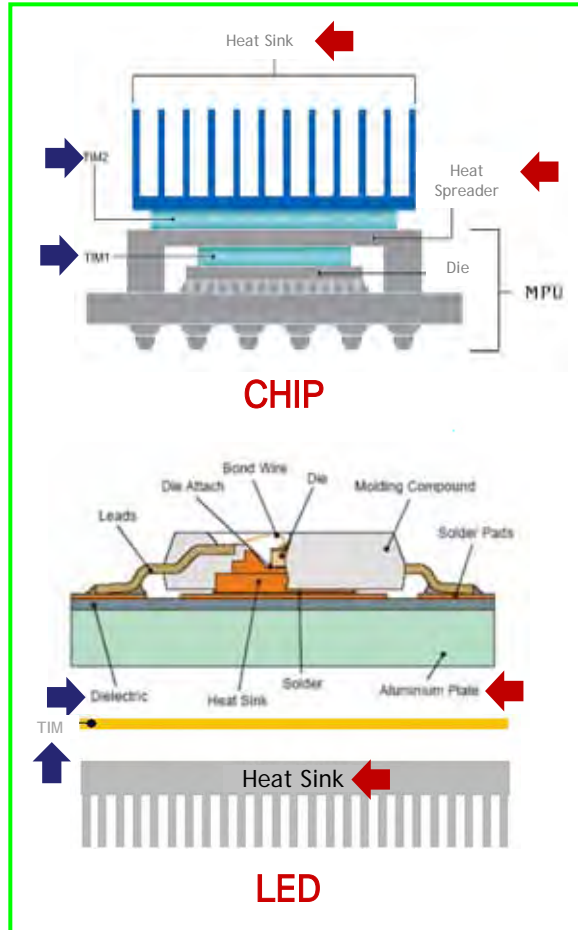
Micro Technology



- Flat Heat Transmitter**
- Micro Channel Technology
 - Vacuum Technology
 - Cold Welding Technology

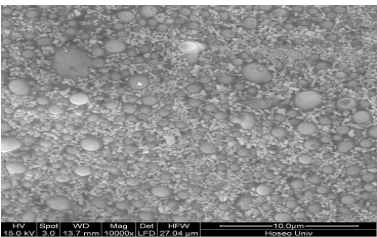
MTRAN®

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



MTRAN → NANOTIM →

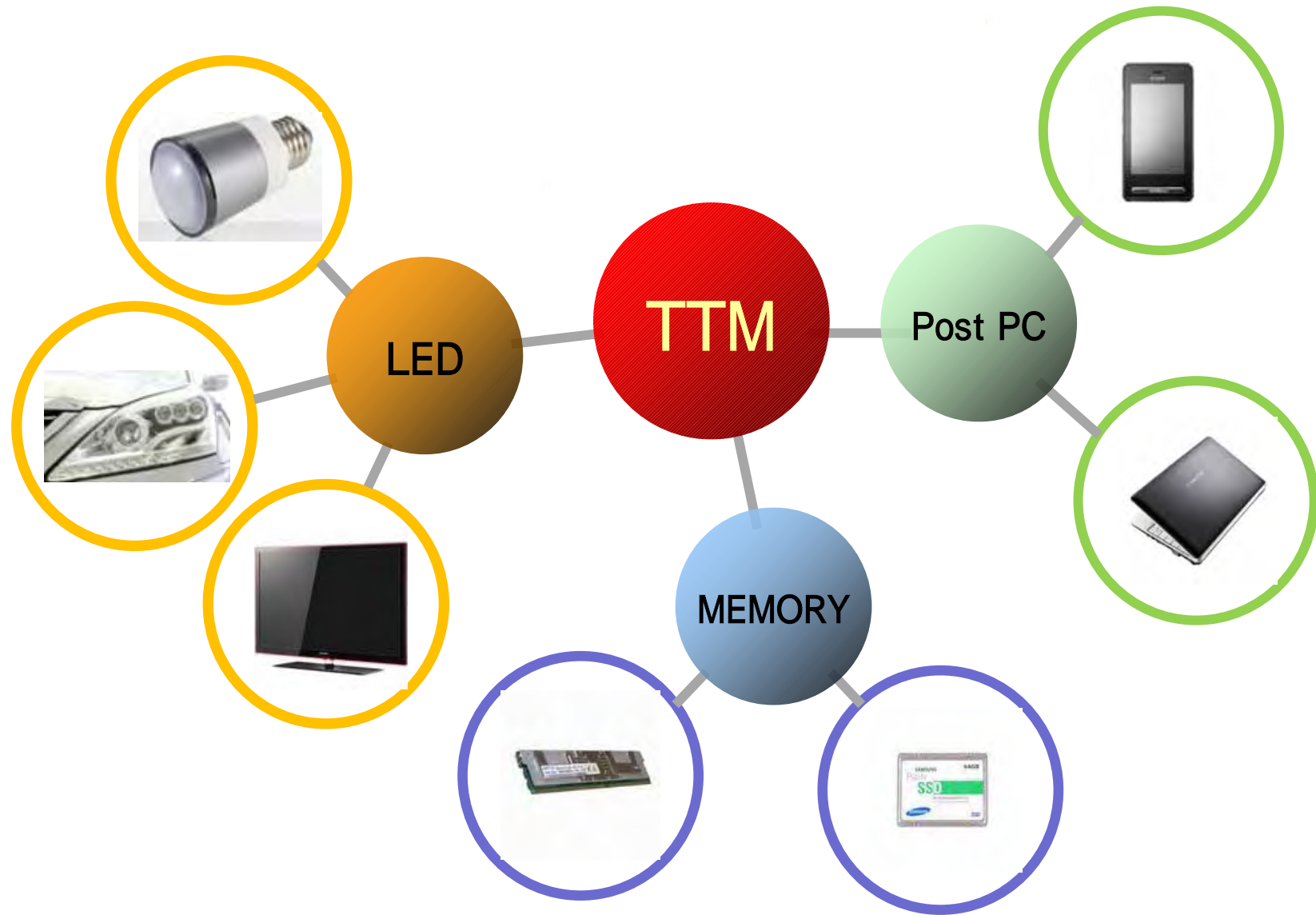
Nano Technology



- Thermal Interface Material**
- Nano Dispersion Technology
 - Sheet Forming Technology

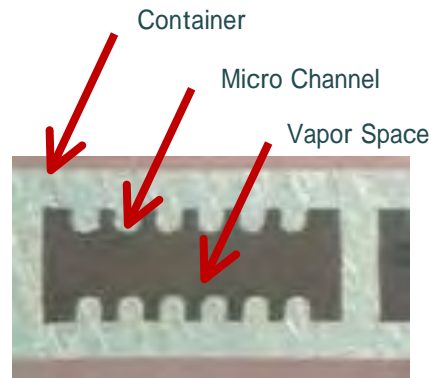
NANOTIM®

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

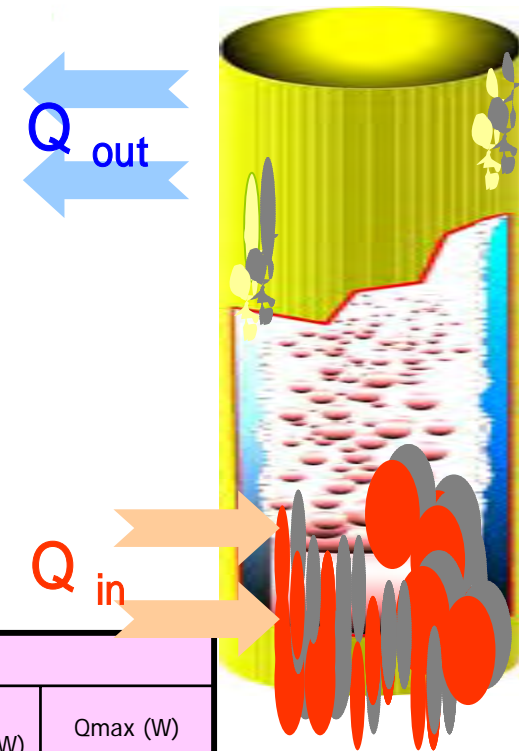


Feature

- 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]



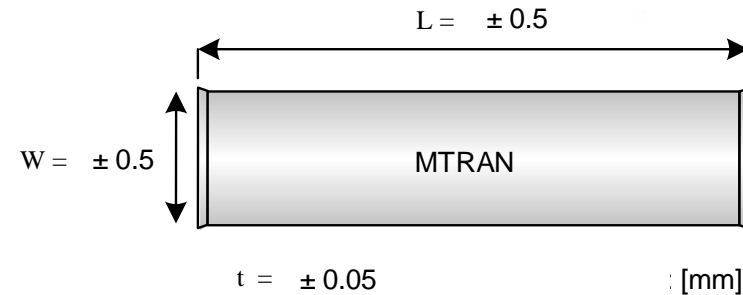
		Cu Heat Pipe		MTRAN		
Diameter D: (mm)	Flat t: (mm)	Thermal Resistance (/W)	Qmax (W)	Thickness t: (mm)	Thermal Resistance (/W)	Qmax (W)
6	2.0t	0.1~0.32	5	2.0t	0.1	50



[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()	0 ~ 90°
Leakage Temperature	170



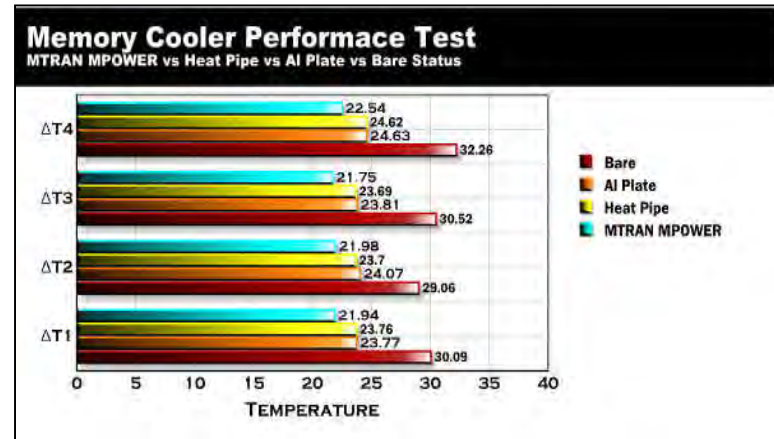
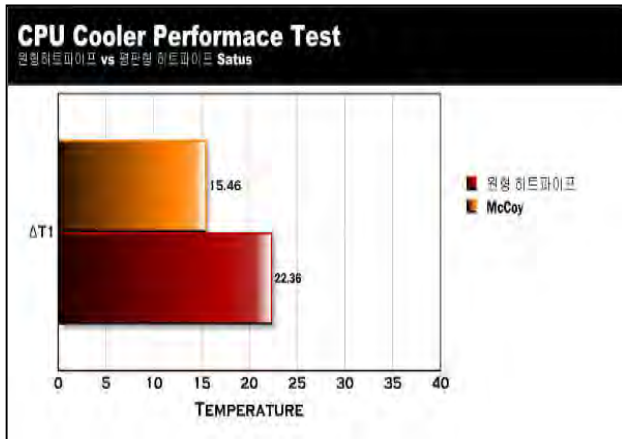
[Dimension]

[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		300	11 ~ 50
TMT-2040A Series	2.0	40			40 ~ 170
TMT-2550A Series	2.5	50			75 ~ 300
TMR-0060A Series	6.0	6.0			25 ~ 90

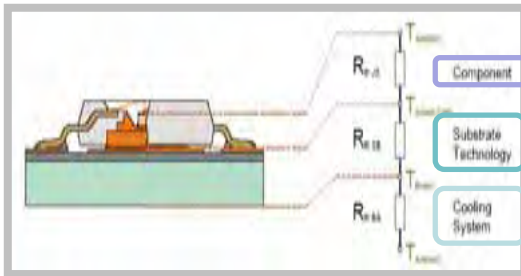


“CPU/MEMORY Cooler”



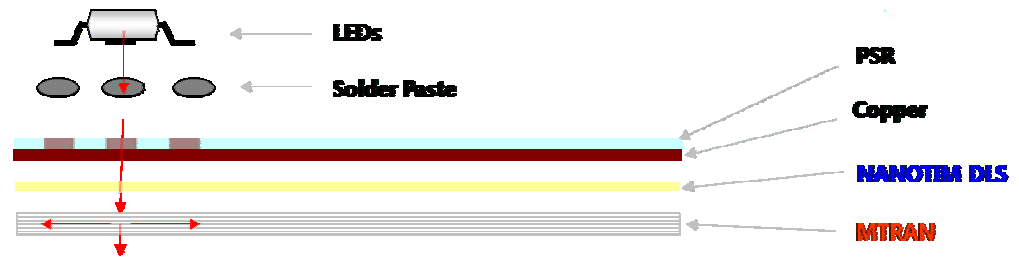
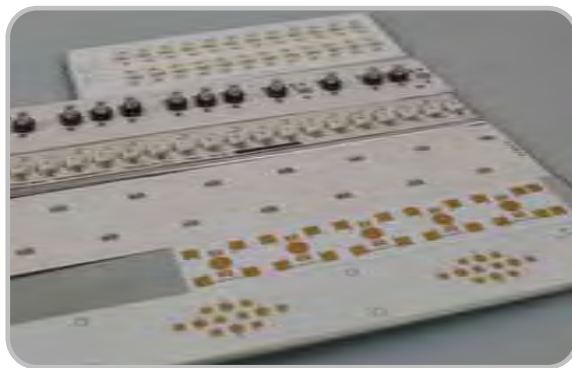
Feature

- MTRAN based MCPCB (Metal Core Printed Circuit Board)
- 1/10 of Thermal Resistance



[Analysis of LED]

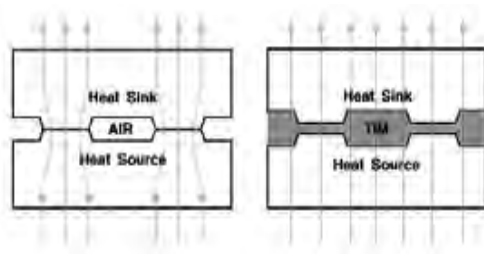
Substrate Technology	Thermal Resistance R_{thSB}
Al MPCB with Enhanced dielectric	3.4 K/W (OSRAM)
MTRAN PCB with Enhanced dielectric	2.1 K/W (TTM)



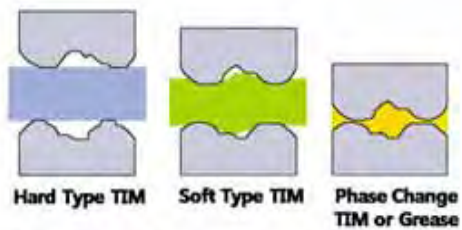
[Basic Structure of MTRAN PCB]

Feature

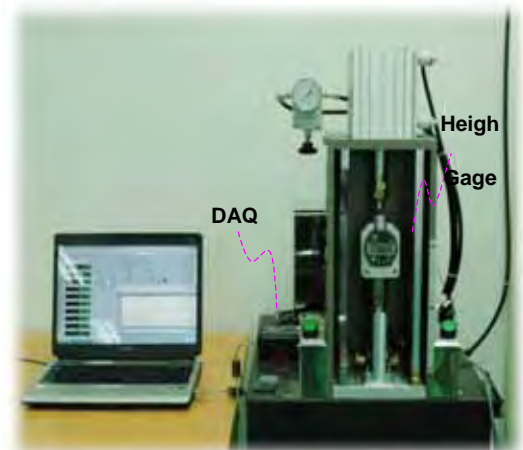
- Various Type of Thermal Interface Material
- Thermal Grease (NANOTIM TGS, Paste)
- Phase Change Material (NANOTIM PCM, PAD/Paste)
- Solid PAD/Sheet (NANOTIM SPS, Various Peel Strength)
- Adhesive PAD/Sheet (NANOTIM APS, No Coating Layer)



[Function of TIM]



[Schematic of functionality TIM]



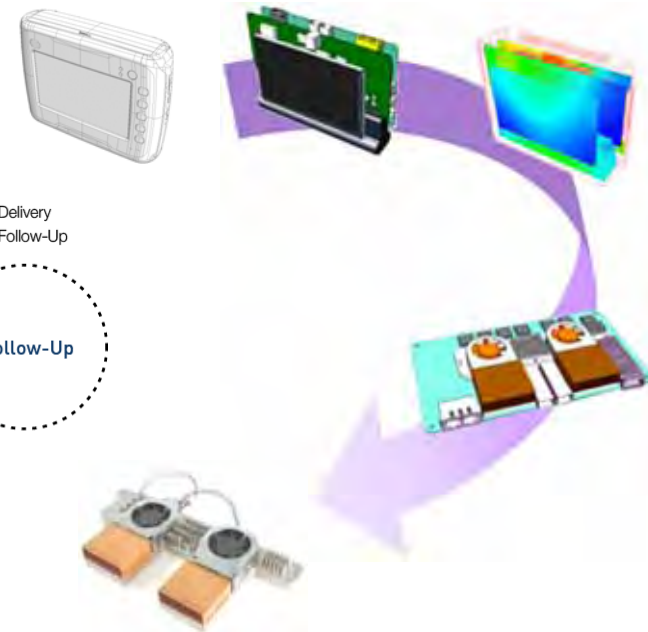
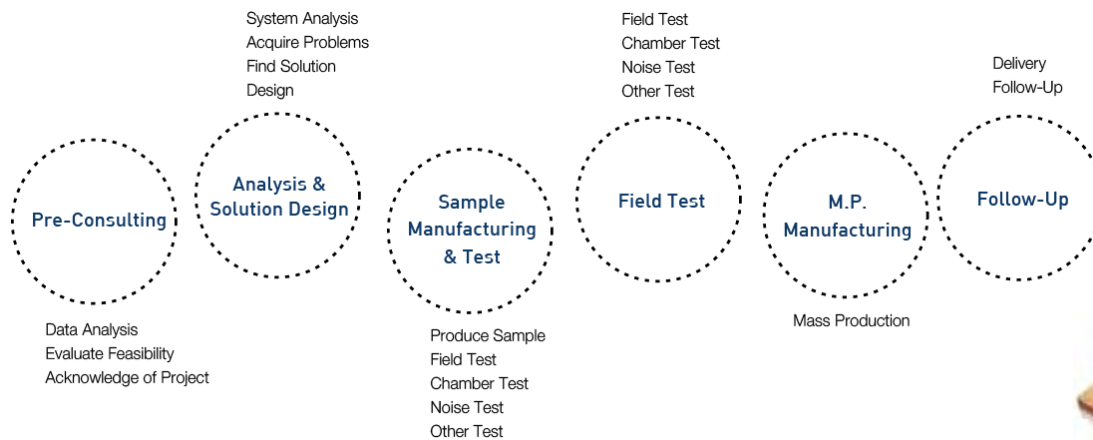
[T-Thermo 200 based on ASTM D5470]



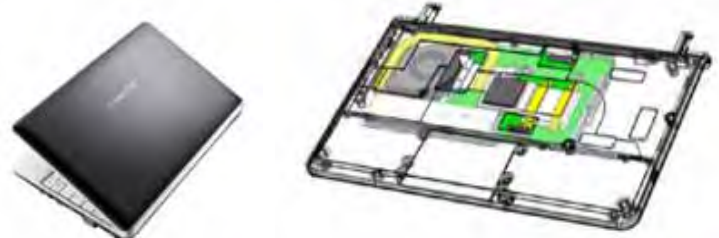
“Conventional Technology Based Products”

“Thermal Analysis & Design Consulting Service”

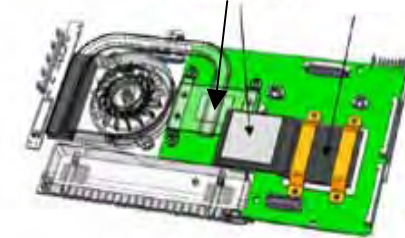
Process



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

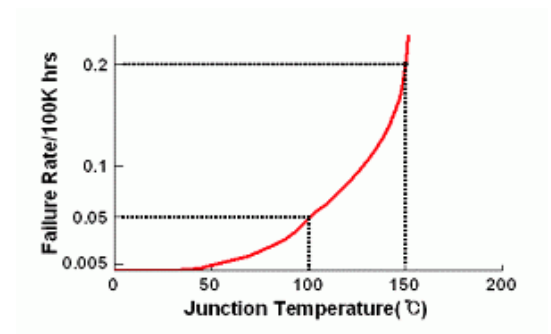
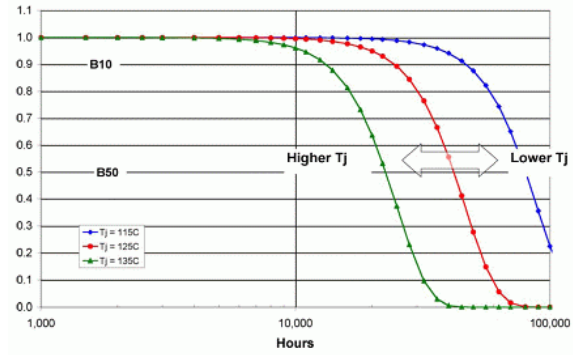
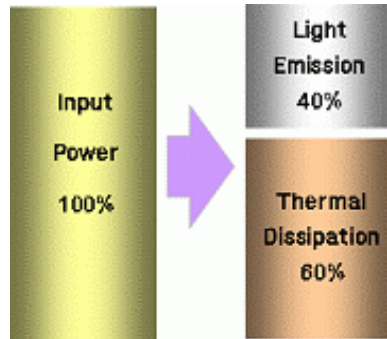


MTRAN /NANOTIM PCM for LED

NANOTIM SPS for Driver IC

NANOTIM SPS/T-SET for Power TR

Thermal Problem in LED



SOURCE [Lumileds]

SOURCE [KOPTI]

Influence of LED package by Heat

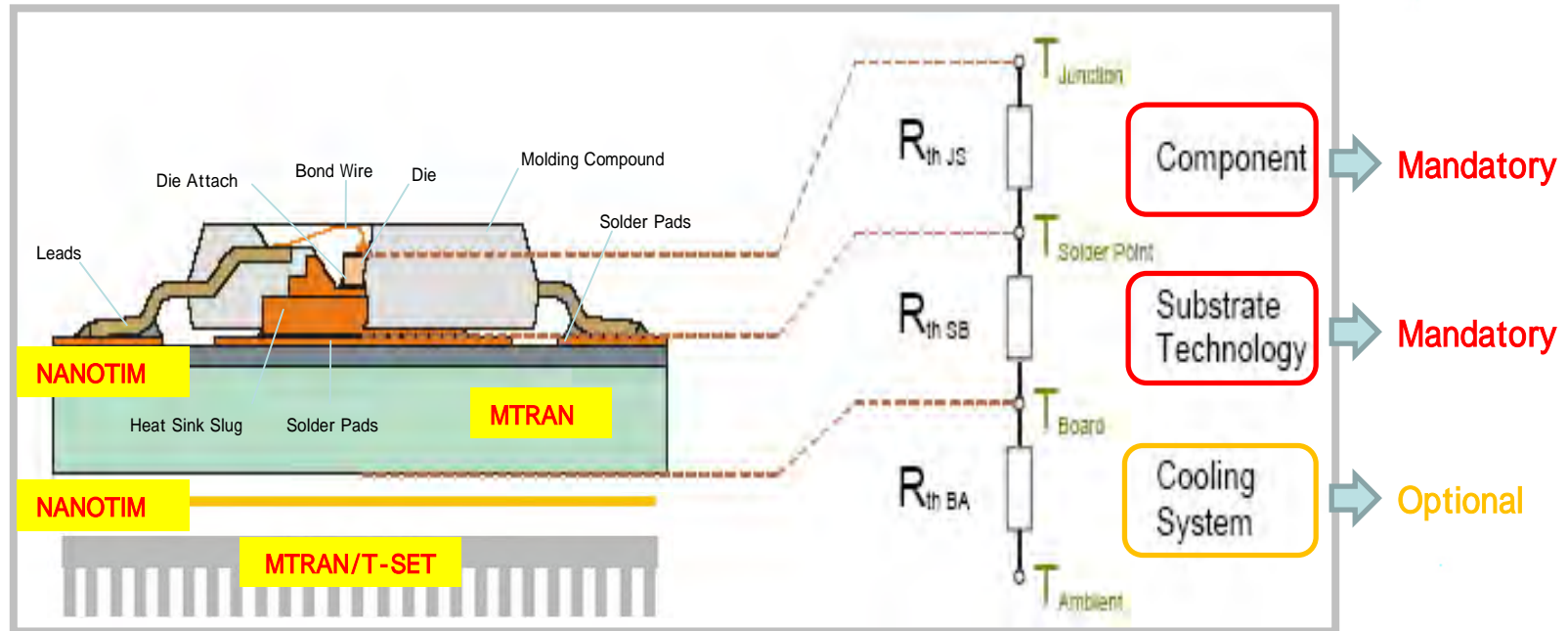
- 1. Yellow Phenomena of Epoxy Resin**
- Decrease of Luminous output
- 2. Separation of Solder Paste Contact**
- LED elements damage
- 3. Break of Wire by thermal overload**
- influence from thermal stress
- 4. Detachment of surface between LED Package and Silicon resin**

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]



- **Conduction**
Fourier's law $Q = -kA (\Delta T / x)$

- **Convection**
Newton's law $Q = hA (T_s - T)$

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



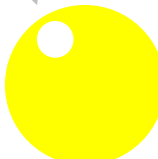
High Thermal Conductivity



Large Cooling Area

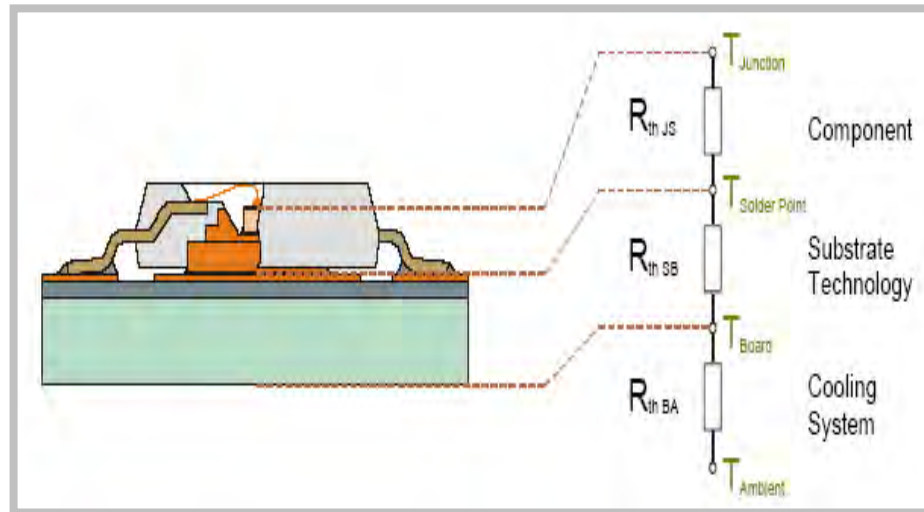


Proper Cooling Flow
@ FC , NC



Too Small Factor

Too many Layers



High Thermal Resistance

- p-GaN
- n-GaN
- Sapphire
- Epoxy
- HS Slug
- Solder
- Circuit
- Copper
- Dielectric
- PCB
- TIM
- Heat Sink
- Fan



■ Properties of Light Source



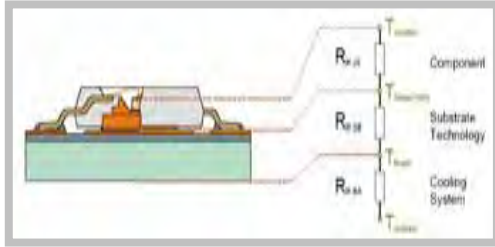
Light source	Luminous Efficacy (lm/W)	Heat Lost (%)	Cost Efficiency (\$/lm)
Incandescent	10-20	90% Radiation, 5% Convection, 5% Conduction	.0003
Fluorescent	75-90	40% Radiation, 40% Convection, 20% Conduction	.0005
Cold Cathode Fluorescent	55-65	40% Radiation, 40% Convection, 20% Conduction	.02
High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

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

- 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

Components
Services
Overview

Optics

- Optics manufacturing
- LED Components

Thermal

- Substrate materials
- Interface materials
- Heatsink engineering & manufacturing

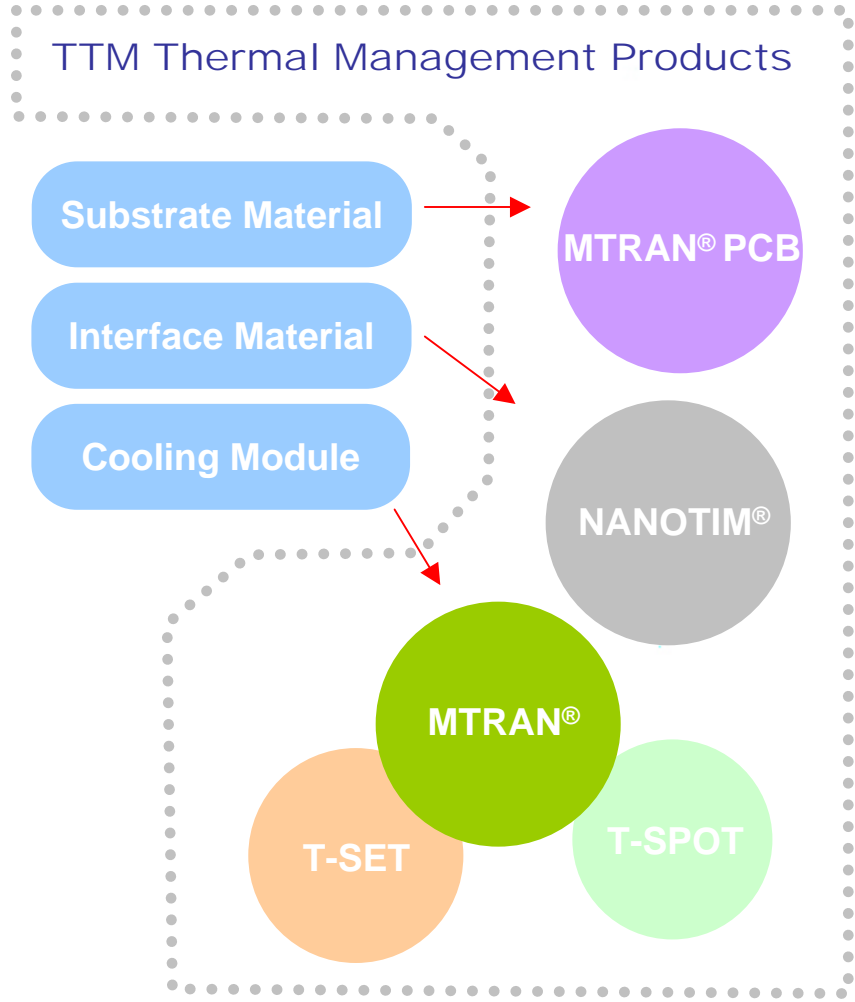
Electronic

- IC driver manufacturer
- Driver circuit supplier

Thermal Solutions

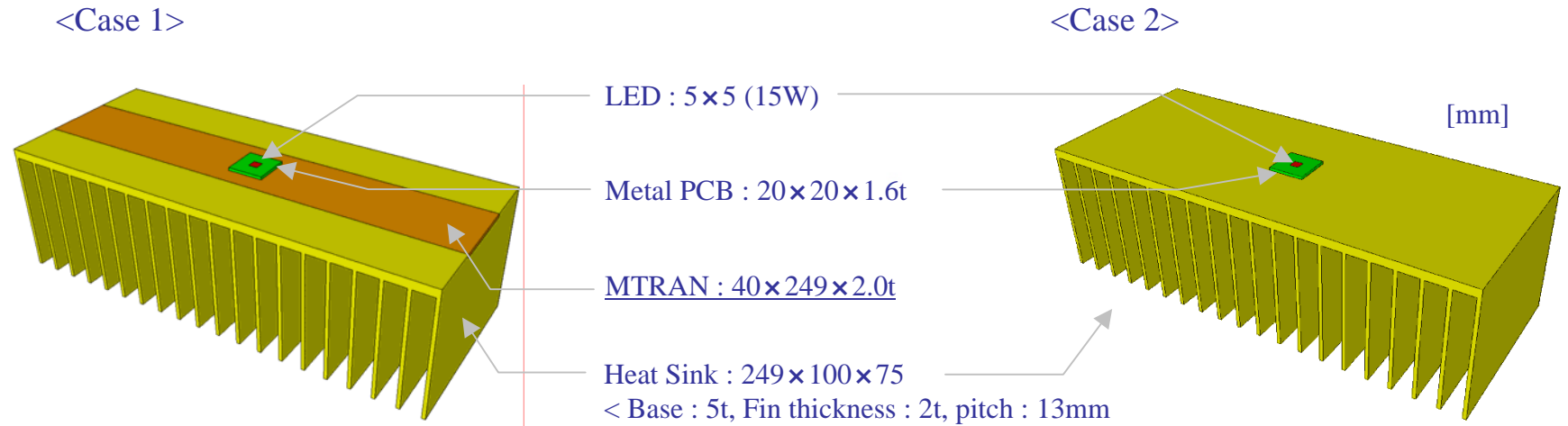
High power LED's generate heat which affects their optical and electrical characteristics as well as lumen maintenance / lifetime. The heat must be transferred away from the LED by the mounting substrate, thermal interface materials and heat sink to the ambient air.

©2007 LED Light for you powered by OSRAM



Cooling Performance Effect Check (@ Heat sink+ MTRAN)

[Geometry Check]

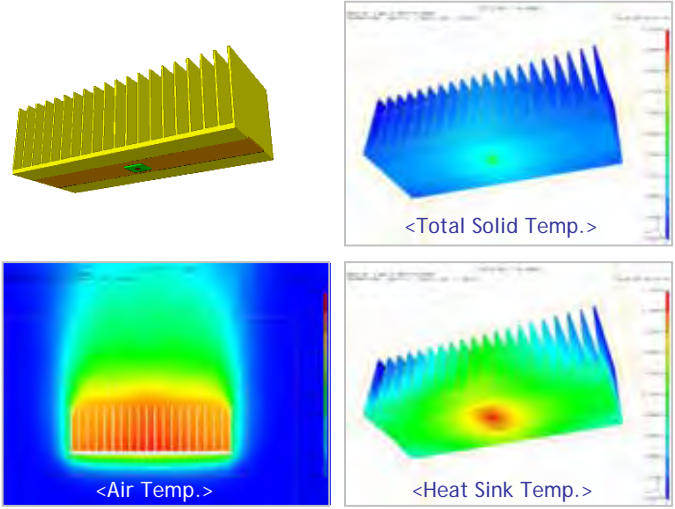
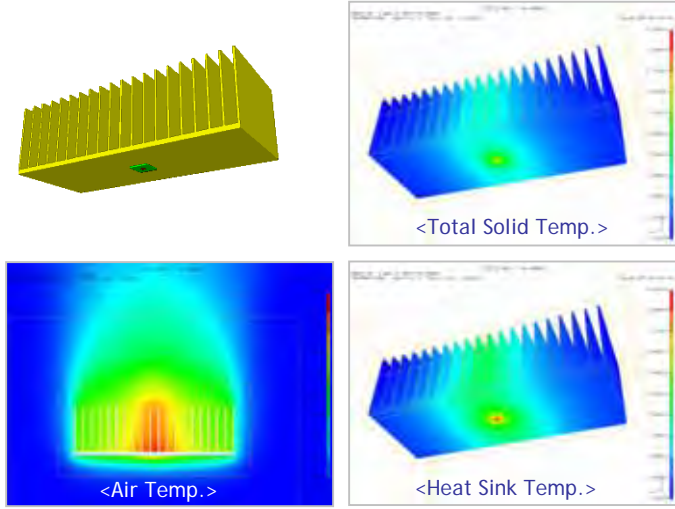


	H/S Weight[g]	MTRAN Weight[g]	Sum of Weight[g]	Cooling Area [m ²]	Remarks
Case 1	1,042	29	1,071	0.3397	Groove for MTRAN
Case 2	1,096	0	1,096	0.3397	

Heat Sink Analysis 2



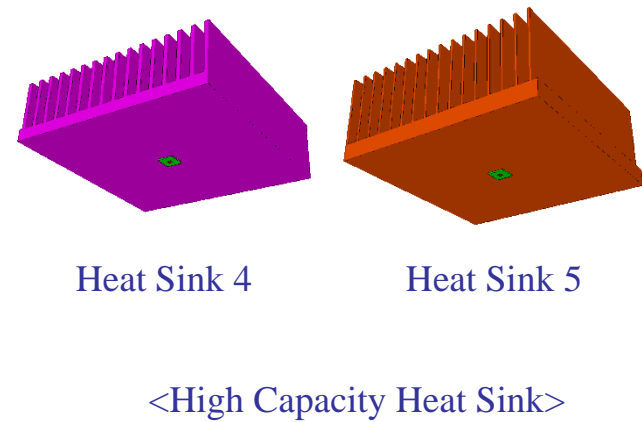
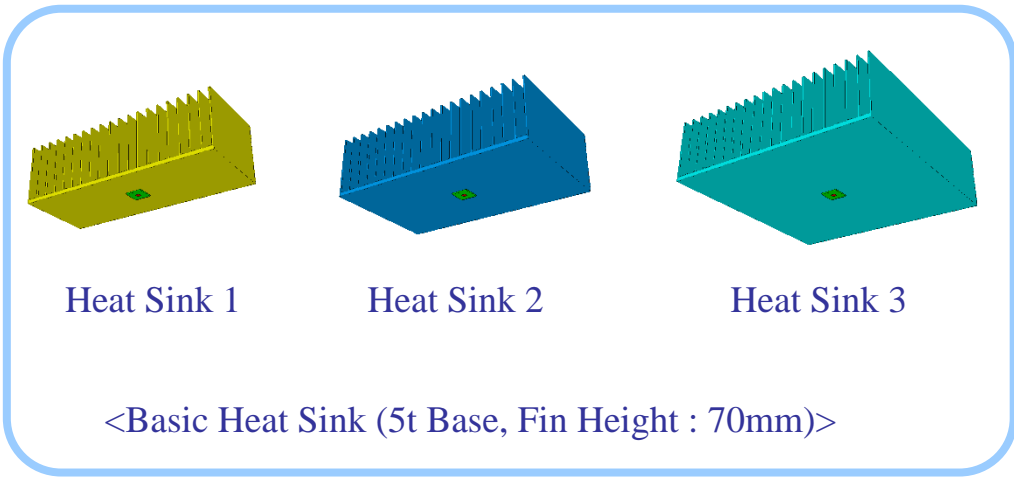
[Simulation Results (@ Ambient 20)]

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 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 Analysis 4

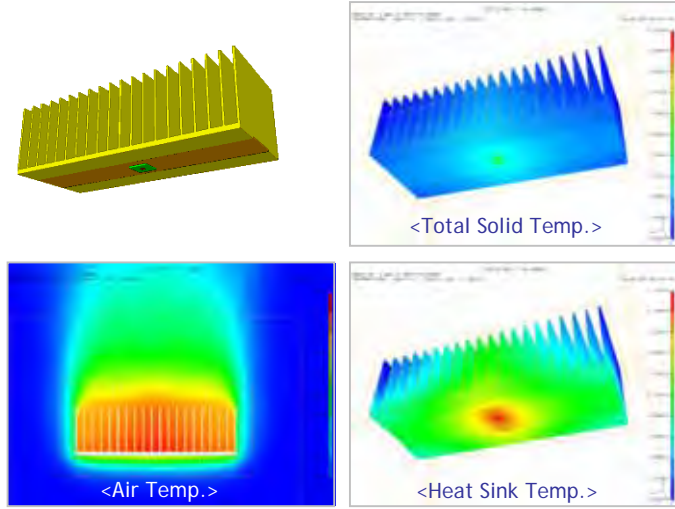
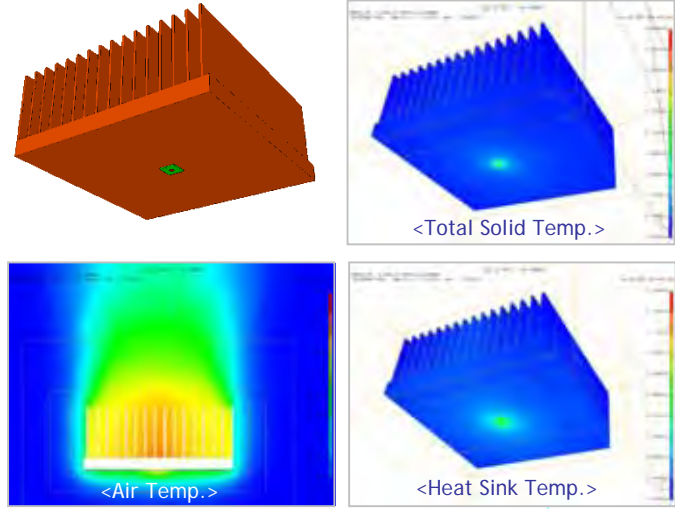


[Simulation Results (@ Ambient 20)]

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 [°C]	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(5×5mm) heat source is effective to cooling as thickness of the Heat Sink Base is more thicker .
(But the weight is increased)

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 [°C]	36.3	36.9
Heat Sink T [°C]	28.9 ~ 31.2 [2.3 °C]	25.1 ~ 32.6 [7.5 °C]

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



69.3

17.2 Drop

Total 26 Drop

[10W LED]

52.1

8.8 Drop

43.3



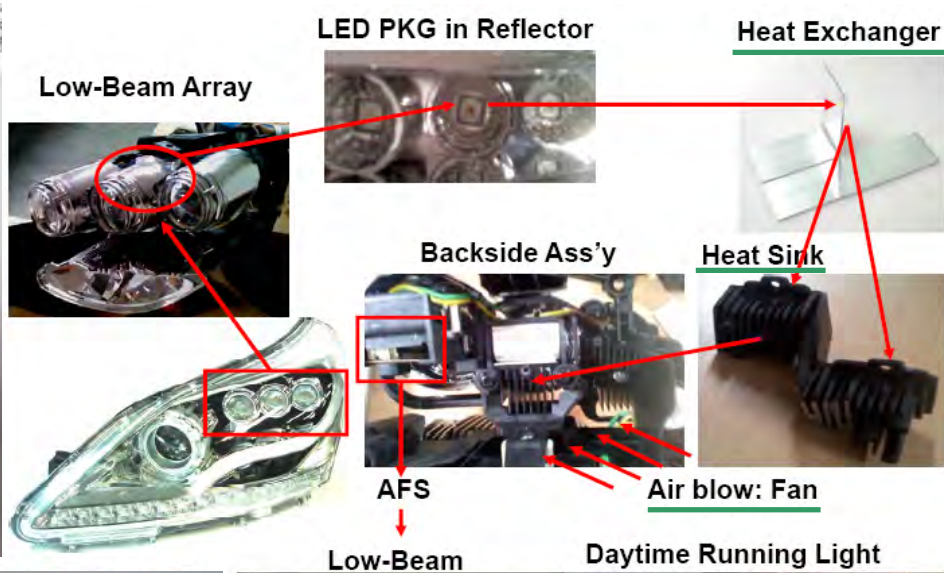
Thermal key point is MTRAN → 17 Cooling
MTRAN + Heat Sink → 26 Cooling



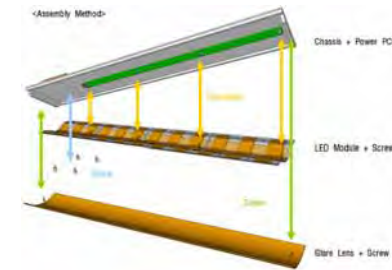
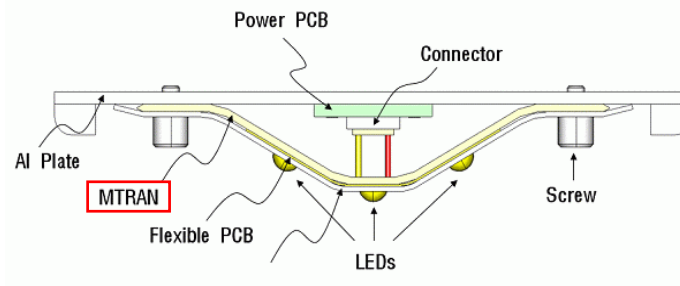
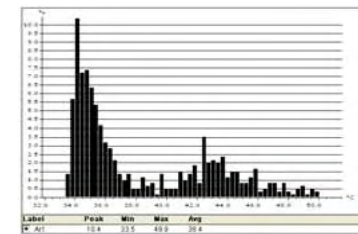
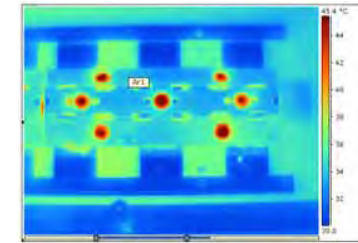
Automobile Head Lamp



HYUNDAI – EQUUS VI Limousine



Bar Type LED Lighting



Concept -1

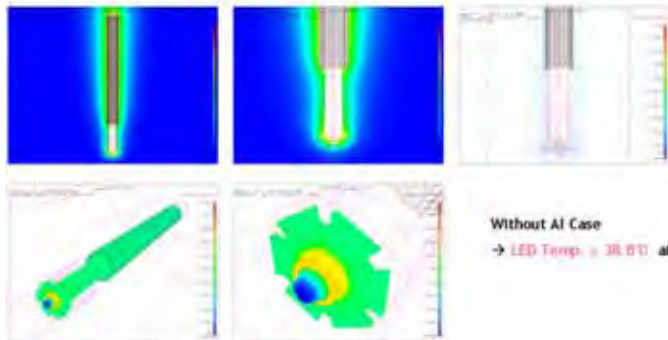
- Fanless Cooling.
- Heat Pipe 를 이용하여 LED Chip 에 집중된 열을 상부로 이송.
- Heat Pipe 끝 단에 Sink 를 결합하여 방열 면적 확보.
- Al Case 를 제거하여 주위 공기와의 대류 열 전달 촉진.

Concept -2

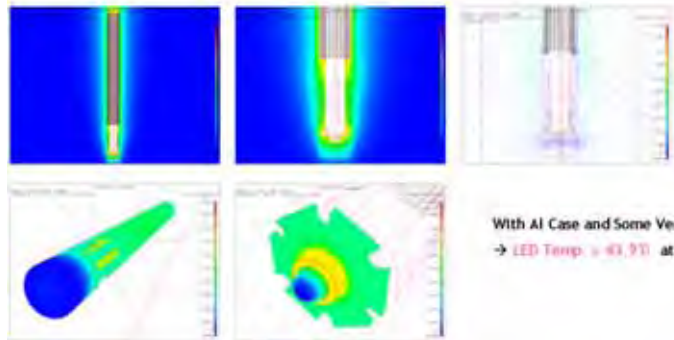
- 제품 보호를 위한 Al Case 결합.
- Al Case 의 하부에 Vent Hole을 가공하여 외부 공기 유입



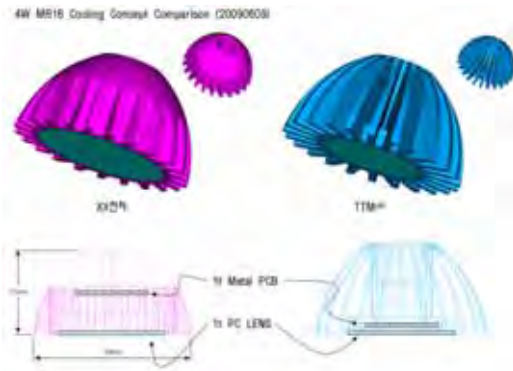
< Concept 1-w/o Case >



< Concept 2-w/ Case >



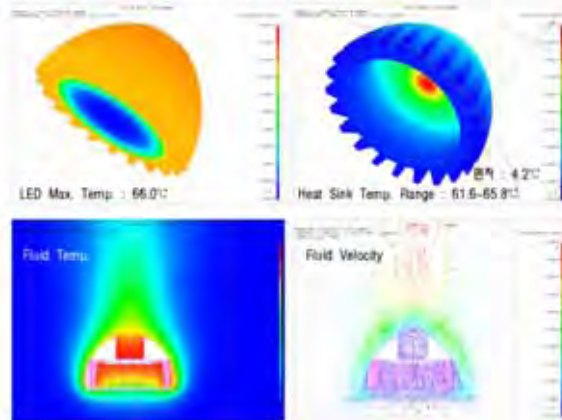
4W LED Lighting



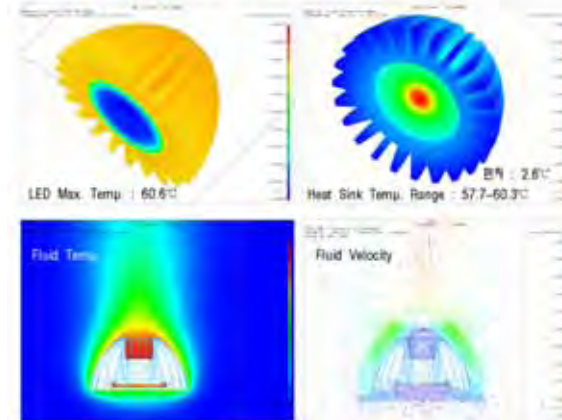
1. 4W MR16 Cooling Concept Comparison (20090609)

구분	LG 전식	TTM TM
무게 [g]	41.0	41.0 [동일함]
표면적 [m ²]	0.0092	0.0164 [약 2배 증가]
HS 재료	AlDC10 [96 W/mK]	AlDC10 [96 W/mK]
LED T _j [°C]	66.0	60.6
Cooling [°C]	0	5.4°C
고급		10.0mm 높이, 5.4°C 냉각

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



3. Simulation Results - TTMTM (Heat Sink 재료 : AlDC10 [96W/mK])



6W LED Lighting



- Thermal Simulation Results

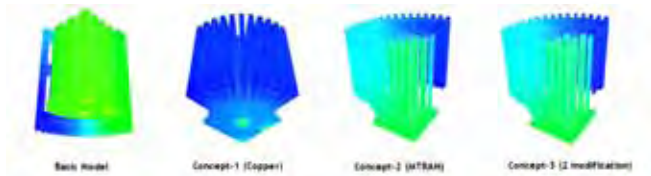


Full Model → Symmetry

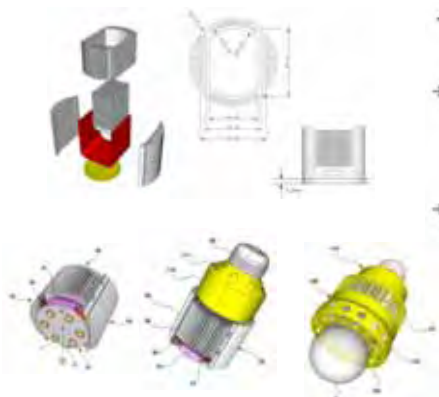
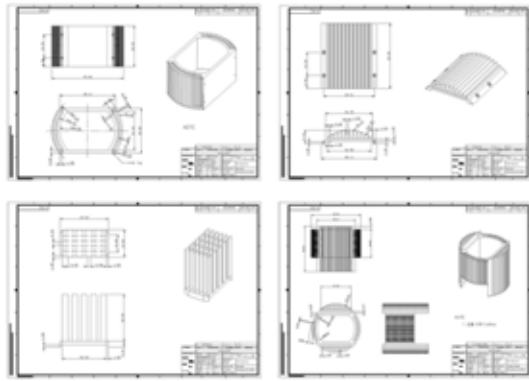


► Strategy of Simplification for Simulation

I-DEAS ESC Special B.C. Use



ΔT [°C]	Sink Fin-base	Housing-bottom	PCB-1
Thermal Test	64.4	55.3	48.0
Basic Model (Re-analysis)	69.0	48.1	70.2
Concept-1 (Copper)	75.9	-	74.8
Concept-2 (MTRAJ)	43.9	42.1	48.4
Concept-3 (2 modification)	55.9	54.7	54.4



- Module Image



<COOLING MODULE>

10W LED Lighting



✓ LED Junction $T_j \leq 55 - 60^\circ\text{C}$ (@ LED 10W, $T_{\text{ambient}} = 20^\circ\text{C}$)
 In general, Thermal engineer use $\Delta T = T_{\text{max}} - T_{\text{min}}$
 TTM ΔT Target = 35-40°C

Simulation !!

Is it possible?

10W

← ABS Housing Mesh Image
 Heat Sink Mesh Image →

• Symmetry Case (1/4 모델 고려)
 - Natural Convection Cooling Regime
 - LED: 0.228W X 42ea = 9.576W (기밀 Chip 에 밀접 부착)

<Solid Temperatures>

• ABS Case Temp. 54.7°C
 LED Case Temp. 45.7°C
 All Heat Sink Temp. $56.7 - 56.6^\circ\text{C}$ →

LED $T_j = 57.1^\circ\text{C}$
 Cooling Factor = 0.17

	FR4 PCB + Housing Contact + HS no hole	FR4 PCB + Housing no Contact + HS no hole	FR4 PCB + Housing no Contact + HS with hole
Solid Temp. [°C]			
LED T _j	57.1	46.3	44.3
T _{amb}	20.0	20.0	20.0
ΔT	37.1	46.3	44.3
T _{max}	56.2 ~ 57.1	56.0 ~ 56.0	43.0 ~ 44.3

• Case 2 와 3의 경우, 냉각 저하가 없음.
 Case 2는, Hole이 없는 경우이며, 상부에 Power 주 PCB가 존재하여 유동 방해 요인으로 인하여 열용량이 없는 구조로 판단됨. 기존 10W Vent 두께로 인하여 0.5mm, 15mm 높이의 Heat Sink로 인하여 0.9mm 냉각 계수됨.
 Case 3의 경우, Housing이 유리와 밀접한 경우를 통해서도 고온에서도, 30~40°C 정도의 냉각이 있음.

14W LED Lighting



Thermal Simulation Purpose (General)

- 1) 다수의 Sample 제작으로 인한 비용 Loss 의 최소화 실현.
- 2) Cooling 이면에 기초한 다양한 Cooling Concept 검토.
- 3) 신규 제품 설계 시, Cooling 부분의 Reference 확보.

LED Lighting Thermal Simulation Purpose

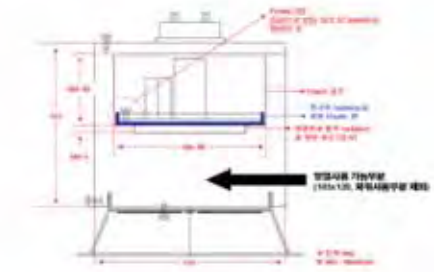
- Natural Convection 을 통한 LED Lighting System Cooling
- Cooling Target : * LED PKG Lead frame 온도 50도 이하 (대기온도 30도 기준) *

$$T_{\text{Lead frame}} \leq 50^{\circ}\text{C} (@ T_{\text{ambient}} : 30^{\circ}\text{C})$$

→ $\Delta T \leq 20^{\circ}\text{C}$ (Cooling Module Weight $\leq 900\text{g}$)

- 기타 고려 사항 : 비용, 제작성, 조립성, 디자인, ...

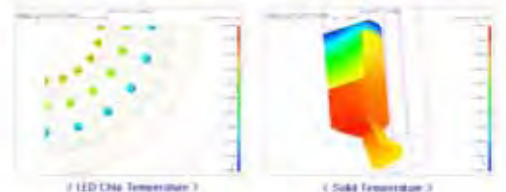
System Analysis



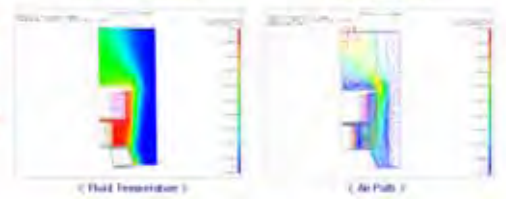
- 방법 : PCB : MCPCB
- 전가대역 : 20W
- LED 예상발광 : 14W

- Simulation Results - LED MAX. Temp. : 42.0°C (@ T_ambient 20°C) → ΔT = 22.0°C (= 14W) → 4.7°C (↓)

- LED Total Power : 14W
- Heat Source Size : 3.5mm (LED 당 0.23W 부하)



- LED 발광을 14W로 가중하였을 경우, 10mm 기압일 때 유사한 4.7도의 온도 감소가 예상된다.
- Heat Source Size 3.5mm로 지정하여 열 해석을 진행한 결과적으로 최대 LED flow 가에 보다 작은 경우 온도 감소가 예상가능함.



<COOLING MODULE>

16W LED Lighting



LED Spec. : Pure White (PWT) 804



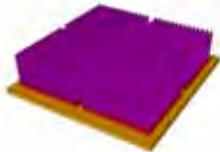
- LED 칩 수 및 Chip Size : 1X1mm 이
Large Chip 으로 구성됨.



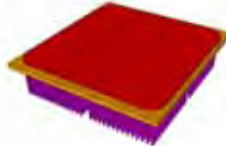
1-2 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Forward Current	I_f	0.4	A
Power Dissipation	P_D	1.6	W
Junction Temperature	T_j	125	°C
Operating Temperature	T_{op}	-30 ~ +85	°C
Storage Temperature	T_{stg}	-40 ~ +100	°C
ESD Sensitivity (1)	-	±20,000V HBM	-

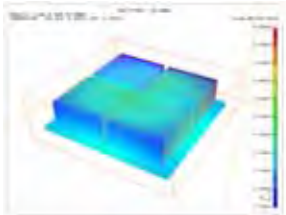
Mounting & Heat Dissipation



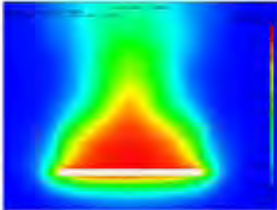
- LEDs Power Dissipation
: 1.6W X 10pcs = 16W
- Cooling Method (Natural Convection Cooling)
: 45X45X12mm Heat Sink X 4pcs



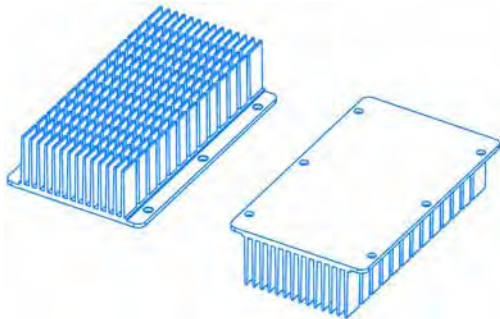
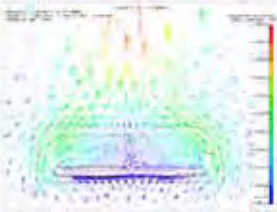
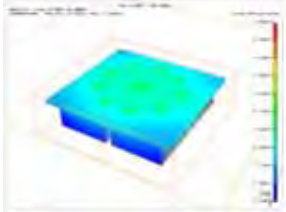
- Thermal Path
: LED → Solder Paste → Metal PCB → TIM
→ Metal Block → TIM → Heat Sink.



LED Max. Temp.
≤ 56.5 °C

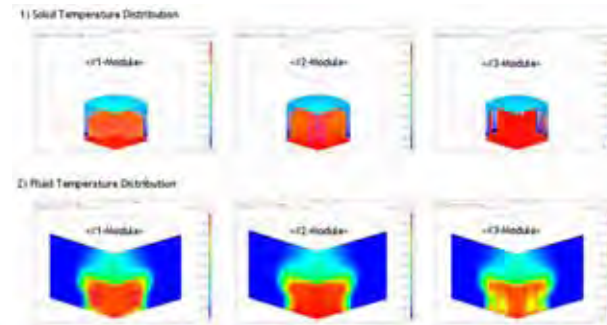
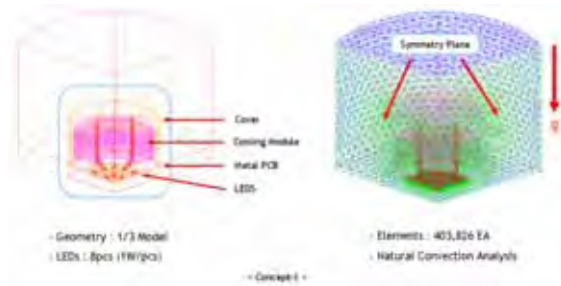
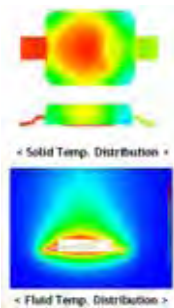


• T_{amb} : 20 °C



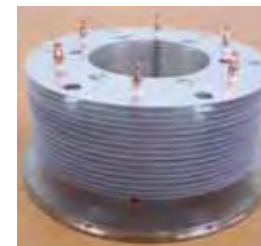
<COOLING MODULE>

24W LED Lighting



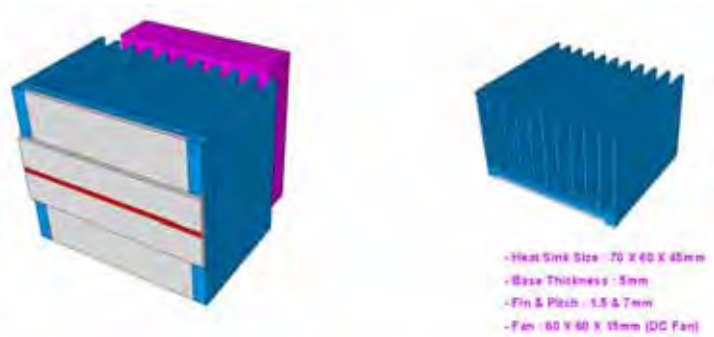
Simulation Model	Concept-1	Concept-2	Concept-3
Module Geometry			
Fin Dim.	O.D.(φ160mm) , I.D.(φ80mm) , 0-4t , 16EA	55mm X 89mm X 0-4t , 75EA	203mm X 20mm X 1.2t , 18EA
Surface Area [m ²]	0.499	0.759	0.144
Cooling Tech.	- On Heat Pipe + Fins - Module Base	- Flat Fin - Module Base	- Flat Fin + Heat Pipe - Module Base
Max. Temp. [°C]	54.4	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 :



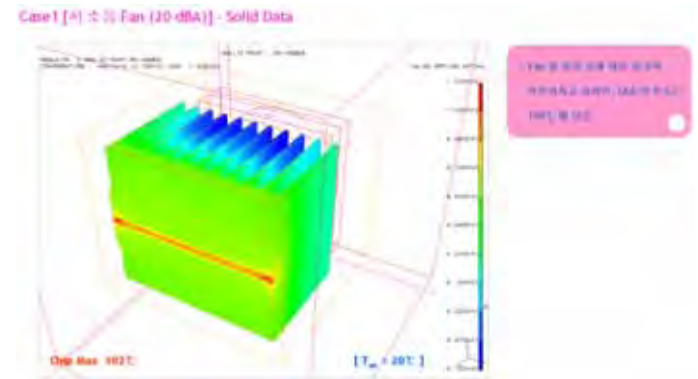
<COOLING MODULE>

54W LED Lighting for Tester



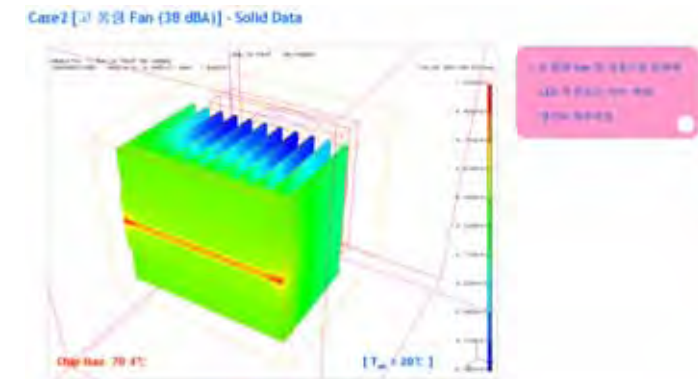
- Heat Sink Size : 70 X 60 X 45mm
- Base Thickness : 5mm
- Fin & Pitch : 1.5 & 7mm
- Fan : 60 X 60 X 15mm (DC Fan)

LED 발열량 : 2.7W X 20 ea = 54 W (@ 35 X 25 X 1.6 mm Metal PCB X 2ea)
 Metal PCB 2 계층 1 set 드 Cooling 이도록 Heat Sink-결계합 (Heat Sink + MTRAN + Fan)



Cooling Concepts - Simulation Case

Case	Heat Sink	MTRAN	Fan	Remarks
1	적용		11.52 CFM	저 성능 Fan (20 dBA)
2	적용		16.20 CFM	고 성능 Fan (38 dBA)




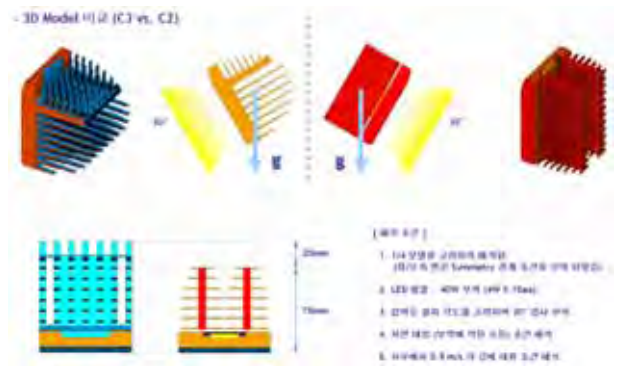
160W LED Lighting



- LED Junction $T_j < 55-60^{\circ}\text{C}$ (@ LED 120W, $T_{\text{ambient}} = 20^{\circ}\text{C}$)
 In general, Thermal engineer use ΔT . ΔT means $T_{\text{junction}} - T_{\text{ambient}}$
 TTM ΔT Target = 30~40°C (@ 120W, $T_{\text{ambient}} = 20^{\circ}\text{C}$)

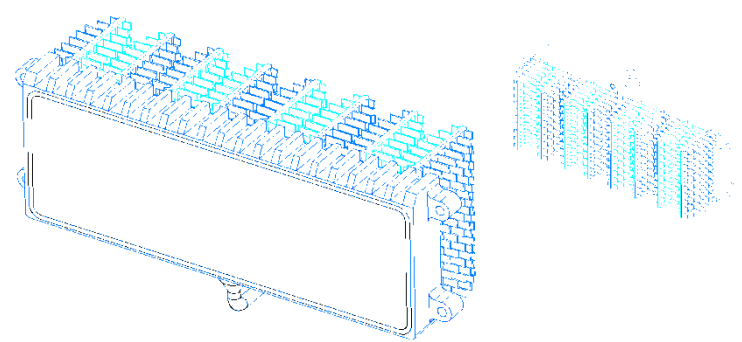
1) LED Lighting Part 의 Cooling Module Part 중 극임자으로 설계된 회, 해결하는 형태도 가장
 중요 선정. (특수 풍-해당 설계가 필요하기 때문)
 2) LED Module PCB 와 MTRAN 의 적층적인 구조를 하기 위하여 Concept 이므로 Cooling Target 을
 5°C 높여서 결정함. (즉 T Target = 40~45°C) (@ 120W)
 3) LED 입사능이 120W → 160W 로 증가하면서 PCB 가 1회 증가하여 Size 또한 커질것
 Cooling 용 회력이 다른 지용한 공간은 어느 정도인가 확인 필요함

- 
- 1) 자연 대류 상태에서 160W 급의 LED 모듈을 냉각 한다?
 Cooling Module 크기가 풍량과 커야 할 텐데...
 - 2) 배타 위에서 자연 대류가 바람이 없이 교호된 날 밤에 보일지나 열려?
 배타의 열 거리가 30cm 이상일 수 있을까? (LED Spec. Check)
 - 3) 배타의 열 거리가 30cm 이상일 수 있을까? (LED Spec. Check)
 - 4) 제품 설계를 자연 대류 상태에서 한다고 했는데, 실제로는 배타 위에서
 유동이 없는 날이 거의 없으리라고 본다. 제품 설계 방법이 타당한가?
 또한, 자연 대류 상태에서 최대의 제품이 강제 대류 상태에서도 최고의
 아니게 없을까...



	C3 (@ V=0 m/s)	C3 (@ V=0.5 m/s)	C2 (@ V=0 m/s)	C2 (@ V=0.5 m/s)
3D Model				
2D Heatmap				
LED T _j	55.0°C	55.0°C	55.0°C	55.0°C
T _{amb}	20.0°C	20.0°C	20.0°C	20.0°C
ΔT	35.0°C	35.0°C	35.0°C	35.0°C

1. Concept 2의 경우, 외부에서 0.5m/s 의 바람이 불 경우 Cooling Target에 근접하는 것을 알 수 있음.
 2. Concept 3의 배타의 외부 Size 를 같도록 Concept 2의 Heat Sink Size 를 크게 한다면, 추가적인 냉각이 가능함.
 3. 배타 크기와 관련하여 열거가 필요함. 또한 Cooling Regime 결정 필요함.
 → 자연 대류만을 고려한 Heat Sink 설계는 문제가 있음

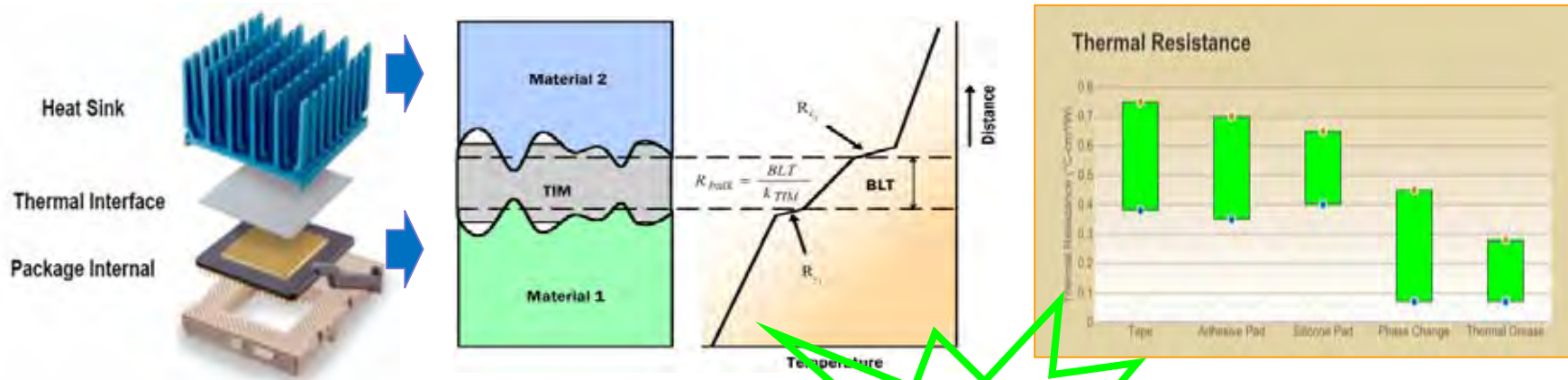


<COOLING MODULE>

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

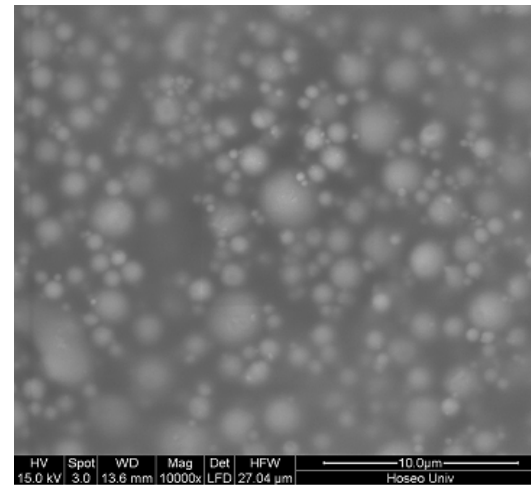
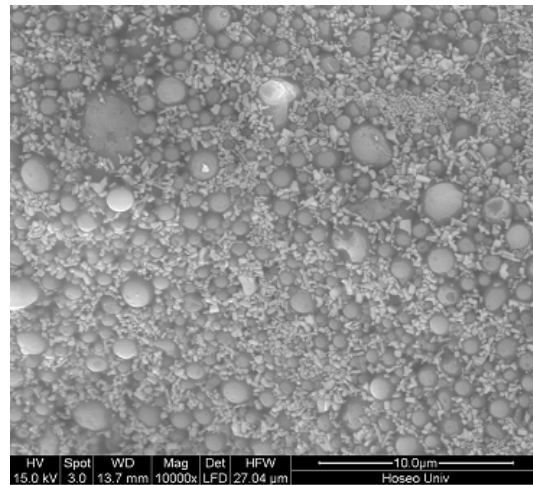
NANOTIM® Series Spec.

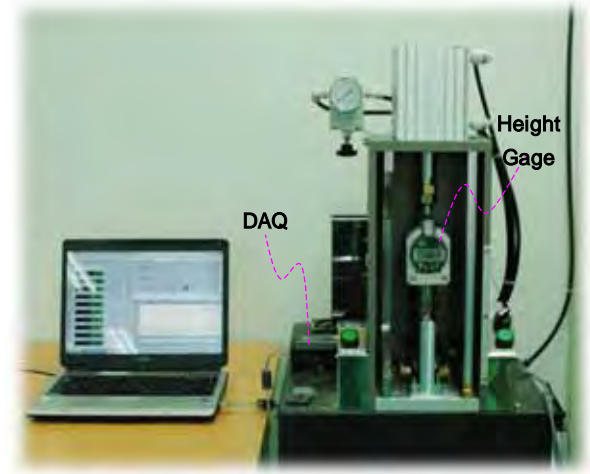
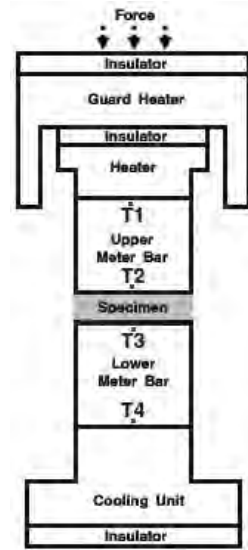
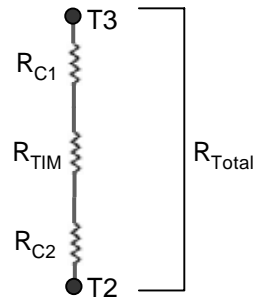
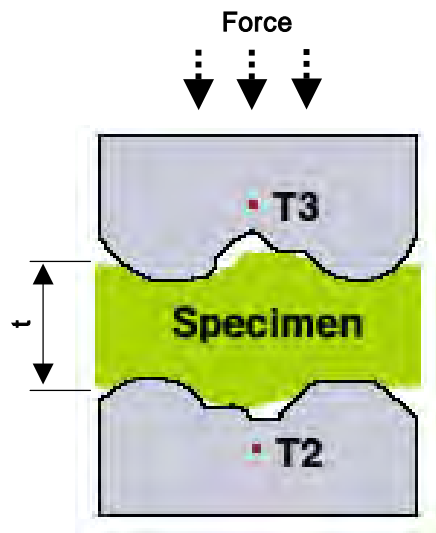
Items	Unit	PCM25			TGS		SPS		APS	
		PCM25	PCM25-SP	PCM-L	A300	C200	SPS	SPS025	APS-S	APS-T
Color	-	Gray	Gray	Gray	Gray	White	Gray	Gray	Gray	Gray
Thickness	mm	0.25	-	0.25	-	-	0.3~10	0.25	0.25	0.15, 0.25
Density	-	3.2	2.2	2.8	2.6	2.4	2.5	2.4		
Thermal Conductivity	W/m-K	4.0	3.0	2.0	4.0	1.7	1.55	1.55	1.0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

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

$$R = \frac{\Delta T \times A}{q} = \frac{t}{k} (^\circ C m^2 / w) \quad : \text{Thermal Resistance}$$

$$R_t (^\circ C m^2 / w) = R_{C1} + R_{TIM} + R_{C2} = R_{TIM} + R_C = \frac{t}{k} + R_C \quad : \text{Thermal Impedance}$$

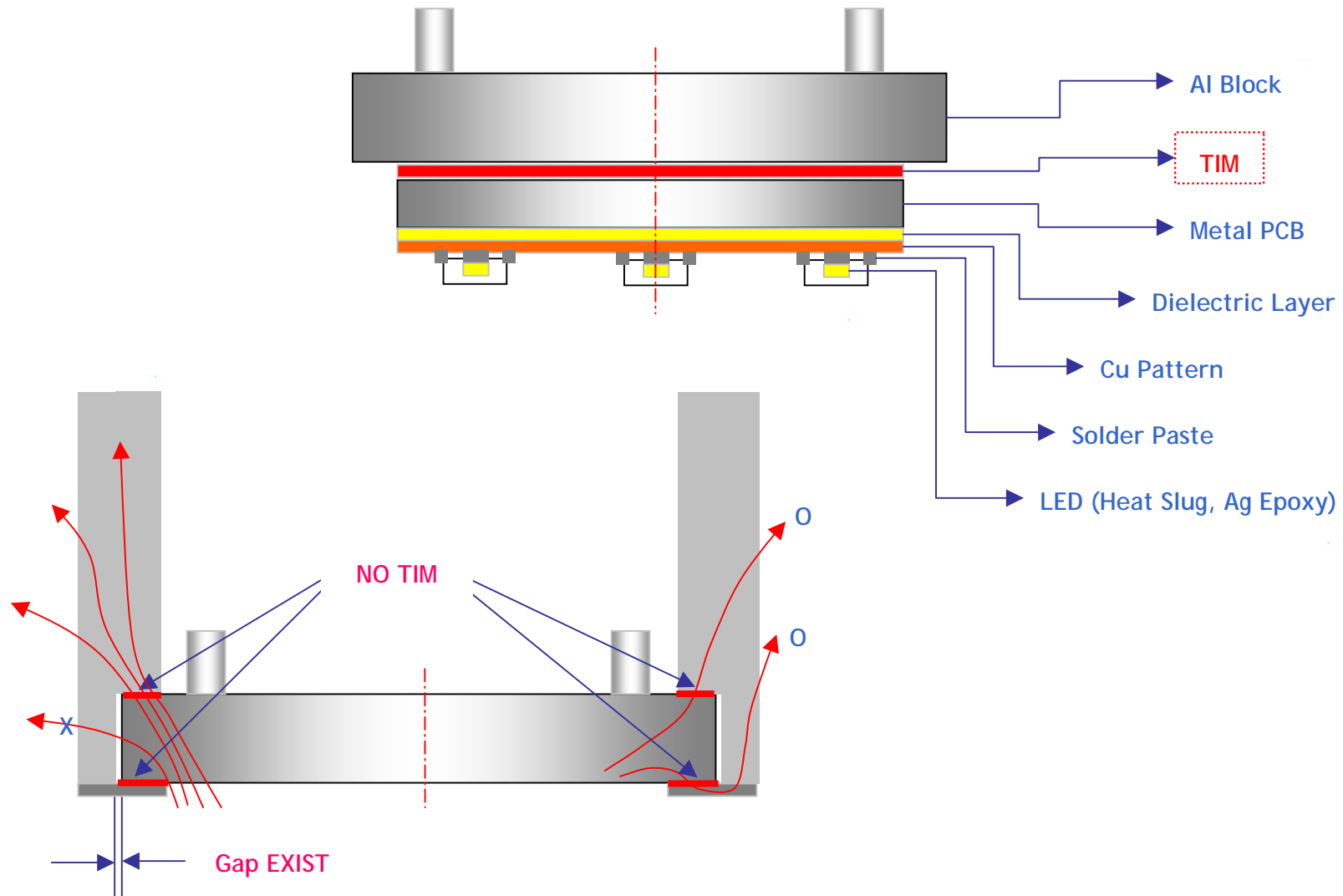


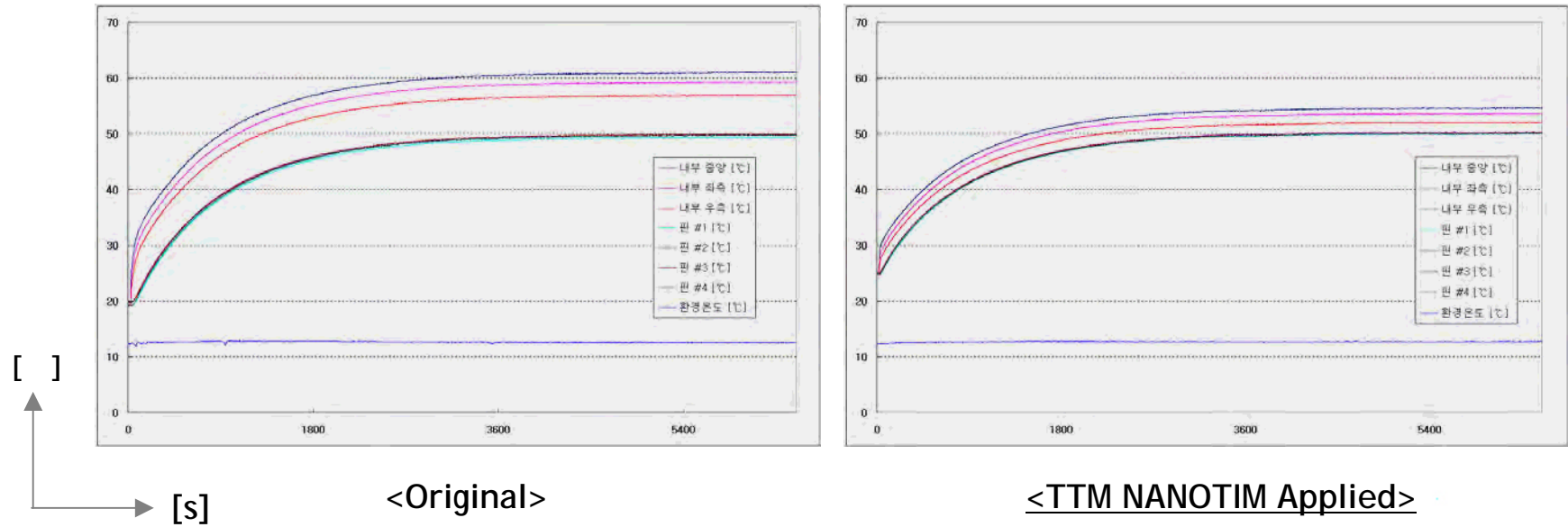


ASTM D5470

T-Thermo200

Performance of NANOTIM®





6 Drop just by changing TIM !

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- MTRAN MEMORY – TANK, WINE, TECHNO
- MTRAN CPU – CPU Cooler

NANOTIM®

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- NANOTIM PCM – Phase Change Material
- NANOTIM SPS – Silicon Thermal PAD
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- Heat sink Module, Heat pipe applied Module, Fan

T-SPOT

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- Thermal and Fluid Flow Analysis