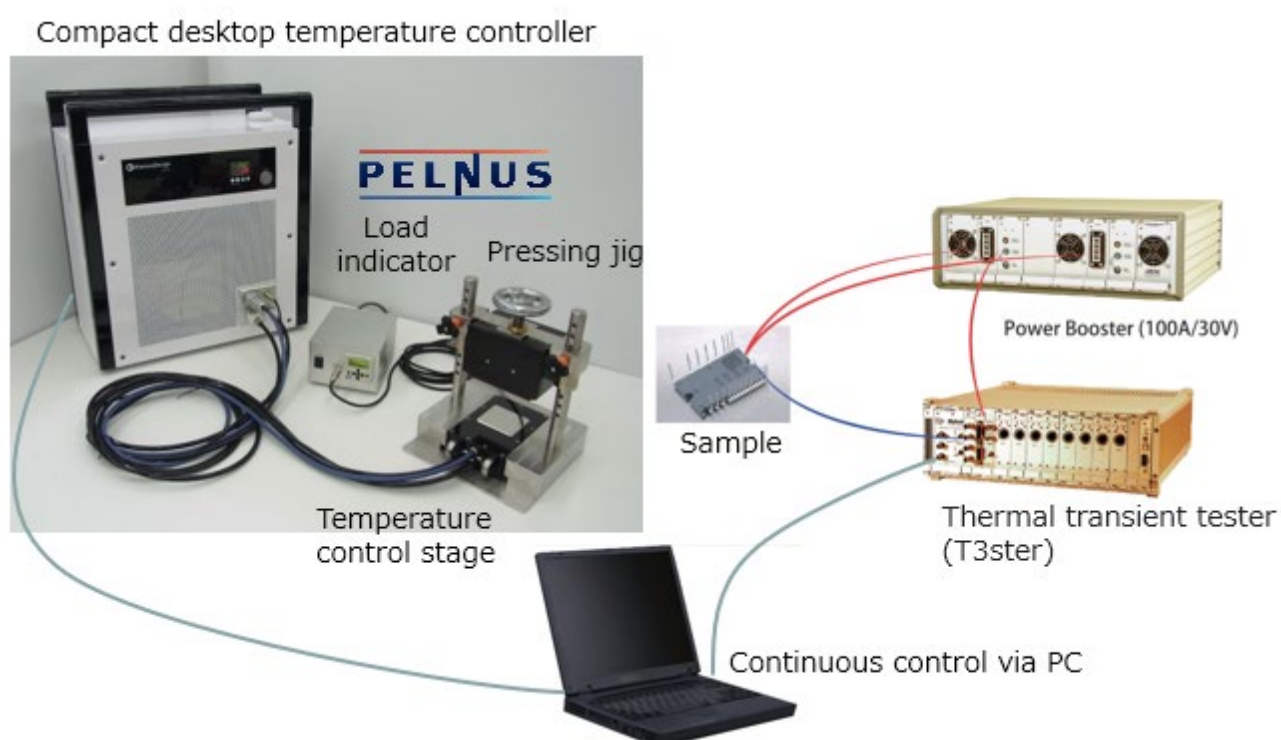


半導體元件熱特性量測客製化 解決方案研討會



日期：2023 / 06 / 16

易富迪科技有限公司

易富迪科技是キーナスデザイン株式会社及 Siemens 的台灣代理商，專注於電子產品熱特性的量測及熱模擬服務，自 2017 年初即成立半導體元件熱特性量測實驗室，獨家提供 Simcenter Micred 產品線的客製化解決方案，包括：

1. Simcenter T3Ster 熱阻量測系統建置規劃與導入訓練
2. Simcenter Power Tester 功率循環及可靠度量測系統建置規劃與導入訓練
3. Simcenter Power Tester 客製化改機服務
4. 熱阻量測外包服務

此活動除了邀請キーナスデザイン株式会社社長分享日本半導體市場現況及客製化服務的實際案例外，我們也將實驗室主要設備架設於會場，於現場進行熱阻量測設備的 LIVE Demo。感謝業界先進踴躍參與本次的技術研討會！

活動議程：

Time	Topics	
13:00 - 13:30	Registration / Welcome Coffee	
13:30 - 13:45	Opening	簡志明 總經理 易富迪科技有限公司
13:45 - 14:30	日本半導體產業現況及客製化服務案例分享	橘 純一 社長 キーナスデザイン株式会社
14:30 - 15:00	易富迪科技熱特性量測實驗室的概況與介紹	蔡杰修 資深經理 易富迪科技有限公司
15:00 - 15:30	Tea break	
15:30 - 16:00	T3Ster 熱阻量測進階案例分享	曾嘉玲 應用工程師 易富迪科技有限公司
16:00 - 16:30	T3Ster 及 KeenusDesign 系統 LIVE demo 展示	曾嘉玲 應用工程師 易富迪科技有限公司
16:30 - 16:50	Q&A	

以上為暫訂議程，易富迪科技保留修改議程內容的權利。

易富迪科技聯絡方式：

軟體部門：

台北市 105 松山區南京東路三段 305 號 5 樓

TEL：+886-2-87724131 / FAX：+886-2-27173122

軟體技術問題：Support@efd.com.tw / 教育訓練及其他客服問題：CSD@efd.com.tw

請將您的問題依照分類寄給上述客服信箱，我們將派專人立刻為您服務。

熱特性量測實驗室：

新北市板橋區雙十路二段 10-2 號 6 樓

TEL：+886-2-22588186

技術及業務相關問題：kris@efd.com.tw

日本半导体行业的现状以 及专用夹具如何提高测量的生产率

2023.6.16

 **KeenusDesign**
橘 純一

The current state of the semiconductor
market in Japan and
Improvement of measurement
efficiency with dedicated jigs

Contents

- Self (company and products) introduction
- Japan's Semiconductor Industry
 - memory
 - logic semiconductor
 - power semiconductor
- Problem Solving with T3Ster (a slightly different use case)
- Jig for T3Ster and airless constant-temperature chamber

➤Company Profile

- Established in 2006, capitalized at 11 million yen, 13 employees

➤Business Description

- Design, manufacture, and sales of cooling and temperature control equipment specialized for electronic devices

➤Tools: SolidWorks

SolidWorks Simulation
SolidWorks FlowSimulation
OneSpaceDesigner

Thermal Resistance Measuring Instrument T3Ster
One-Shot 3D Shape Measuring Machine

- ☆Wind free temperature chamber
- ☆Power Cycle Test Peripheral Equipment
- ☆Temperature control system for -55°C to 250°C
- ☆Small cooler KTC-300 capable of 300W cooling
- ☆Torque driver for SMA connectors, etc.

About the company name

Keenus is based on the word "Keen," which also means keen, nice, and excellent. We aim to create such a product and corporate culture.



TECNUS

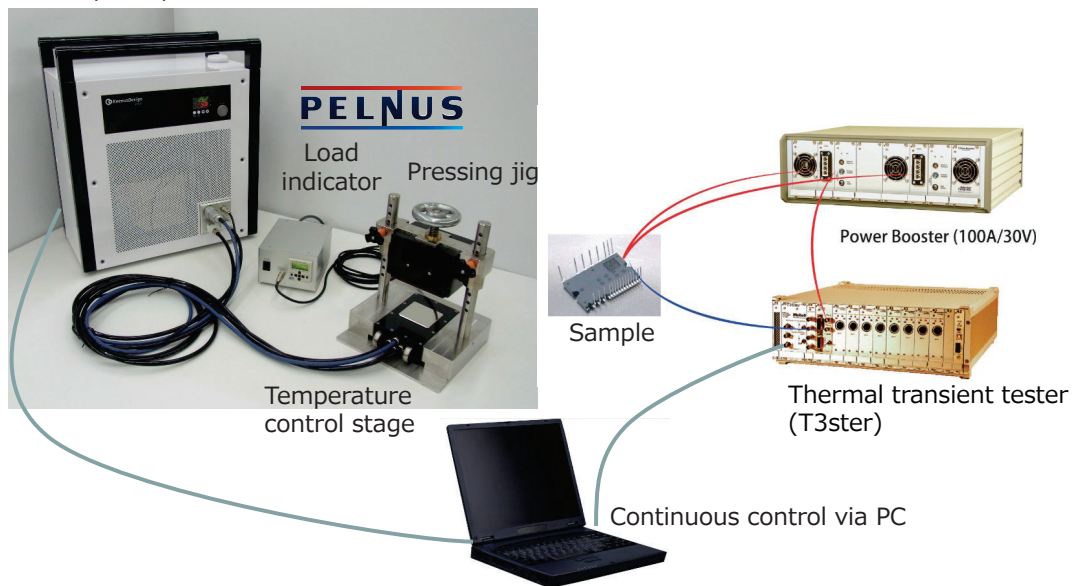
Wind free temperature chamber for optical instruments and components

Temperature evaluation of optical materials, lenses, camera modules, etc.



Temperature and pressure control fixture for thermal resistance measurement system (T3STER)

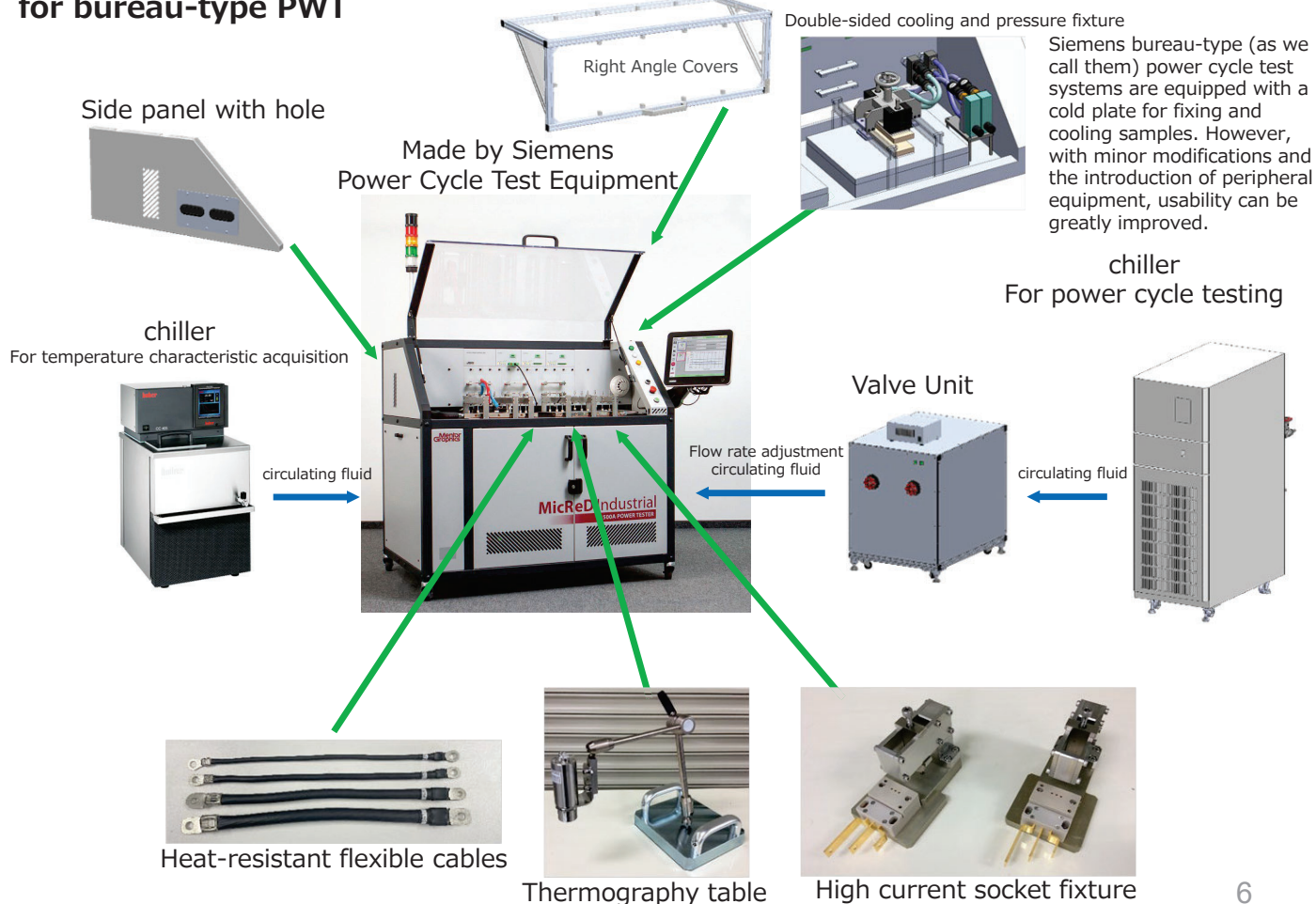
Compact desktop temperature controller



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Jigs and fixtures for power cycle test equipment for bureau-type PWT

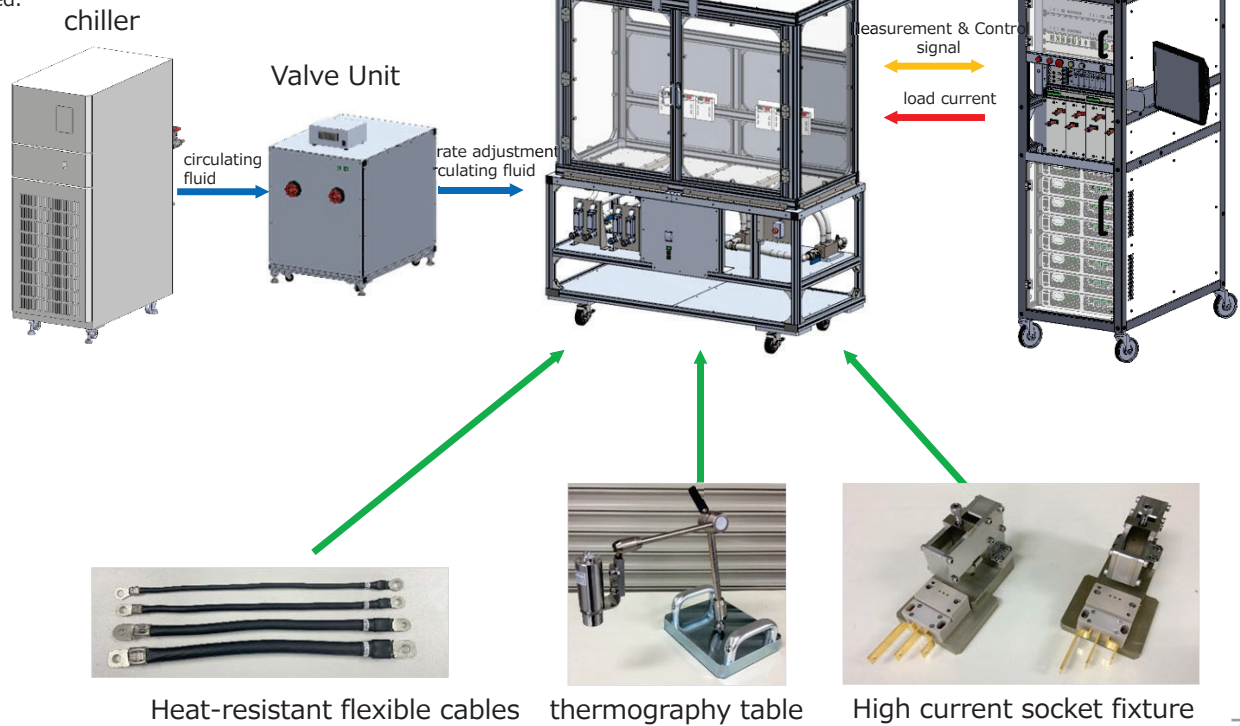


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Jigs and fixtures for power cycle test equipment for rack-mounted PWT

Siemens rack-mounted power cycle test equipment is not equipped for fixing or cooling samples. For this reason, peripheral equipment such as chambers for safe operation and chillers to supply cooling water are required.



Made by Siemens
Power Cycle Test Equipment

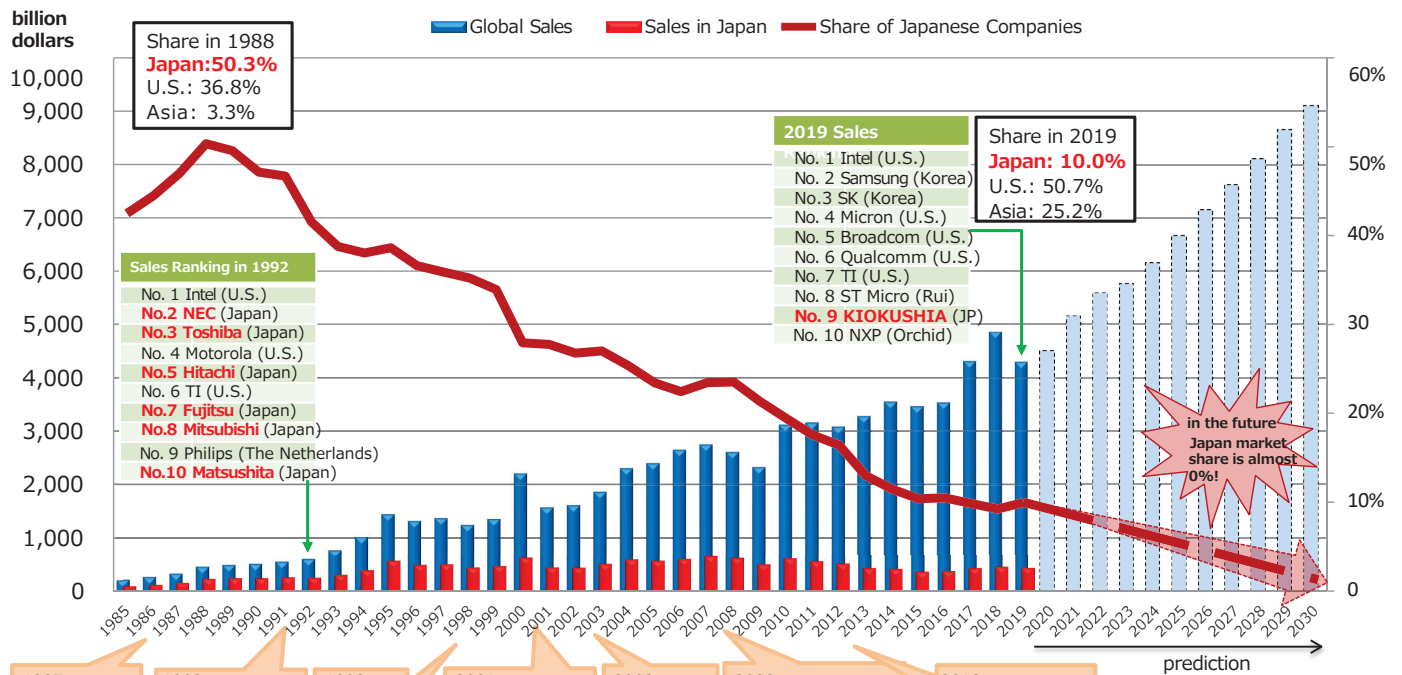
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The State of the Semiconductor Industry in Japan

The Fall -The current state of Japan's semiconductor industry (declining international market share)

- Japan's semiconductor industry has **gradually declined in stature since the 1990s**.



From METI data

<https://www.meti.go.jp/press/2021/06/20210604008/20210603008-4.pdf>

(Source: Compiled by METI based on Omdia data)

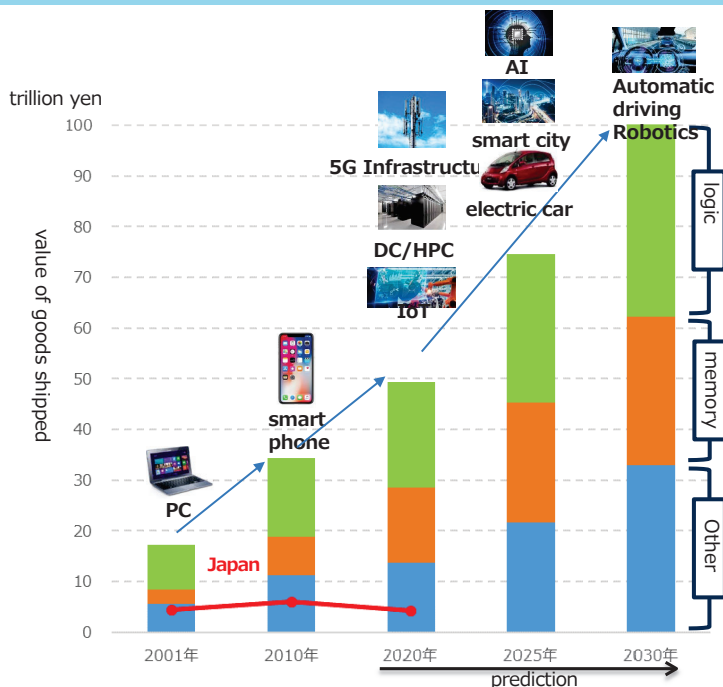
9

Digital Revolution in After Covid-19

Semiconductor Market Overview

- The semiconductor market will continue to **grow steadily** (approx. 100 trillion yen in 2030) as the **digital revolution** progresses.
- The volume zone is **logic** and **memory** used in **smartphones, PCs, DC, and 5G infrastructure**, with the **U.S., Korea, and Taiwan** dominating the market.
- In the future, on the **foundation of 5G and post-5G infrastructure**, new semiconductor demand growth in **edge computing application devices (self-driving, FA, etc.)** is expected, and this is the **last chance for Japan to enter the market**.

Global Semiconductor Market



From METI data

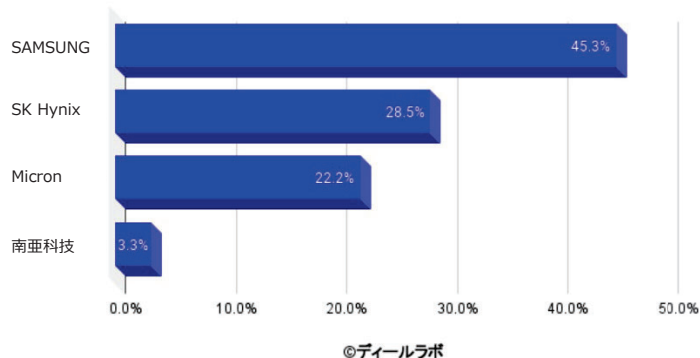
<https://www.meti.go.jp/press/2021/06/20210604008/20210603008-4.pdf>

	market scale 2018	Product Examples	major corporation
Logic (for control)	21 trillion yen	processor	intel tsmc
		GPU	QUALCOMM NVIDIA
		SoC	
memory (for data storage)	18 trillion yen	DRAM	SAMSUNG SK hynix
		NAND	Micron KIOXIA
Other	15 trillion yen	analog LSI	infineon SONY
		power semiconductor	ON MITSUBISHI ELECTRIC
		Image Sensors	

(Source: Compiled by METI based on Omdia data)

Memory

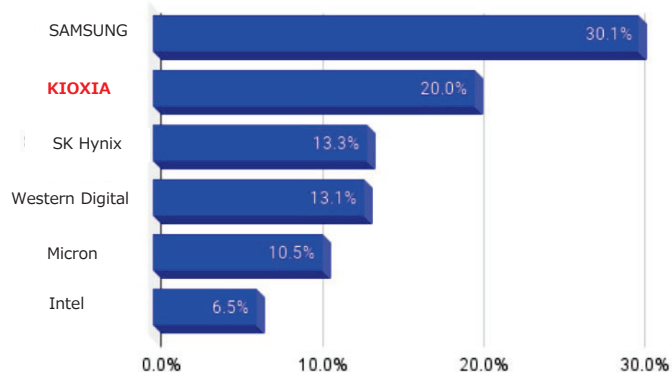
DRAM industry market share (2021)



©ディールラボ

<https://deallab.info/dram/>

NAND flash industry market share (2021)



©ディールラボ

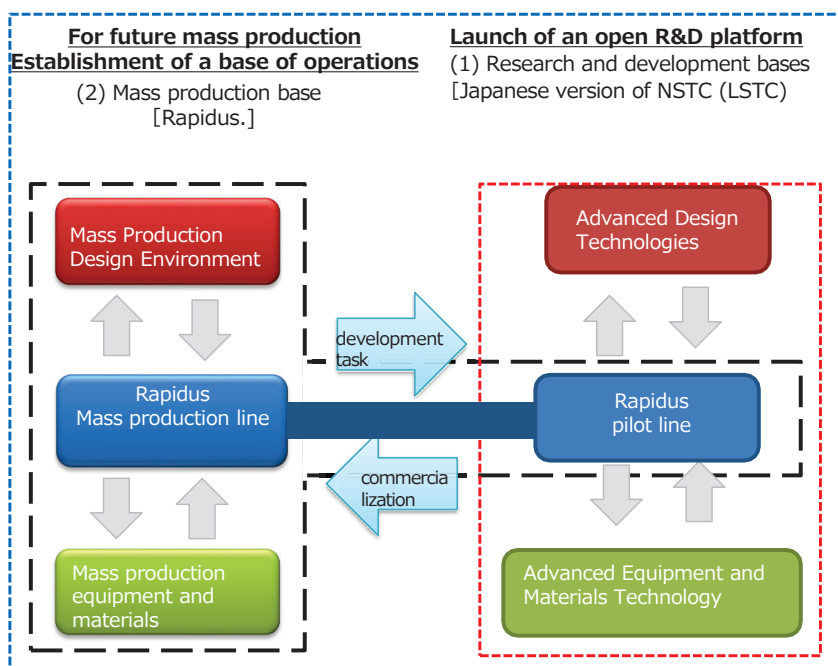
<https://deallab.info/flashmemory/>

Japanese companies are not ranked

The only Japanese company is Kioxia (ex-Toshiba)

Next Generation Semiconductor Project Structure

- Toward the realization of a short TAT mass production infrastructure for next-generation semiconductors (Beyond 2nm),
 (1) Establish an **open research and development** center for **elemental technologies for advanced design, advanced equipment and materials**.
 [Leading-edge Semiconductor Technology Center
 (2) Establish a **mass-production manufacturing** base **with a view to launching a mass-production system in the future**. [Rapidus Corporation]



Formation of joint research projects

Overseas academic research institutions and companies

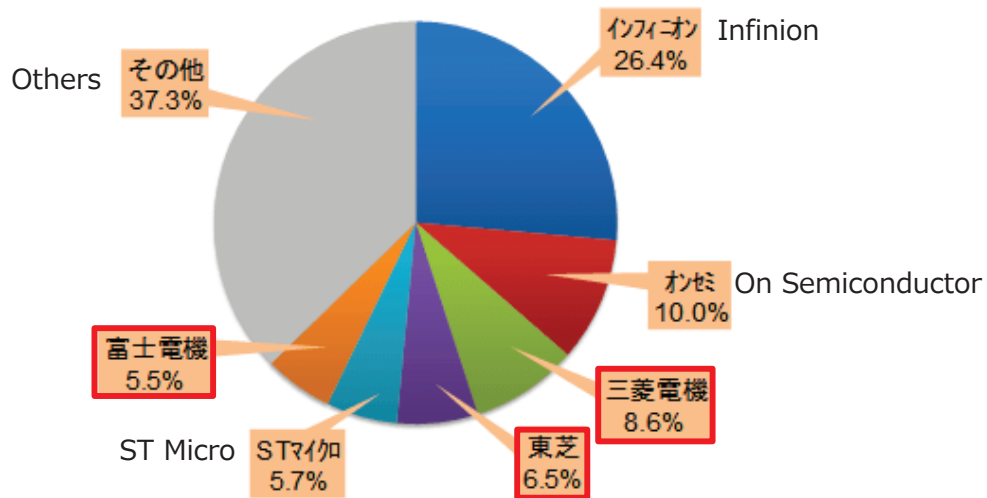
- ✓ U.S.-NSTC and IBM, White, IMEC, and other volunteer national and regional research institutes and companies

Domestic academic research institutions and companies

- ✓ Semiconductor User Organization
- ✓ Digital Design Related Organizations
- ✓ Semiconductor production, manufacturing equipment and materials related organizations, etc.

Power

Power semiconductor industry market share



From Toyo Securities 出所：各種資料をもとに東洋証券作成

Japan top3 Total : 20.6% < Infineon 26.4%

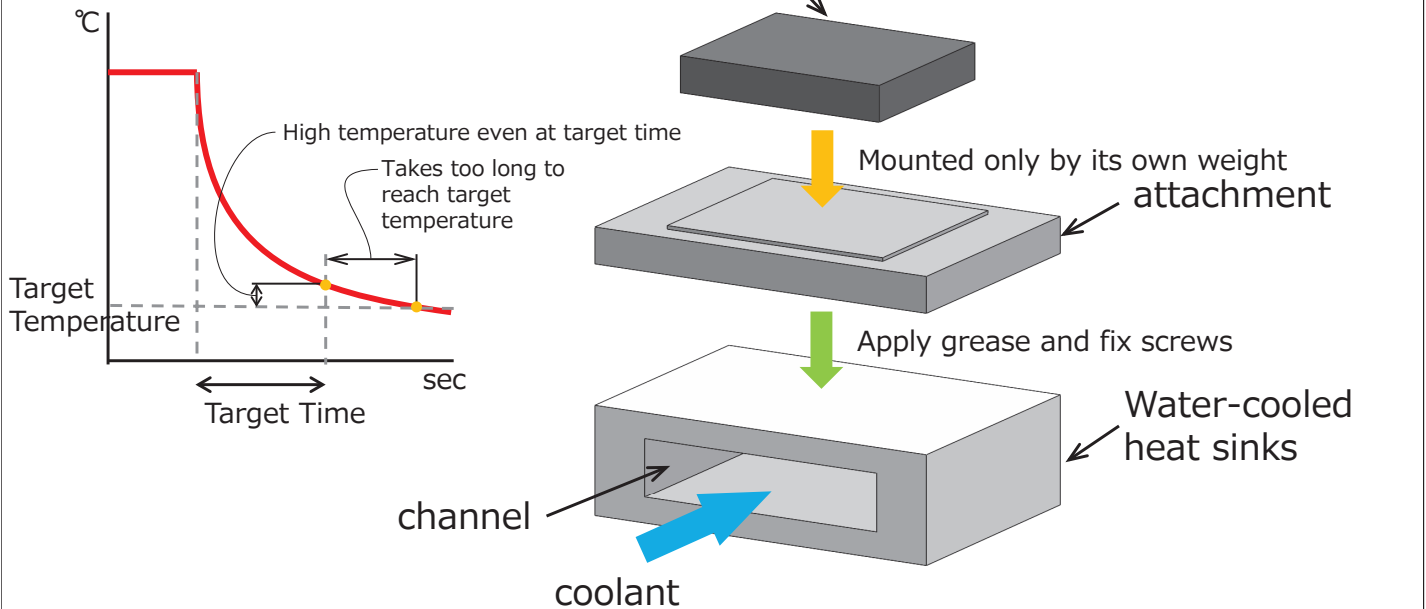
A slightly different application of T3Ster

Background of the case studies presented

A problem arose in the development of equipment for rapidly cooling samples that did not perform as expected.

Purpose of the device:

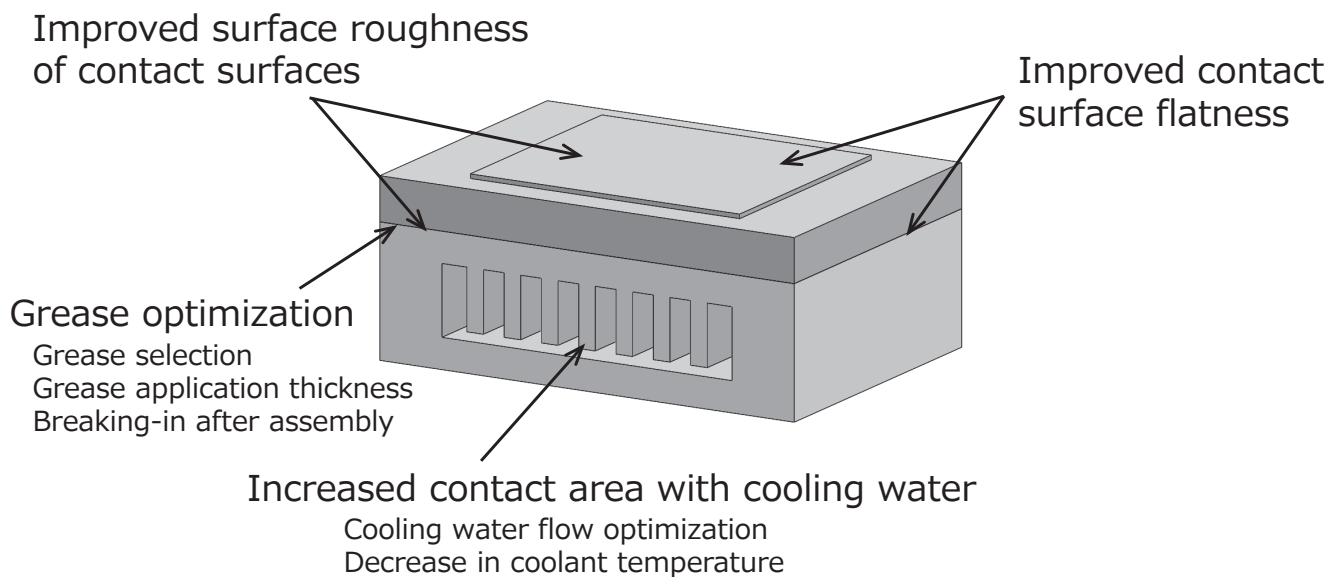
Samples that are hot from the previous process need to be sufficiently cooled before being sent to the next process.



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Countermeasures and innovations that can be taken on the equipment side

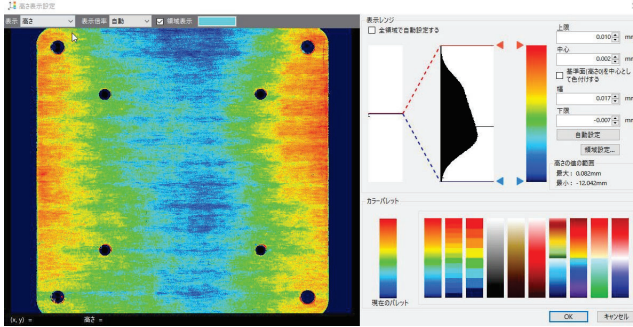


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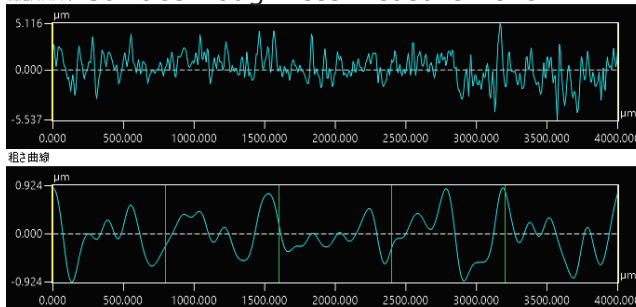
16

Countermeasures and innovations that can be taken on the equipment side

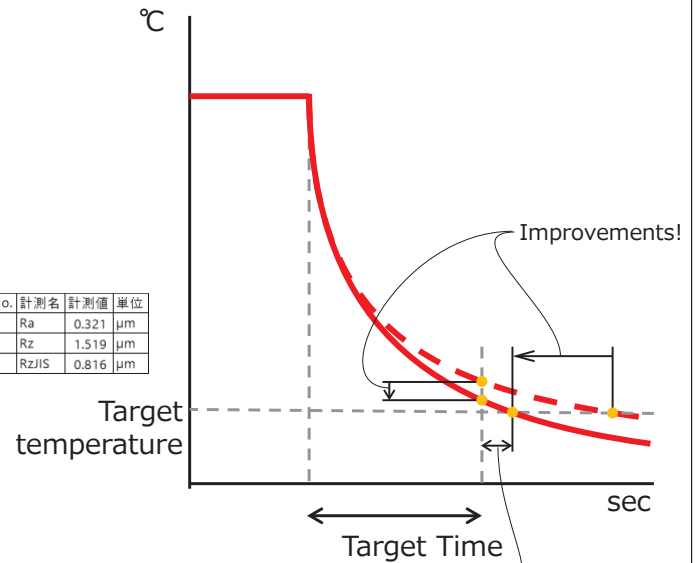
Flatness measurement



Surface Roughness Measurement



No.	計測名	計測値	単位
1	Ra	0.321	μm
2	Rz	1.519	μm
3	RzJIS	0.816	μm



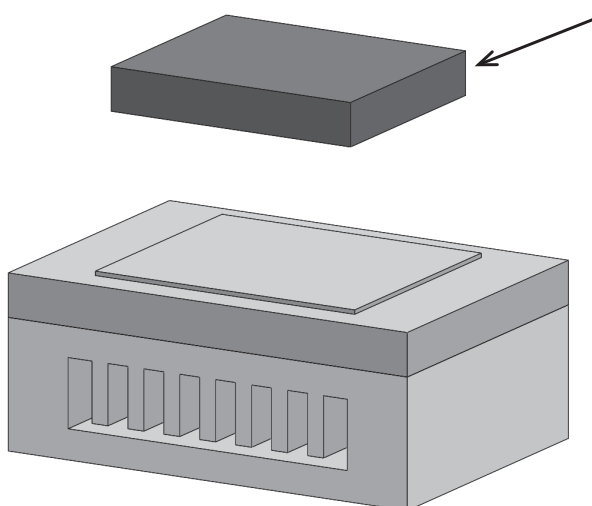
All measures that could be taken on the equipment side were taken.
However, it is still not enough.

If we use T3Ster to determine the cause of the problem...

Where is the thermal resistance?

Various measures taken on the equipment side have not been effective...

Hypothesis: In fact, is there not enough contact between the sample and the attachment, and is the thermal resistance in the contact area dominant?

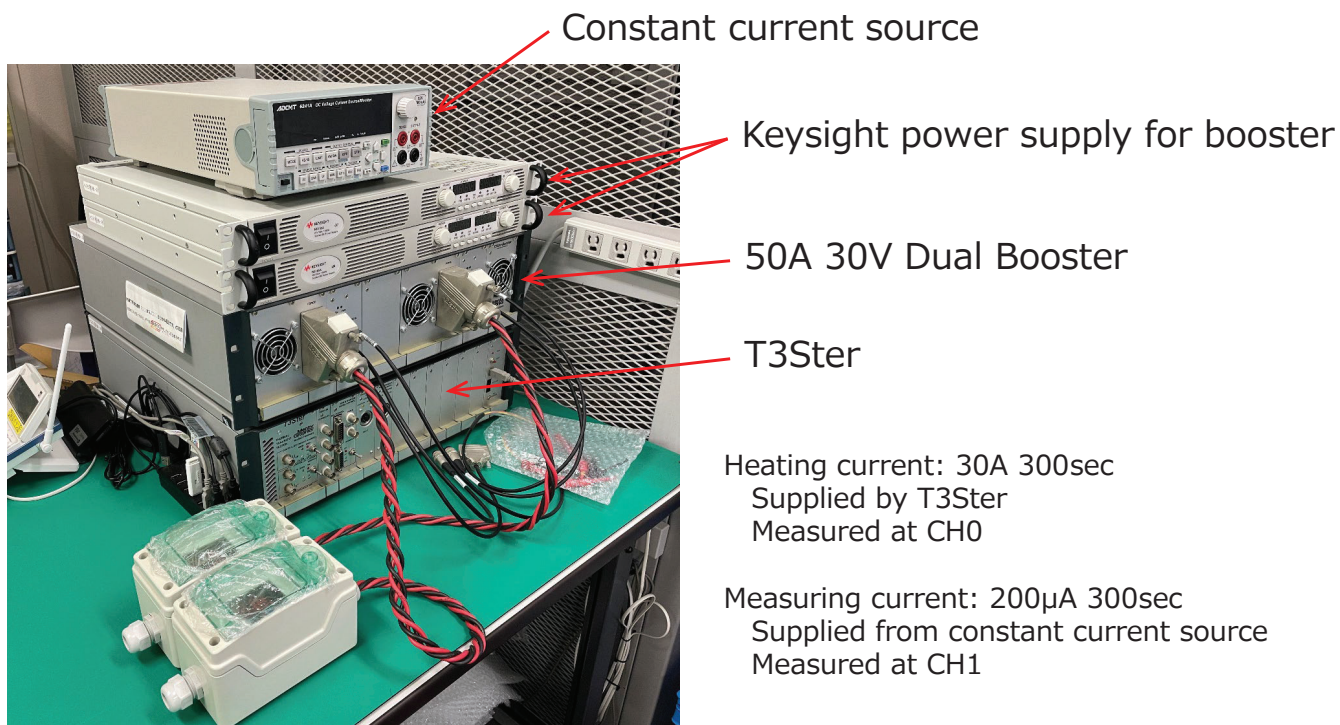


sample

Temperature monitoring is possible by obtaining the K-Factor of the internal diode.
Using the transistor as a heat source, thermal resistance can be measured with T3Ster.

Circulate water to heat sinks,
◆ with the sample loaded with its own weight,
◆ When mounted with grease applied
Can we find the thermal bottleneck by comparing the two in the following way?

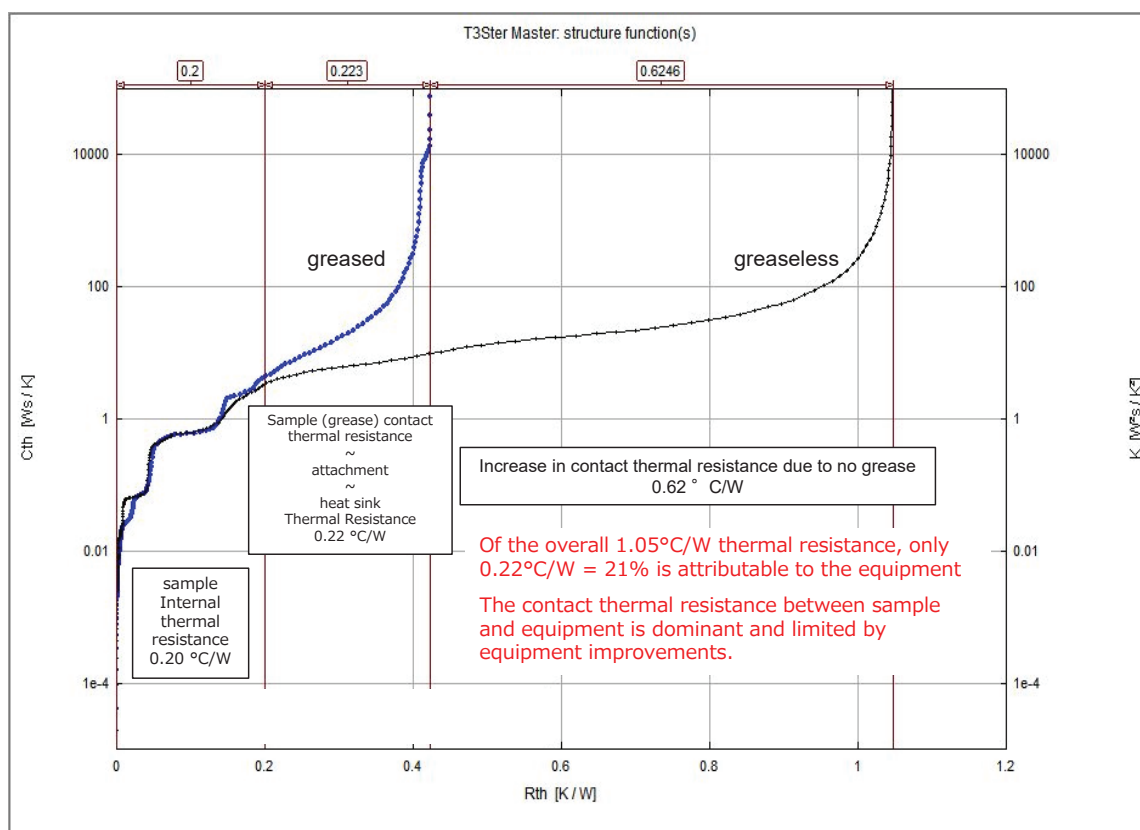
Measurement with T3Ster



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Where is the thermal resistance?



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Iterim summary

Equipment was built and evaluated according to development requirements.



Various efforts were made to achieve the target specification values, but they could not be reached.



I stopped and thought about whether we are taking the right measures.



By measuring and quantifying the facts, the problem was made apparent.



We were able to measure "thermal resistance," which is scattered throughout the system and tends to be a sensory experience, and materialize it as a numerical value.

We were able to steer them in the right direction without getting bogged down in abstract discussions.

By fleshing out the issue (correctly identifying the cause of the problem), we were able to avoid watering down the issue.

T3Ster requires Increased Productivity with Peripherals

What happens when there is a good measurement environment

Preparation can be done in a short time.

Accurate and reproducible results → Reduced rework

Fewer things (phenomena) that are not well understood

→ Fewer inquiries (extra work)

Damage is done when environmental deficiencies are noticed after the equipment is installed.

Difficult to budget for recovery

Important.

Have a good environment from the time the equipment is up and running.

Consideration should be given at the time of equipment introduction

→ Introduce well-thought-out jigs.

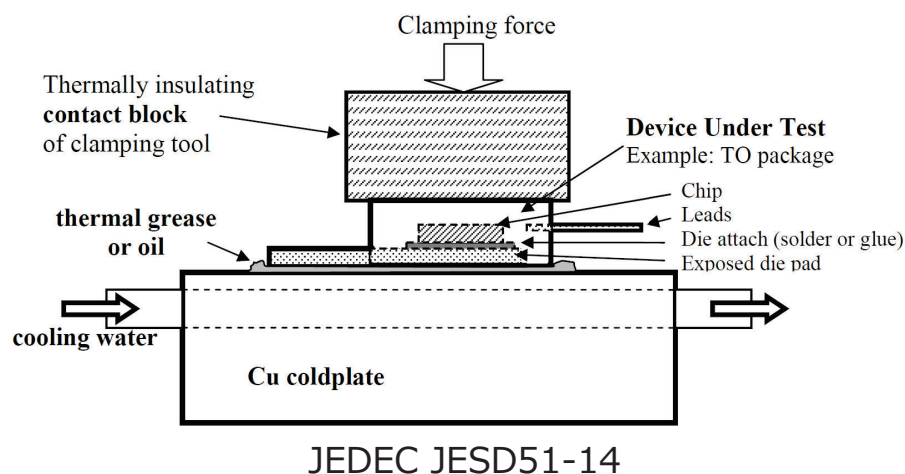
What is an appropriate test environment?



T3Ster is a high-speed, high-performance measuring instrument, but without a testing environment...

Depending on the person and the day, the measurement results may differ.

What is an appropriate test environment?

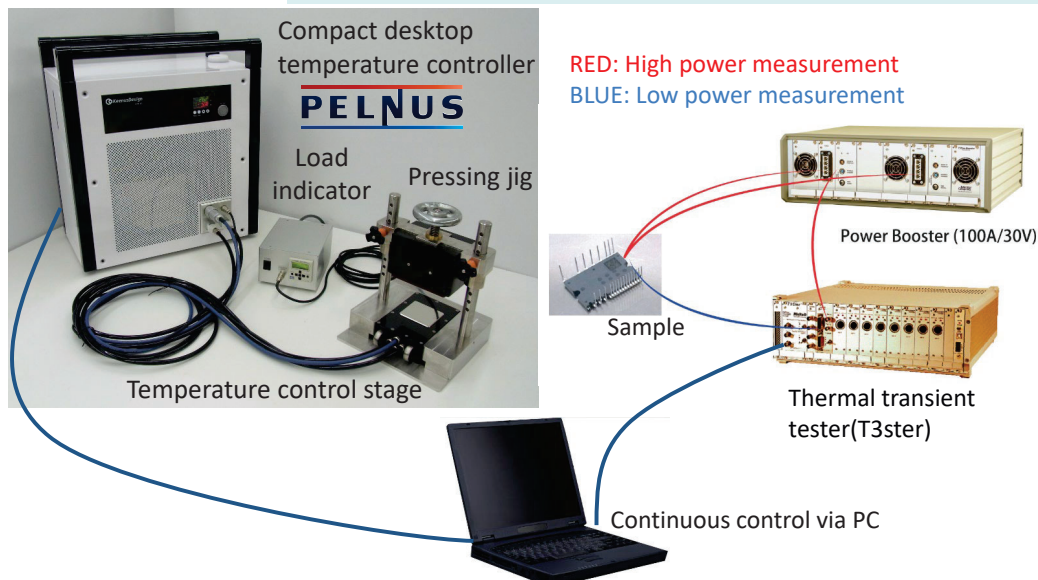


The standard specifies the test environment to be prepared, but it is rather vague.

Appropriate test environment?

We read the standards and receive advice from users
Embodying the standard environment

Complies with JEDEC JESD51-14
Operable from T3Ster Master in conjunction with T3STER
Adjustable temperature control stage from room temperature to max 200°C
Assuming a load of 10N/10mm², □150mm supports 2500N
Real-time display of loads

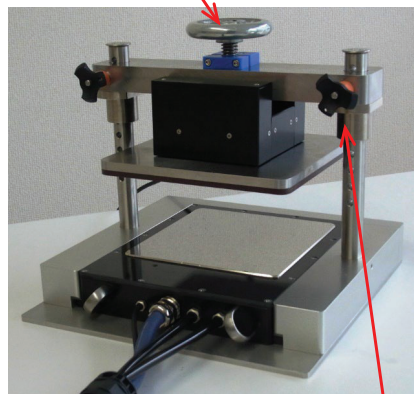


Improvement of pressure fixture

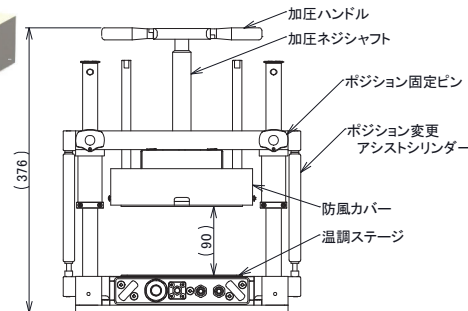
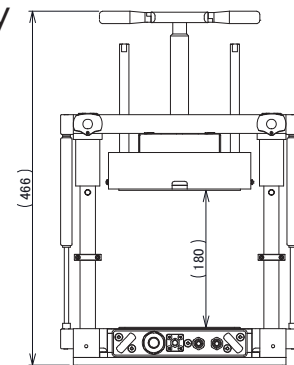
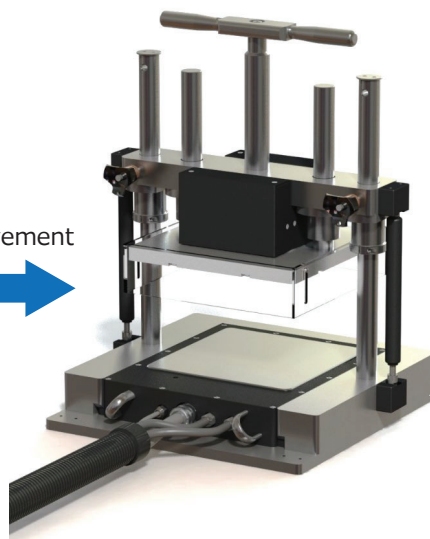
Longer screwing stroke
In working and pressurized positions
Improvement of workability

First item

Short screw-in stroke



improvement



Adjust height by pin insertion position

If you pull the pin, it will drop.

Further improvement of pressure fixture

After pressurizing the sample, the load changes due to expansion and contraction when the temperature changes



Birth of the automatic control pressure fixture
so that the load is always constant.



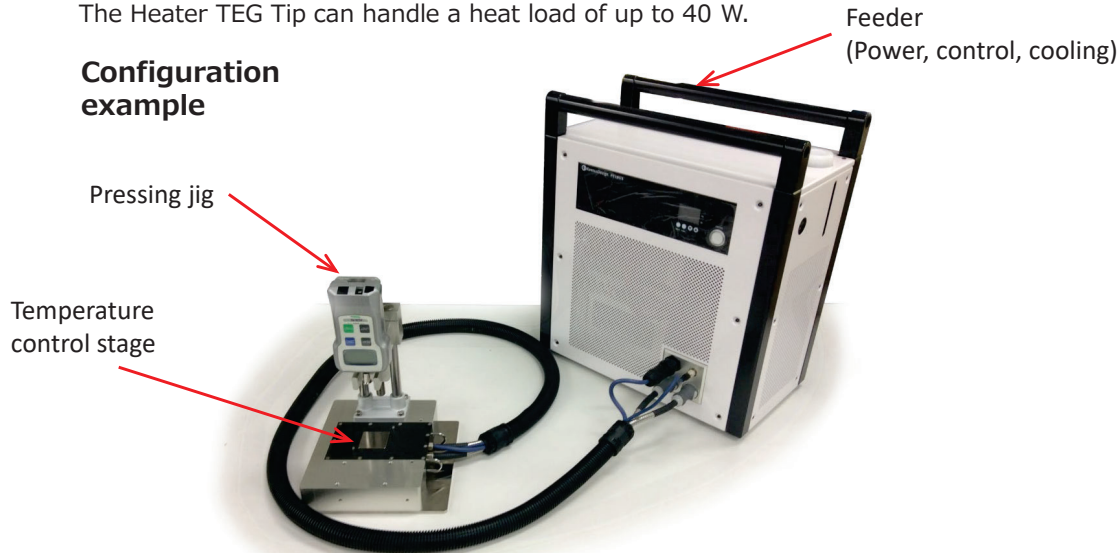
Pressure jig for heater TEG chip

For measurement of bonding materials with small time constants, TIM, and associated contact thermal resistance

This product is a jig that positions a heater TEG chip on a workpiece set on a high-precision temperature-controlled stage and applies pressure and current with a probe. It is suitable for measuring bonding materials and TIMs with very small-time constants and their associated contact thermal resistance.

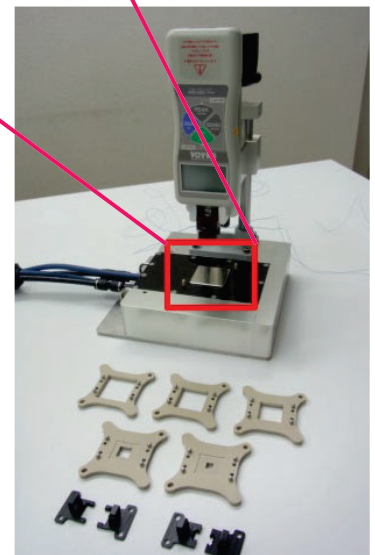
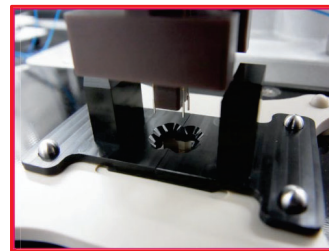
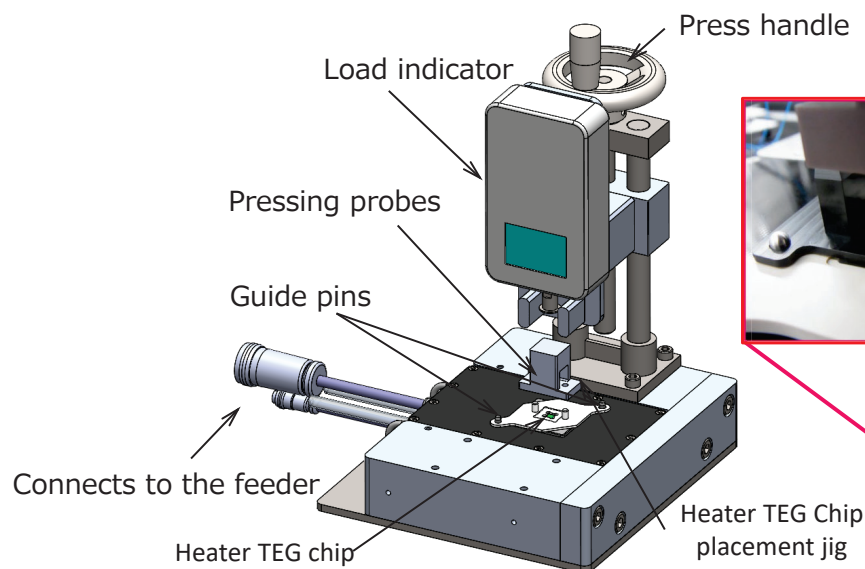
The Heater TEG Tip can handle a heat load of up to 40 W.

Configuration example

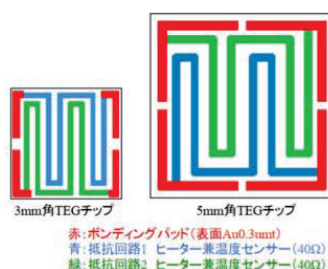
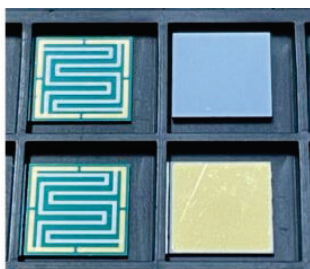


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1. This fixture allows cooling and evaluation while controlling the load.
2. The size of the heater TEG chip is □5 mm and the maximum heat generation load is 40 W.
3. A separate temperature control feeder (KTA-02) is required for temperature control of the stage.

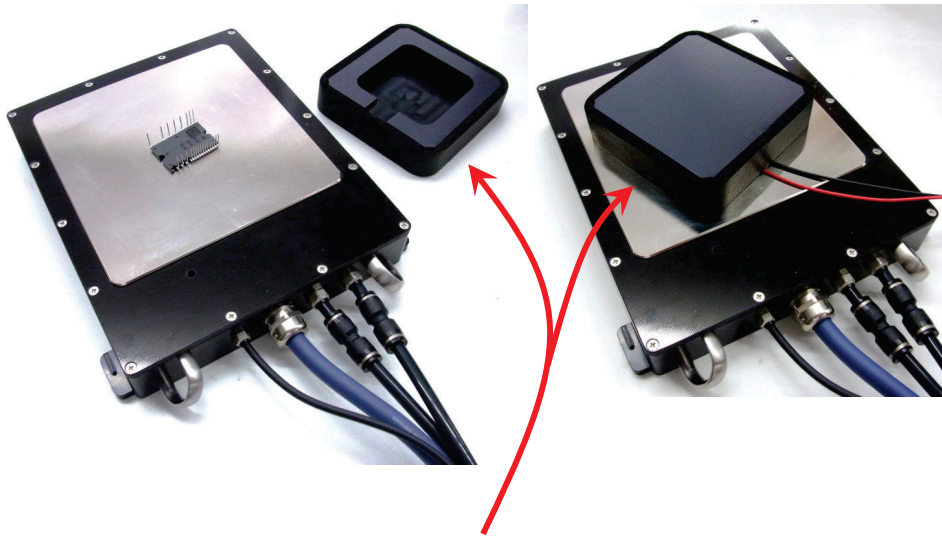


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Conversion of temperature control stage to "Wind free chamber"

Developed an option for fast measurement of K-factor



A cover with high thermal conductivity and ultra-thickness is installed on the temperature control stage. The internal space is temperature-controlled from all sides. In other words, a uniform temperature space without wind, which is necessary for K-factor measurement, is created at high speed. A windless, uniform temperature space is created at high speed.

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TECNUS

Wind free temperature chamber for optical instruments and components

Temperature evaluation of optical materials, lenses, camera modules, etc.

Sophisticated optical devices are now used in harsh environments such as automobiles and surveillance cameras. This has necessitated even more stringent temperature environment testing to ensure reliability. The Tecnas system allows for windless environments that could not be achieved with conventional constant-temperature chambers, and real-time measurement of temperature effects using optical measuring instruments.

Touch-screen controller and feeder
□100mm H50 or H100mm tank space
Optical access to interior spaces without
condensation thanks to windows with
insulated construction

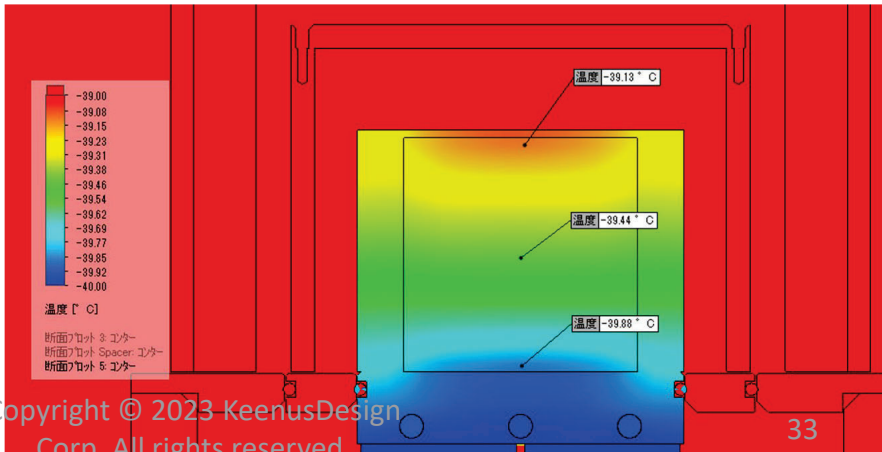
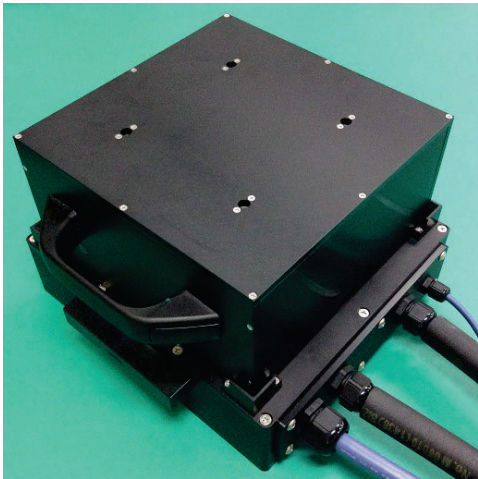
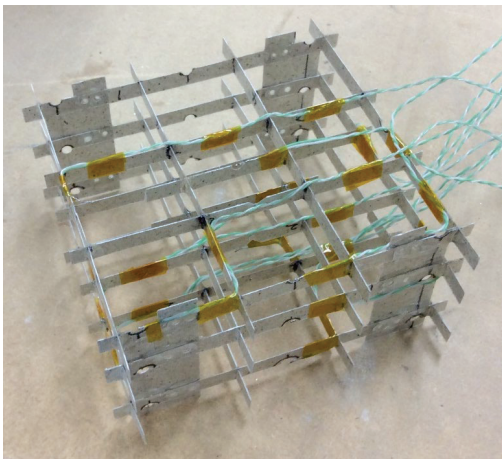
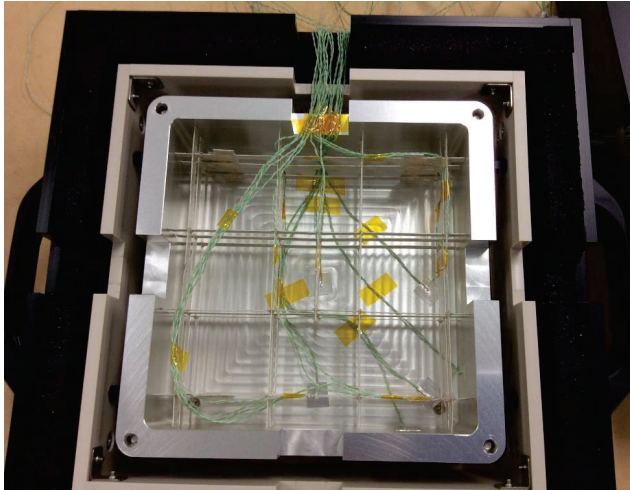


Optional window arrangement allows observation from the top or laser beam penetration from the side

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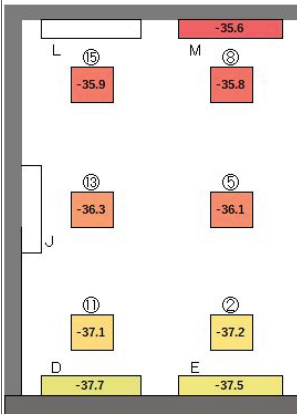
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Example of the wind free chamber evaluation

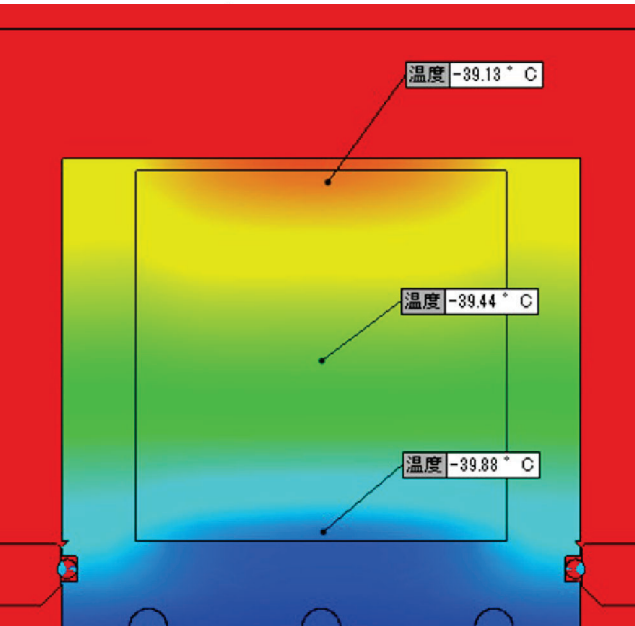


室温(25°C)で放置後

PV=-40°C到達後 :

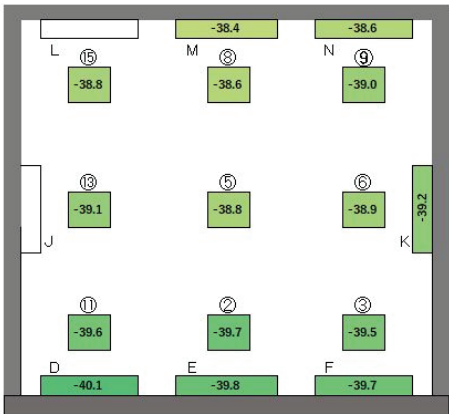


全体	MAX	-35.6	MIN	-40.1
	Δ T	2.1		
空間	MAX	-35.8	MIN	-37.2
	Δ T	1.4		
ステージ表面	MAX	-37.4	MIN	-37.7
	Δ T	0.3		
カバー表面	MAX	-35.6	MIN	-36.4
	Δ T	0.8		



全体	MAX	-35.6	MIN	-40.1
	Δ T	2.1		
空間	MAX	-35.8	MIN	-37.2
	Δ T	1.4		
ステージ表面	MAX	-37.4	MIN	-37.7
	Δ T	0.3		
カバー表面	MAX	-35.6	MIN	-36.4
	Δ T	0.8		

PV=-40°C到達後 : 40分



全体	MAX	-38.4	MIN	-40.1
	Δ T	1.7		
空間	MAX	-38.6	MIN	-39.7
	Δ T	1.1		
ステージ表面	MAX	-39.7	MIN	-40.1
	Δ T	0.4		
カバー表面	MAX	-38.4	MIN	-39.2
	Δ T	0.8		

summary

- Self (company and products) introduction
- Japan's Semiconductor Industry
 - memory
 - logic semiconductor
 - power semiconductor

- Problem Solving with T3Ster (a slightly different use case)

The distribution of thermal resistance was clarified by measuring it with a T3Ster. The results of this measurement allowed us to concretize the issue and prevent waterboarding.

- Jig for T3Ster and airless constant-temperature chamber

The higher the performance of the instrument, the greater the influence of the test environment on the results.

Ensuring safety is also an important factor.

Specific examples of equipment for T3Ster were presented.



易富迪科技

熱特性量測實驗室的概況和介紹

Hardware Manager

Kris Tsai

Mail: kris@efd.com.tw

TEL: 02-2258-8186



01
EFD Corp.

台北辦公室

- ◇ 成立於 2012 年 7 月
- ◇ 地點：臺北市松山區(捷運南京復興站六號出口)
- ◇ 產品：Siemens Simcenter 軟硬體產品
KKE 粒子與多相流分析軟體
KeenusDesign溫控設備
- ◇ 服務：軟硬體產品銷售及技術支援服務
熱流分析及設計顧問服務
- ◇ 網址：www.efd.com.tw

熱特性量測實驗室

- ◇ 成立於 2019 年 1 月
- ◇ 地點：新北市板橋區
(捷運江子翠站步行7分鐘)
- ◇ 服務：半導體元件熱阻量測服務
功率循環(壽命)量測服務
硬體DEMO及教育訓練

每年通過Siemens 認證



硬體部-T3Ster系列應用產品



TeraLED
光熱耦何量測

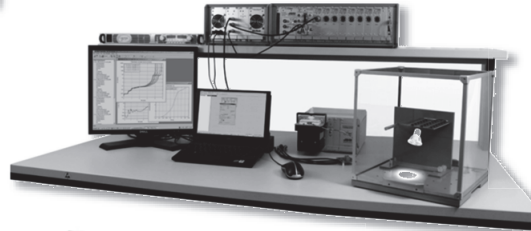
T3Ster
JESD51-14 Rthjc 量測
JESD51-2A Rthja 量測



T3Ster S



DynTIM
材料熱傳導係數量測



Power Tester 1500A
Power Tester 1800A
Power Tester 3600A
功率迴圈之可靠度測試



Power Tester 600A
Power Tester 2400A
功率迴圈之可靠度測試

硬體部-KeenusDesign 溫控平台



PELNUS Series

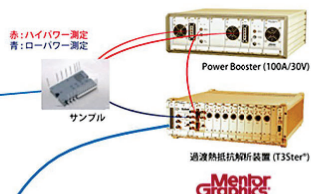


TECNUS Series

可和T3Ster結合使用



熱抵抗値を
高精度に測定



KTC Series

02 Our clients

Worldwide Customers



TOYOTA

DENSO



上汽集团
SAIC MOTOR



HUAWEI



上海微技术工业研究院
Shanghai Industrial Technology Research Institute



University of
Nottingham
UK | CHINA | MALAYSIA

寧波分校

Taiwan Customers



03

熱特性量測實驗室

量測實驗室演進過程



2019.1 ~ 至今

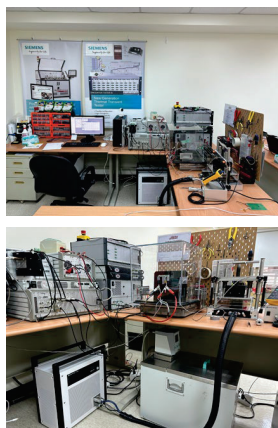
- ◇ 從1人1機的服務到2人2機的服務
- ◇ 同時10家客戶進行量測
- ◇ 不只有單純的量測，
解決客戶在熱方面的問題及量測設備的客製程序



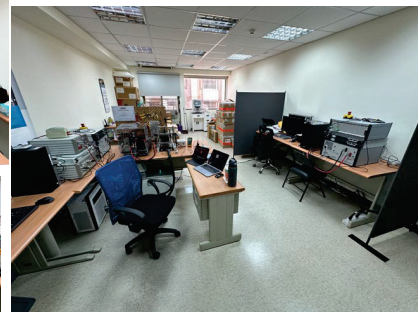
2019



2020~21

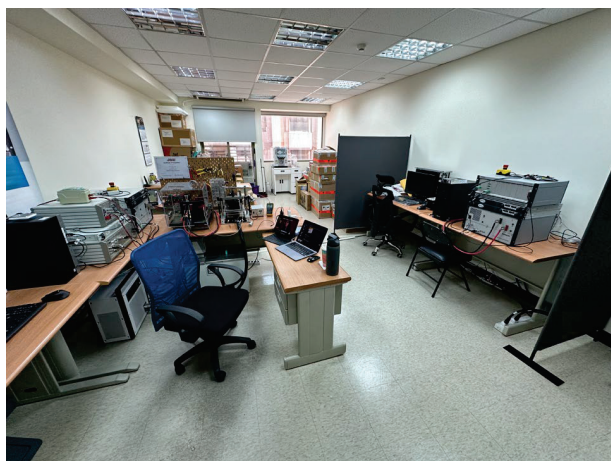


2022~23.05



23.06~

獨立熱特性量測實驗室



提供給客戶的服務

- ◇ 完整的Demo及教育訓練
- ◇ 客戶產品熱特性的Benchmark
- ◇ 半導體元件代測服務
- ◇ 面對面的技術探討

可量測元件

- ◇ LED, Logic IC, Diode
- ◇ MOSFET (discrete or module)
- ◇ IGBT (discrete or module)
- ◇ 通電後有電壓差變化者皆可量測

可得量測結果

- ◇ 元件的 R_{thjc} 、 R_{thjb} 、 R_{thja} 熱阻值
- ◇ 元件的 ΔT_j 溫度變化
- ◇ Z_{th} (R_{th} v.s. time)
- ◇ Pulse Thermal Impedance
- ◇ SOA (Safety Operation Area)
- ◇ Structure Function 結構函數

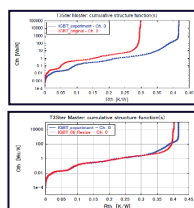
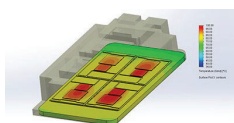
全台唯一獨立量測實驗室

T3Ster 的九大優勢

SIEMENS
Ingenuity for life



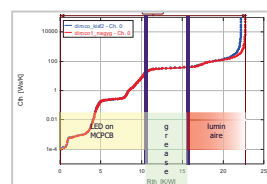
9. Detailed Thermal Model Calibration



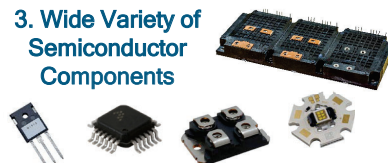
1. Simple & Easy



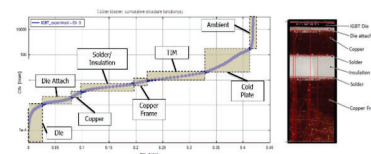
2. Repeatable & Reproducible



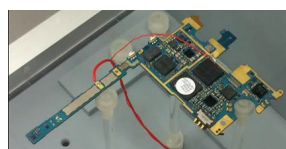
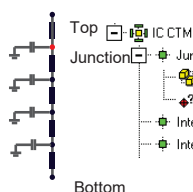
3. Wide Variety of Semiconductor Components



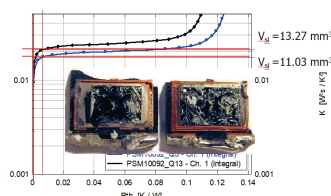
4. Insight into Thermal Structure



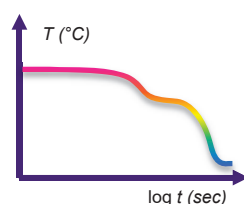
8. Test-Based Compact Thermal Models



7. Tests Components in Situ



6. Non-Destructive



5. Fast Throughput (non-Repetitive)

您可以從T3Ster得到什麼？



1 您可以在Data Sheet上得到更精確更詳細的數據

∞ 結構函數(SF)

- 可藉由結構函數分析待測元件各層熱阻與熱容值

∞ 接面溫度變化曲線(ΔT_j)

- 可得到實際接面溫度

∞ 暫態熱阻函數圖 (Zth)

- 熱阻對應時間之圖形

∞ Pulse 熱阻函數圖

- 可得到不同duty cycle下之元件熱阻特性

∞ SOA (安全操作區域)

- 可藉由分析軟體計算出元件在DC下之安全操作範圍

2 您可以在設計和研究上更快速找出並解決問題

∞ 製程良率確認

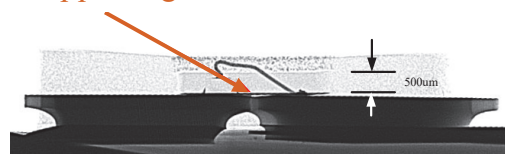
∞ 製程變異的結果

∞ 元件老化程度

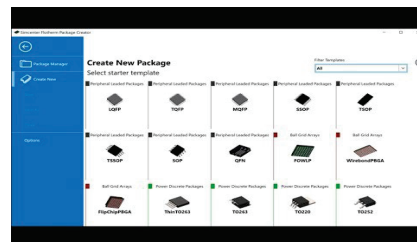
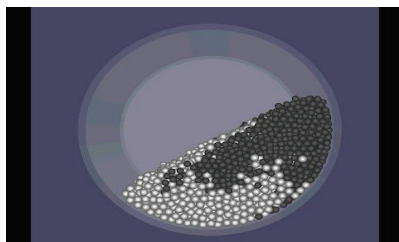
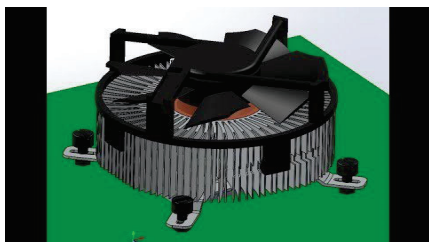
∞ 未知元件資訊的先行獲得

ex: Tjmax 的確認

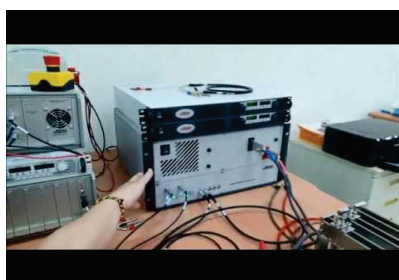
DA appealing



軟體線上教育訓練課程



硬體及熱特性量測線上教育訓練課程



▶ 每個月更新 📢 完全免費的學習資源

EFD 的完整售前售後服務



- 每月電子報發送，提供案例分享，課程訊息及產品訊息。
- 保固期間若有軟體版本更新時，免費升級至最新版本。
- 保固期間不限人次之免費軟體基礎教育訓練。
- 軟硬體問題不限時數、次數之電話熱線服務。
- 不限次數之E-mail 快速回覆服務。
- 免費參加本公司所主辦之所有付費活動。



Contact us

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*Thanks for
your attention*





T3Ster Advance Measurement Case

Application Engineer
Connie Tseng
Mail: connie@efd.com.tw
TEL: 02-2258-8186



01 T3Ster Principle

Principles, Advantages, etc.

T3Ster熱阻量測原理概要



T3Ster



- 電性量測法 (Electrical test method, ETM)
- 由電壓變化求得真正接面溫度 T_J
- 精確(0.01°C)且即時(1μs)的量測
- 符合JEDEC國際量測規範
- 穩態量測及暫態量測
- 可測得封裝分層熱阻

溫度敏感係數

TSP(K factor)

$$K = \frac{(T_{Hi} - T_{Lo})}{(V_{Hi} - V_{Lo})}$$

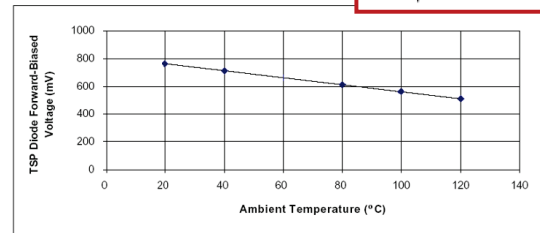


Figure 11. Typical $V_F - T_A$ curve for temperature-sensing diode forward biased with I_A

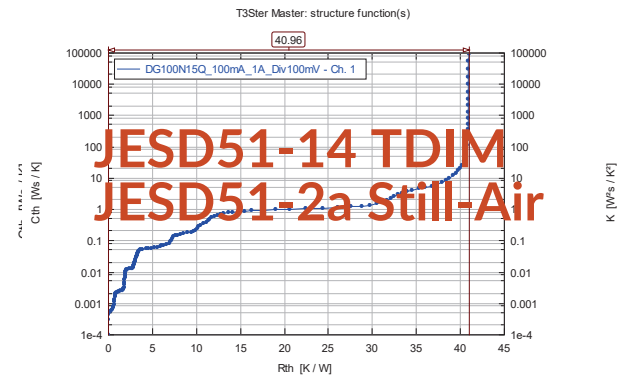
Specification of R_{th}

JESD51-1
ETM

$$R_{JX} = \frac{T_J - T_X}{P_H}$$

(JC/JA/JB)

where R_{thX} = thermal resistance from device junction to the specific environment (alternative symbol is θ_{thX}) [°C/W]
 T_J = device junction temperature in the steady state test condition [°C]
 T_X = reference temperature for the specific environment [°C]
 P_H = power dissipated in the device [W]



T3Ster 完整量測過程

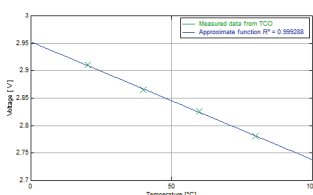


Open the measurement results by using T3Ster Master

TSP calibration

TSP: K factor

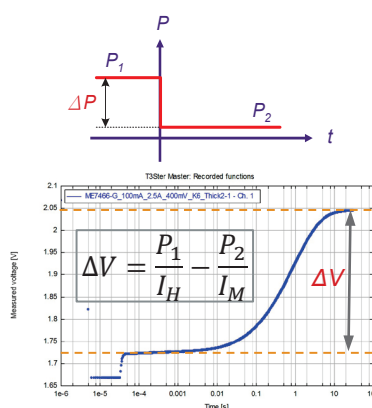
$$K = \frac{\Delta T}{\Delta V}$$



Input sensitivity(K) of DUT into the control software

Transient measurement

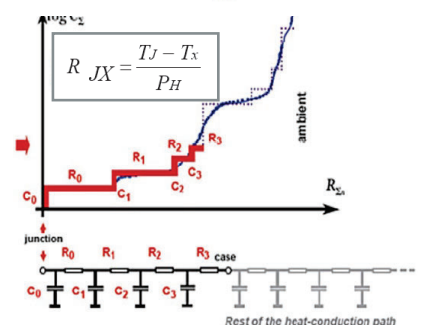
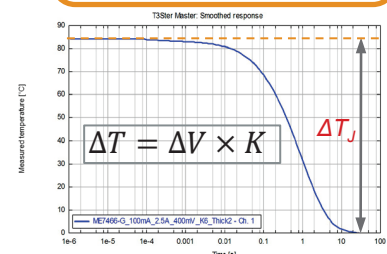
大電 I_H 小電 I_M



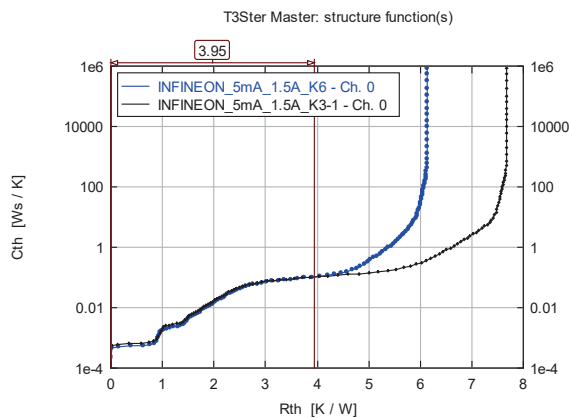
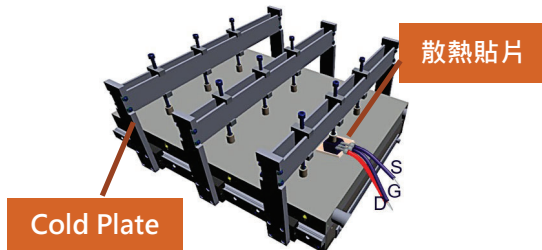
Get RAW data

*.par *.pwr
*.rec *.raw

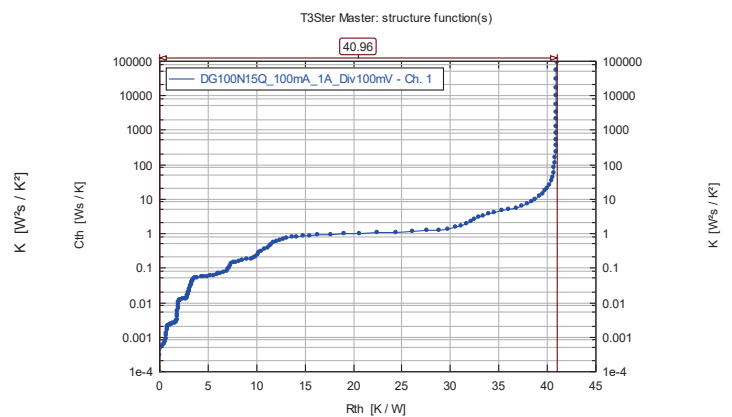
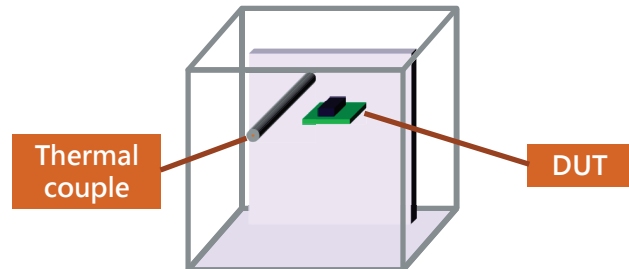
T3Ster Master Evaluation



JESD51-14 TDIM 異介質量測法-強制熱傳



JESD51-2a Still-Air 自然對流量測法-靜止空氣



02 Case Study

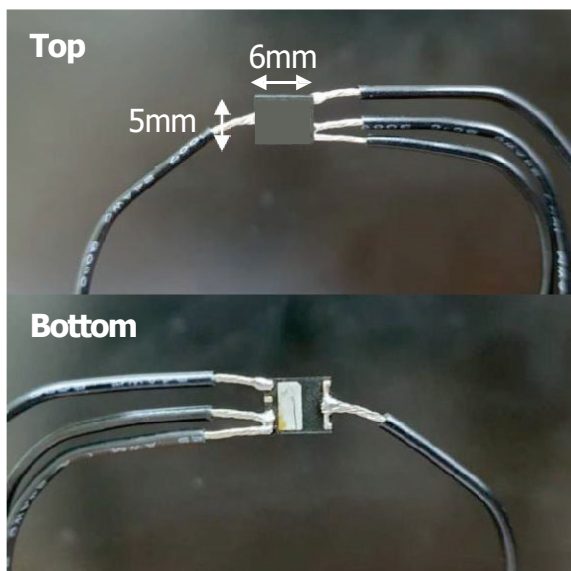
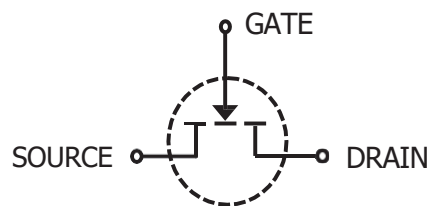
To show the benefits of T3Ster by some cases for you

Case 1

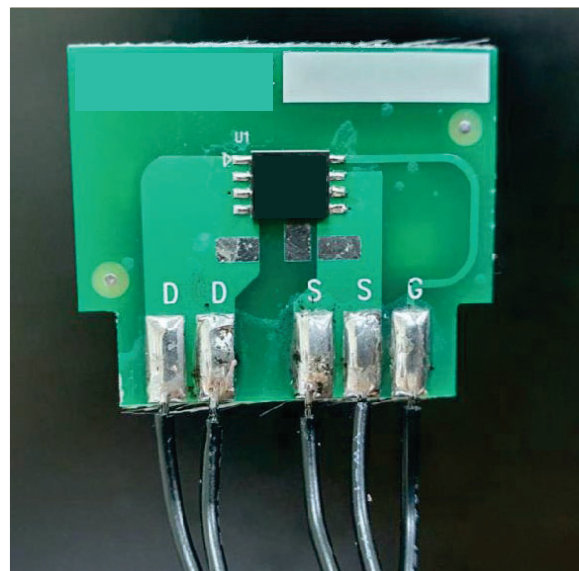
GaN HEMT 熱阻量測分析

Device Description

- ∞ This device is GaN HEMT
- ∞ Rthjc measurement



Sample1(w/o PCB)



Sample2(w/ PCB)

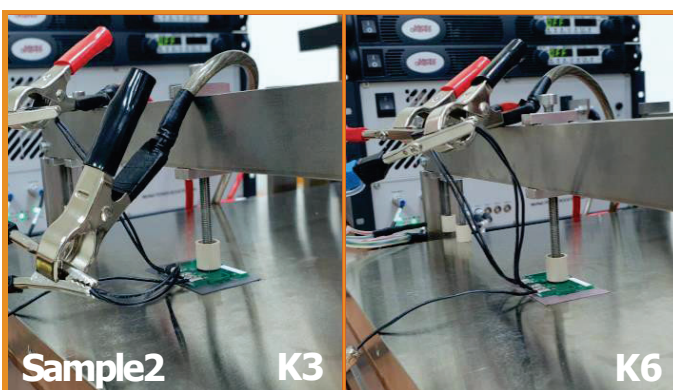
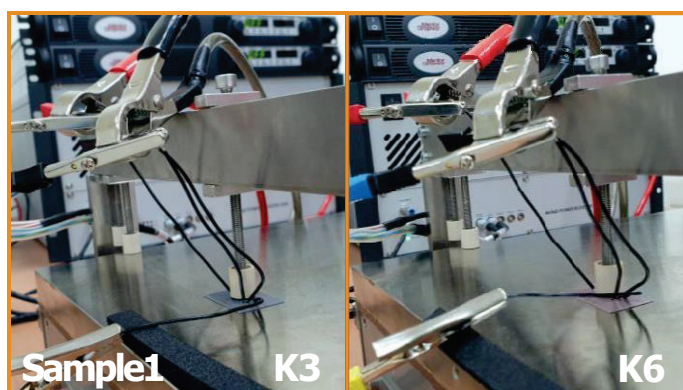
Measurement Detail_ R_{thjc}

- ☞ DUT put on **Cold plate(水冷板)** and measurement
- ☞ Measurement Parameter as bellow:

Set Parameter	GaN
V_{gs}	5V
I_M	500mA
I_H	3A(Sample1) / 2A(Sample2)
Ambient Temp.	25 °C

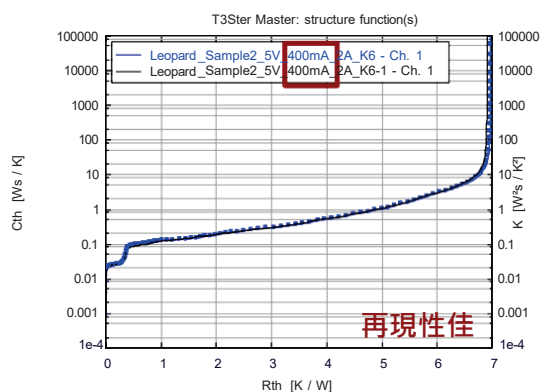
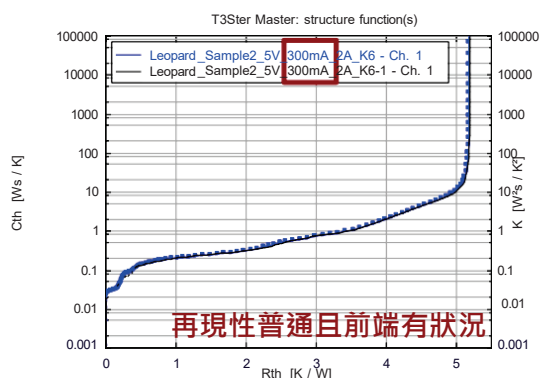
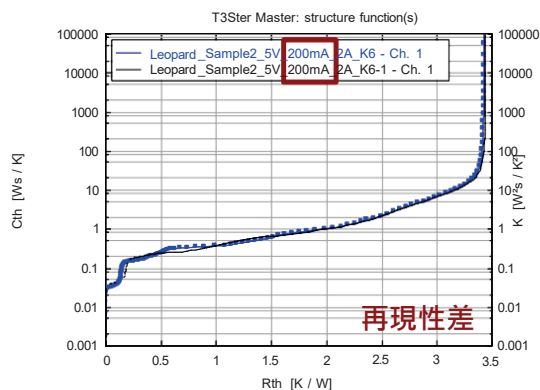
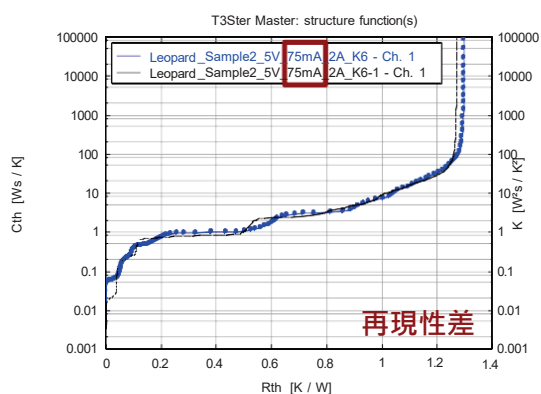


※Remark: I_S is sensing current and I_H is heating current.

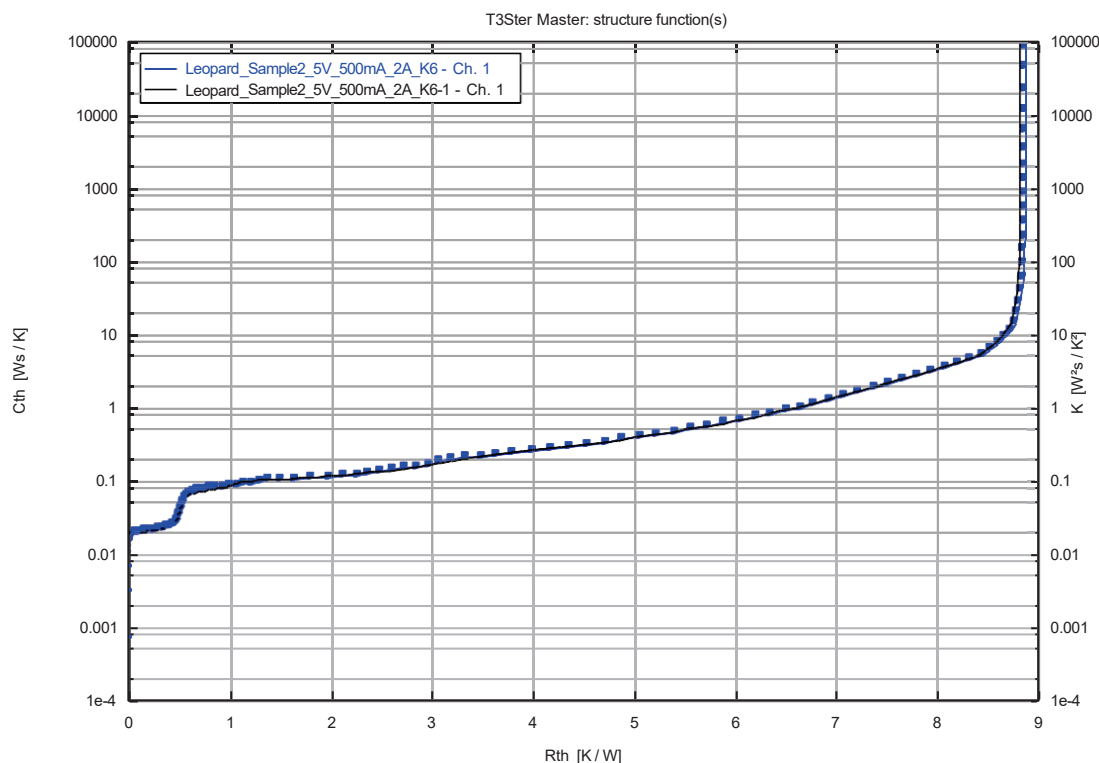


Measurement Detail_ I_S

- ☞ 調整小電(I_S)，每個小電各測試兩次，來觀察結構函數的再現性。

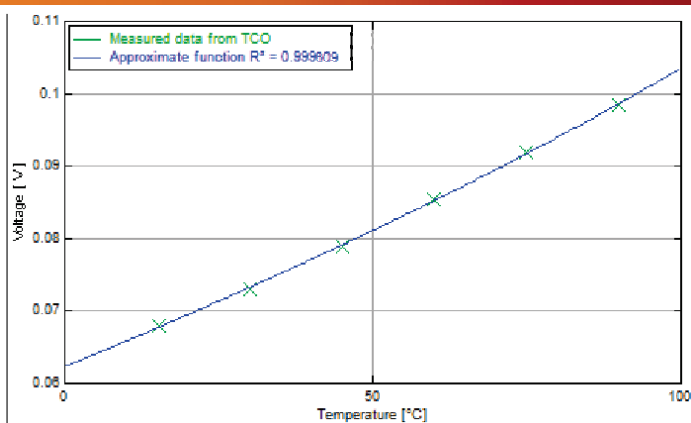


小電(I_S)為500mA時兩條結構函數疊合良好，再現性優異。

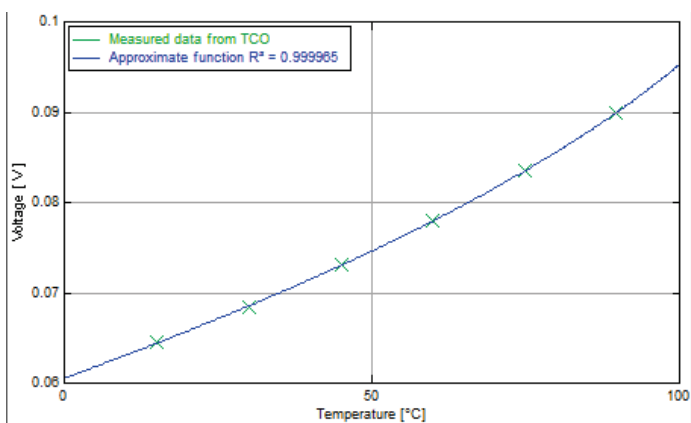


T3Ster Measurement Results- TSP Calibration – GaN

DUT	GaN-Sample1	
Item	T (°C)	V _F (V)
T1	15.2	0.067958
T2	30.05	0.073036
T3	45	0.078969
T4	59.93	0.085414
T5	74.8	0.091932
T6	89.8	0.098402
Sensitivity (mV/K)	0.412315 ※Sensitivity equals to TSP or K factor	



DUT	GaN-Sample2	
Item	T (°C)	V _F (V)
T1	15.14	0.064491
T2	30	0.06847
T3	44.96	0.073036
T4	59.87	0.077943
T5	74.8	0.083534
T6	89.8	0.08993
Sensitivity (mV/K)	0.339366 ※Sensitivity equals to TSP or K factor	



T3Ster Measurement Results -Rthjc- ΔT_j and T_j - GaN-S1

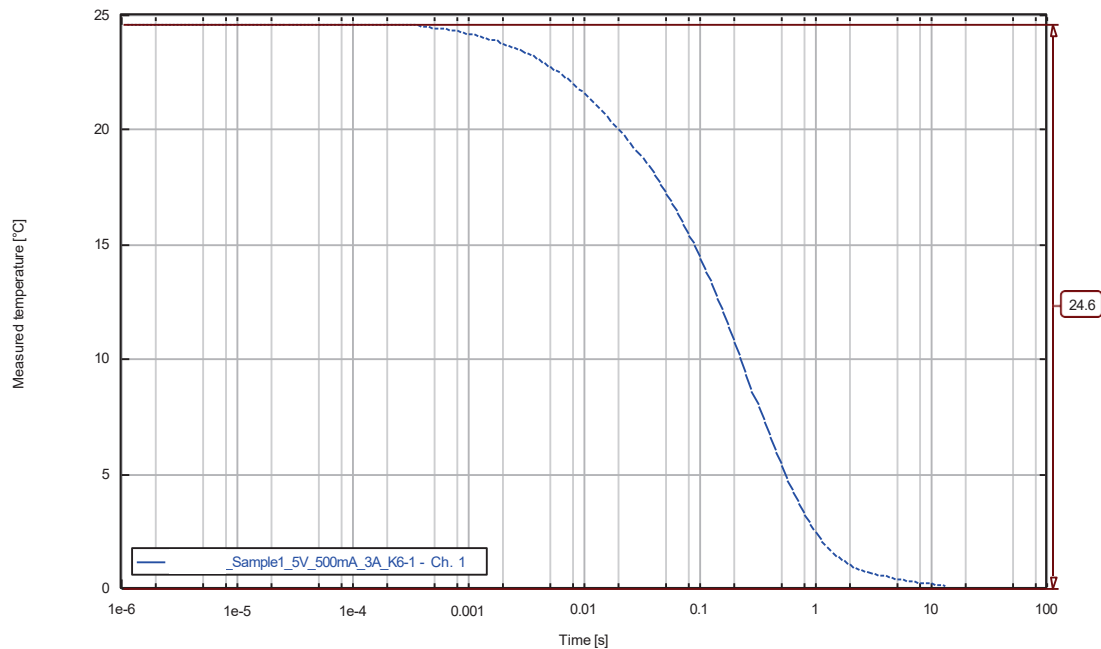


∞ ΔT_j @ 25°C is 24.6 °C

∞ $T_j = \Delta T_j + T_{ref.} = 24.6 + 25 = 49.6$ °C

Sample1

T3Ster Master: Smoothed response



T3Ster Measurement Results -Rthjc- ΔT_j and T_j - GaN-S2

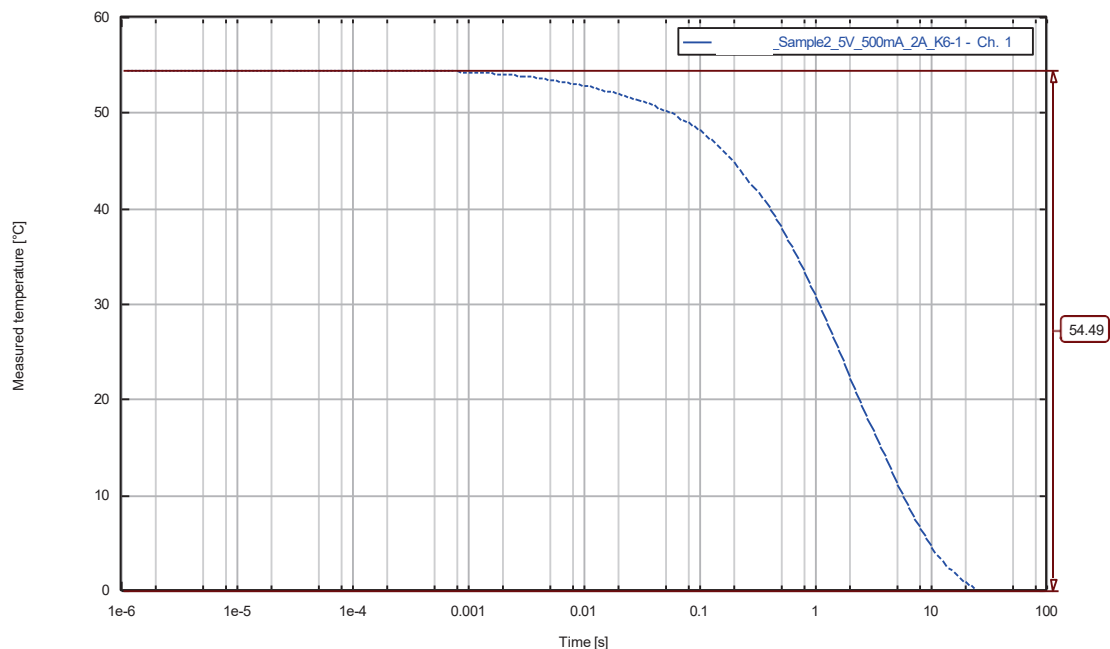


∞ ΔT_j @ 25°C is 54.49 °C

∞ $T_j = \Delta T_j + T_{ref.} = 54.49 + 25 = 79.49$ °C

Sample2

T3Ster Master: Smoothed response



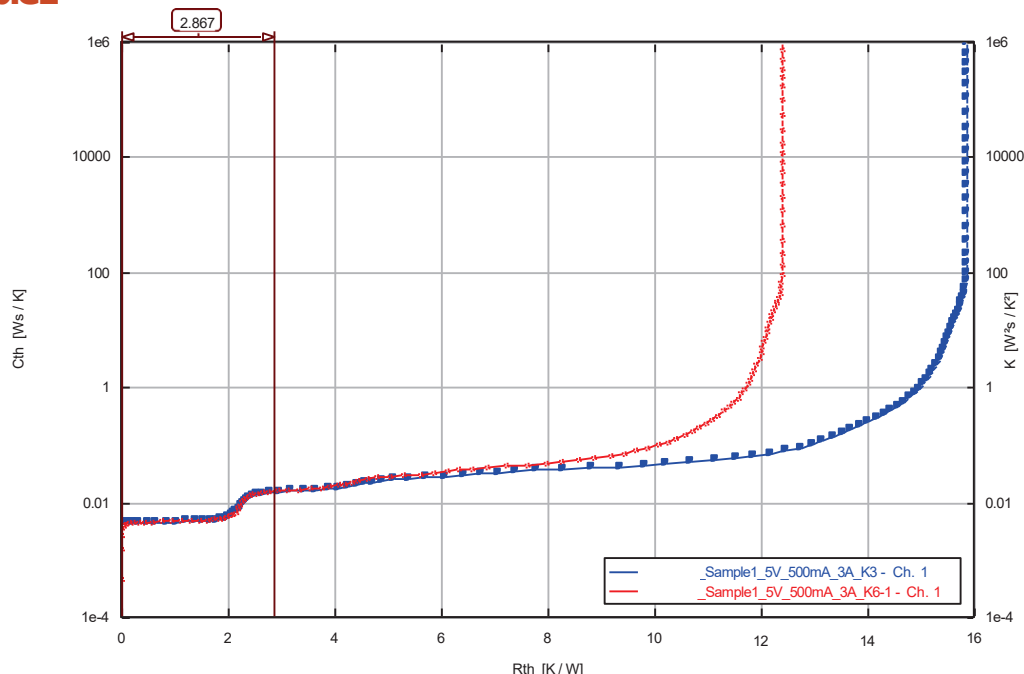
T3Ster Measurement Results-Rthjc- Structure Function- GaN-S1



- Integral Structure Function@ 25 °C
- JESD 51-14 TDI Method , Thermal pad : K3/K6
- Rthjc = 2.867K/W (分岔點以前，不含板熱阻)

Sample1

T3Ster Master: structure function(s)



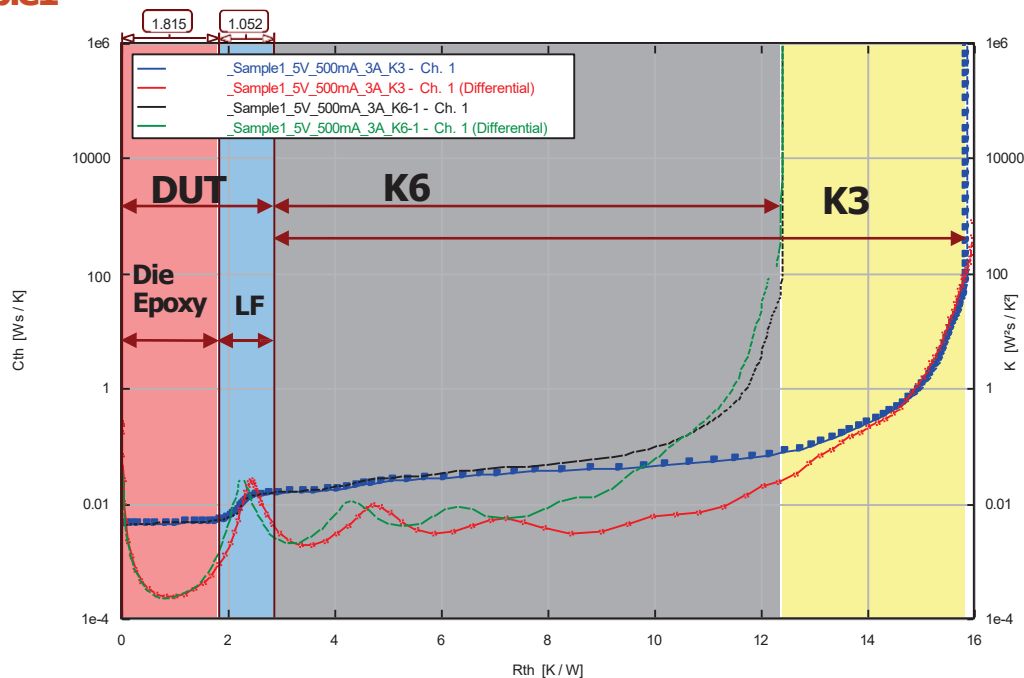
T3Ster Measurement Results-Rthjc- Structure Function- GaN-S1



- Integral Structure Function@ 25 °C
- JESD 51-14 TDI Method , Thermal pad : K3/K6
- Rthjc = 2.867K/W (分岔點以前，不含板熱阻)

Sample1

T3Ster Master: structure function(s)

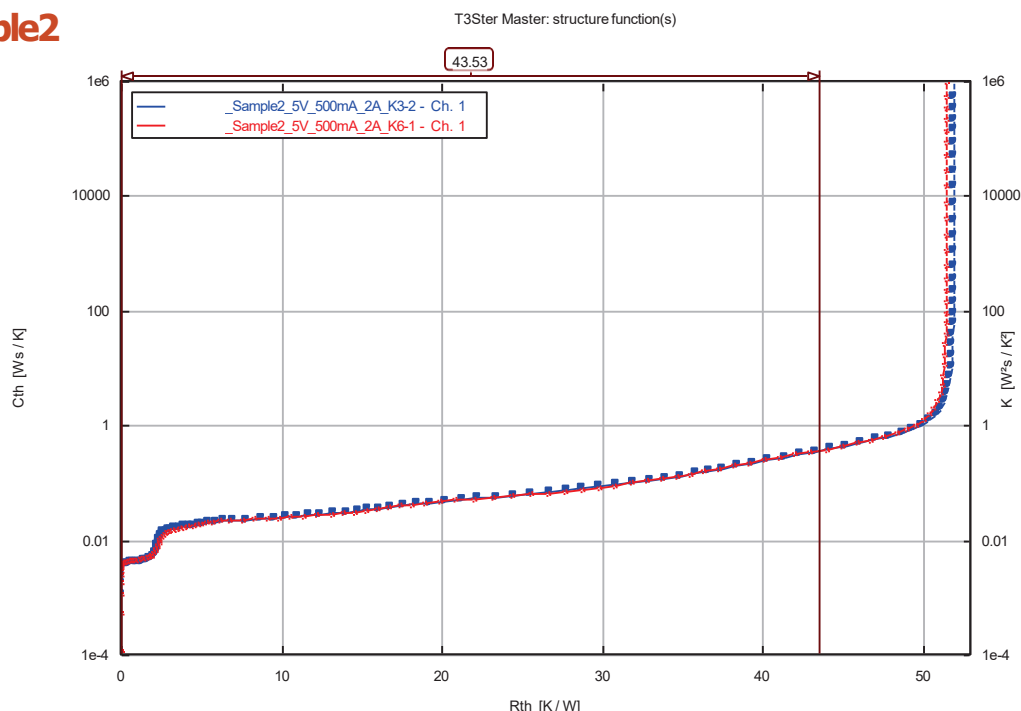


T3Ster Measurement Results-Rthjc- Structure Function- GaN-S2



- Integral Structure Function@ 25 °C
- JESD 51-14 TDI Method , Thermal pad : K3/K6
- Rthjc = 43.53K/W (分岔點以前，不含板熱阻)

Sample2

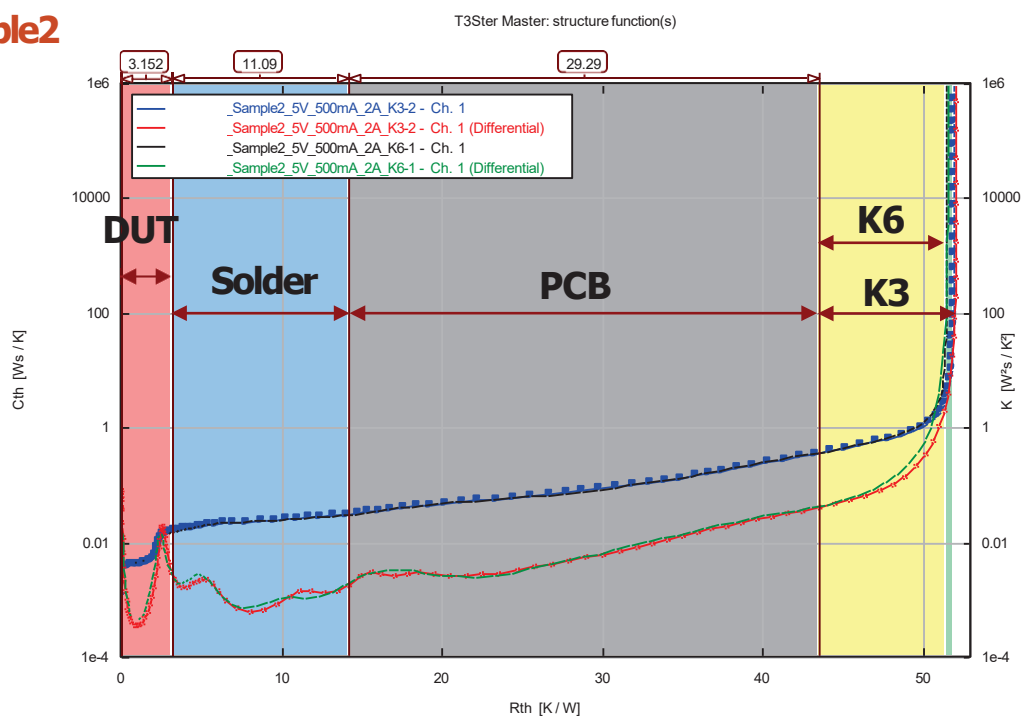


T3Ster Measurement Results-Rthjc- Structure Function- GaN-S2



- Integral Structure Function@ 25 °C
- JESD 51-14 TDI Method , Thermal pad : K3/K6
- Rthjc = 43.53K/W (分岔點以前，不含板熱阻)

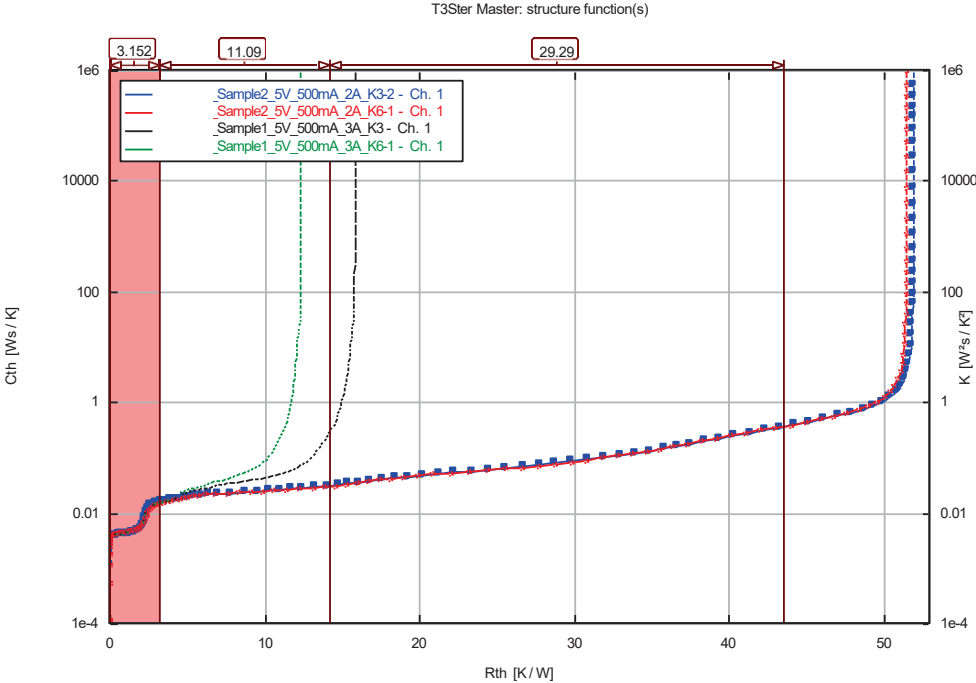
Sample2



Summary of T3Ster Measurement - Rthjc



GaN	ΔP_{K6}	TSP	ΔT_j	T_j	R_{th-DUT}	$R_{th-solder}$	R_{th-PCB}
Sample1(w/o PCB)	1.992W	0.412mV/K	24.6 °C	49.6°C	2.375K/W	-	-
Sample2(w/ PCB)	1.058W	0.339mV/K	54.49°C	79.49°C	3.152K/W	11.09K/W	29.29K/W



Case 2 IC Design Change

Case IC Design Change

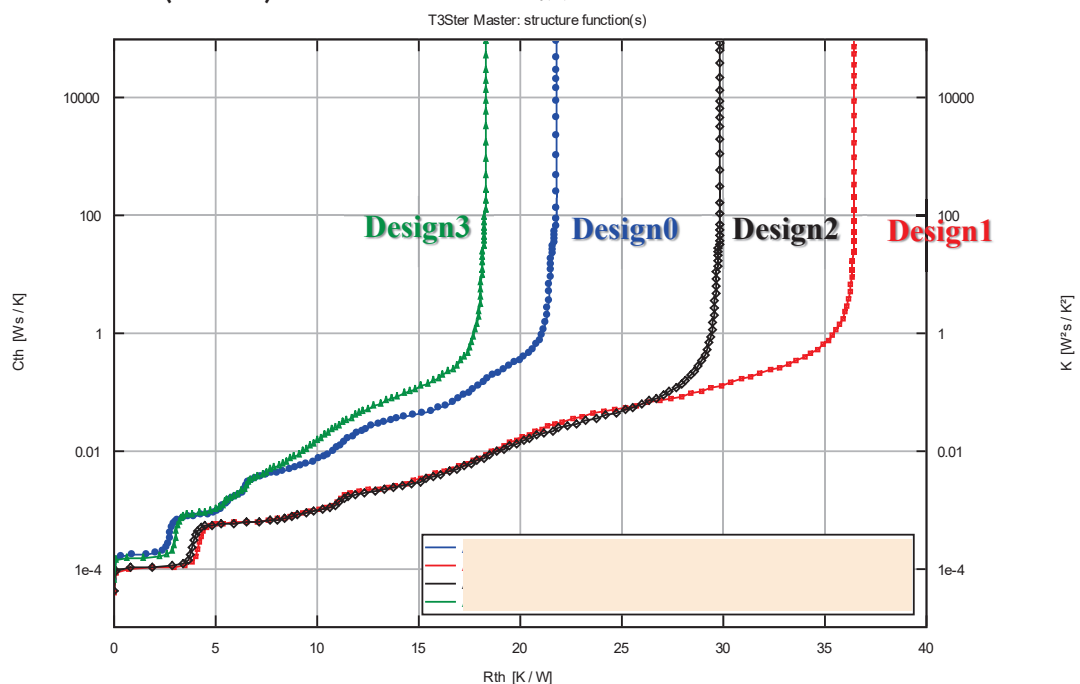


量測樣品	封裝樣式	Rthjc	Rthja
Design 0 (Case1)		V	V
Design 1 (Case2)	● 沒有封裝 (Open face) + EVB (PCB2) ● 電源從PCB2上方拉出 ● 量測θ_{Jc} & θ_{Ja}的結果	V	V
Design 2 (Case2)	● 沒有封裝 (Open Face) 不上EVB (PCB2) ● 電源由PCB1下端拉出 ● 量測θ_{Jc} & θ_{Ja}的結果	V	V
Design 3 (Case2)	● 有封裝(compound) 不上EVB (PCB2) ● 電源由PCB1下端拉出 ● 量測θ_{Ja}的結果	V	V

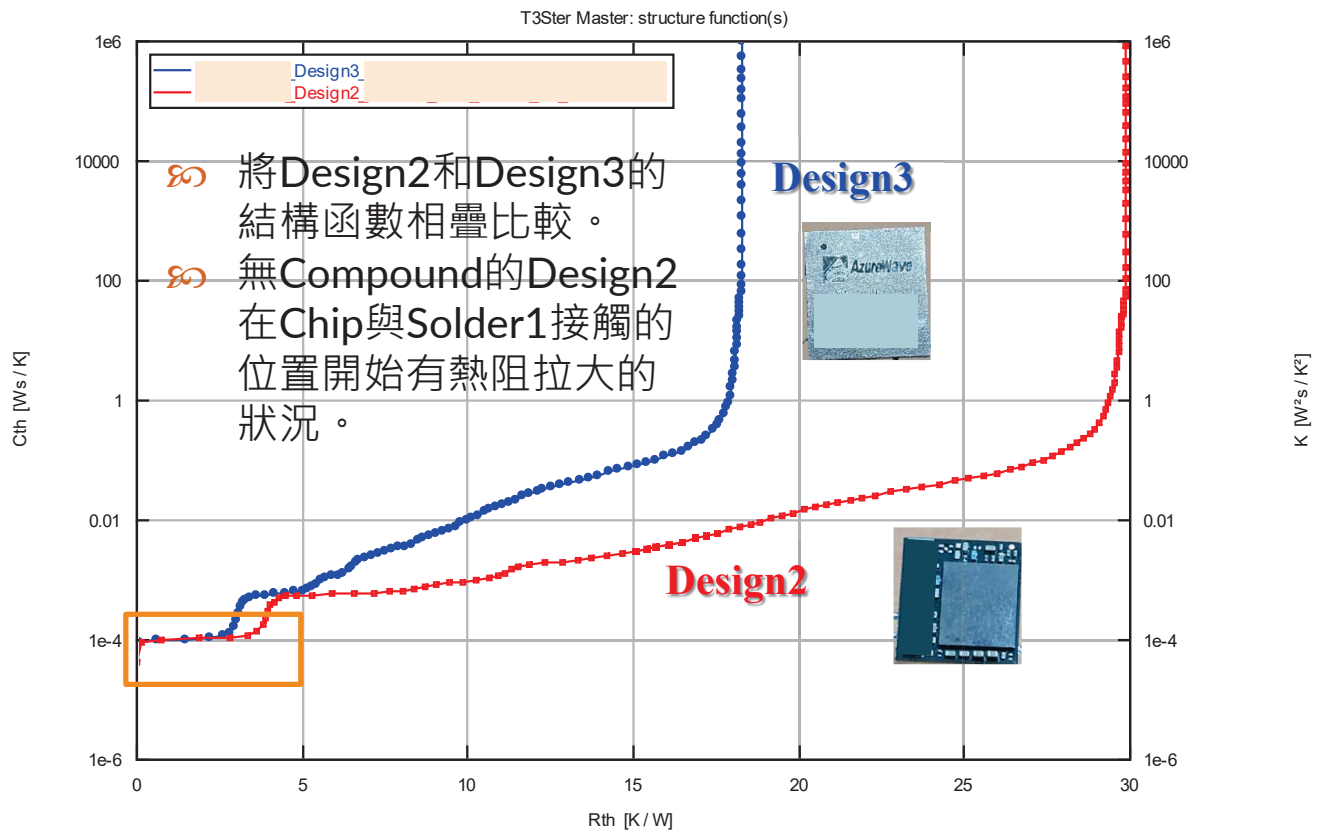
Case IC Design Change



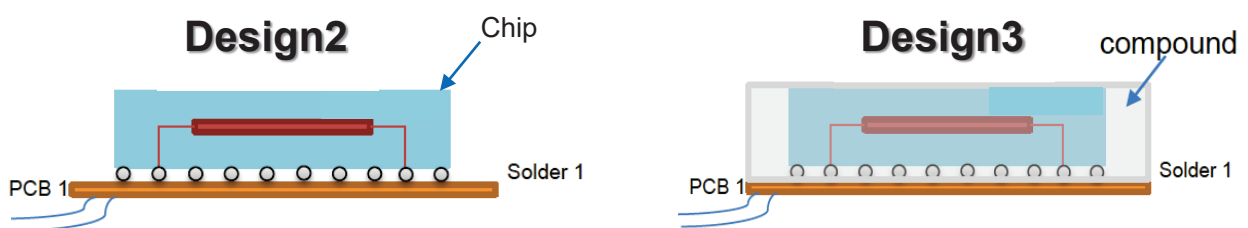
- 將Design0~Design3的結構函數放在一起比較，在整體熱阻上，可發現有Compound的設計(Design0, Design3)量測出來的熱阻較小。
- 且上板樣品(Design0, Design1)相較於無上板樣品(Design2, Design3)，可能因為多一層EVB(PCB2)的關係，有熱阻較大的現象。



Case IC Design Change



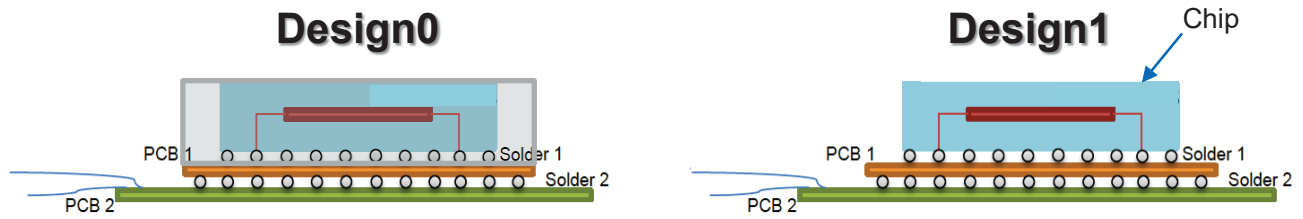
Case IC Design Change



	Rth	Design2	Design3	w/ compound
Chip		3.364 K/W	2.617 K/W	-22.2%
Solder1		7.262 K/W	3.664 K/W	-49.5%
PCB1		15.74 K/W	8.262 K/W	-47.5%

有Compound，對於各層材料的熱阻皆有顯著的改善。

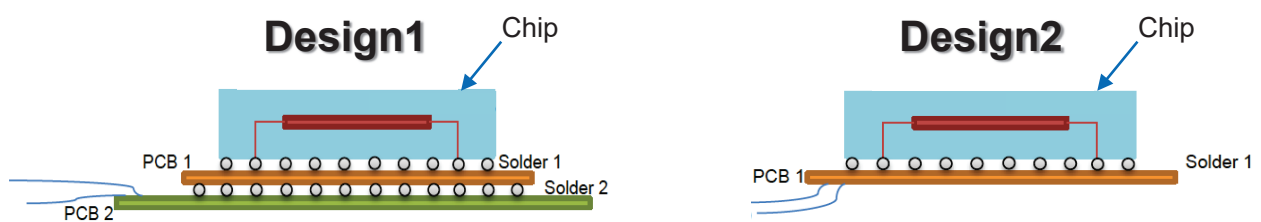
Case IC Design Change



Rth	Design0	Design1	w/ compound
Die	2.559 K/W	3.468 K/W	-26.2%
Solder1	3.516 K/W	6.975 K/W	-49.6%
PCB1	4.042 K/W	11.65 K/W	-65.3%
Solder2 & PCB2	5.488 K/W	11.88 K/W	-53.8%

有Compound的熱阻差異，在上板後對PCB1改善幅度更加明顯。

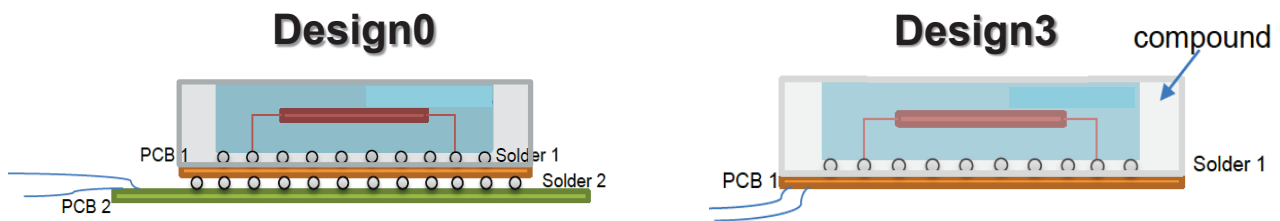
Case IC Design Change



Rth	Design1	Design2	w/ PCB2
Die	3.468 K/W	3.364 K/W	+3.09%
Solder1	6.975 K/W	7.262 K/W	-3.95%
PCB1	11.65 K/W	15.74 K/W	-26.0%
Solder2 & PCB2	11.88 K/W	-	-

無Compound的樣品在上板後，PCB2對Die和Solder的影響小於4%，但對PCB1的散熱有明顯的幫助。

Case IC Design Change



Rth	Design0	Design3	w/ PCB2
Chip	2.559 K/W	2.617 K/W	-2.2%
Solder1	3.516 K/W	3.664 K/W	-4%
PCB1	4.042 K/W	8.262 K/W	-51.1%
Solder2 & PCB2	5.488 K/W	-	-

有Compound的樣品在上板後，PCB2對PCB1的散熱有明顯的幫助。

Case IC Design Change

有Compound的影響：

- 無上板時，有Compound的樣品，對於各層材料的熱阻皆有顯著的改善，改善程度皆在20%以上。
- 有上板時，有Compound的樣品比上板前，在Die和Solde1的改善狀況相近，而PCB1的改善幅度增加了15%以上。

有EVB(PCB2)的影響：

無論樣品是否有Compound，上板樣品相較於無上板樣品，對Die和Solde1影響較小皆在4%以內，但對PCB1的熱阻則有大幅改善：無Compound時PCB1熱阻改善26%，而有Compound時則可改善約51%。推測有上板的情況下，PCB2對PCB1的散熱有明顯的幫助。

藉由不同設計變更的IC元件，在Rthjc的量測上可比較出「有無封裝」及「有無EVB」，對於IC元件各層熱阻的影響，並且可計算出量化的分析結果。透過T3Ster暫態熱阻量測的協助，讓客戶在IC散熱設計上有了更深一層的確證與進展。

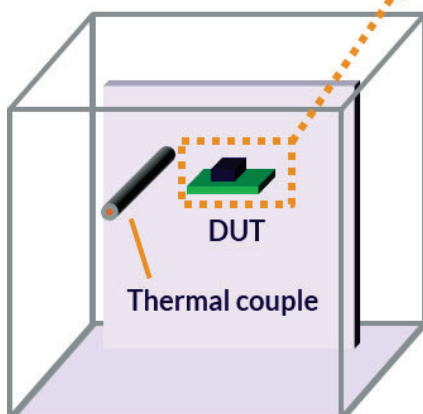
Case 3

R_{thja} 進行Flotherm模擬

T3Ster Principle- R_{thja}

JESD51-2a

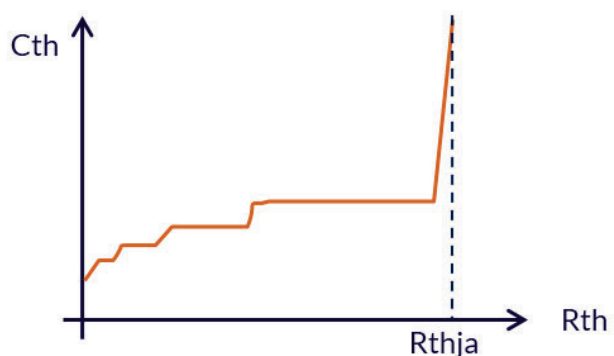
量測環境
自然對流箱
(Still-Air Chamber)
30cm*30cm*30cm



樣品設置的側視圖



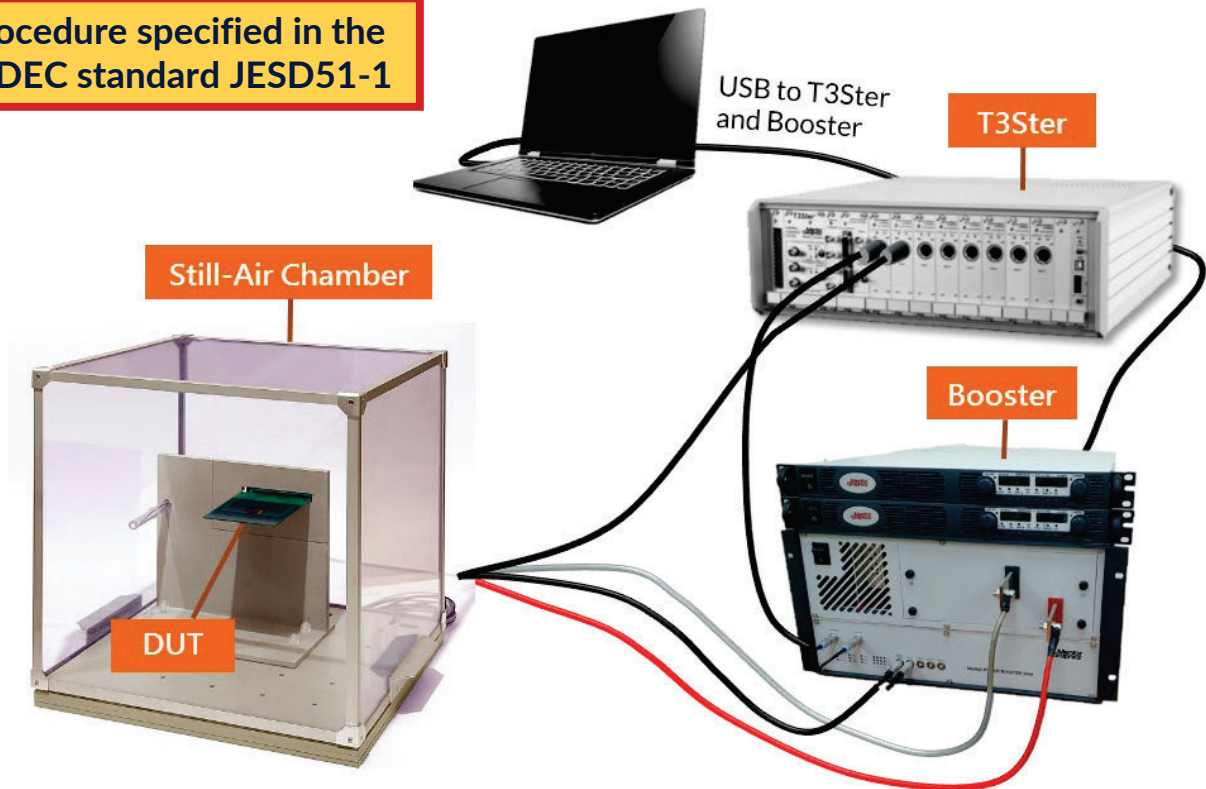
R_{thja} = R_{th} of junction to ambient



T3Ster Principle-Rthja



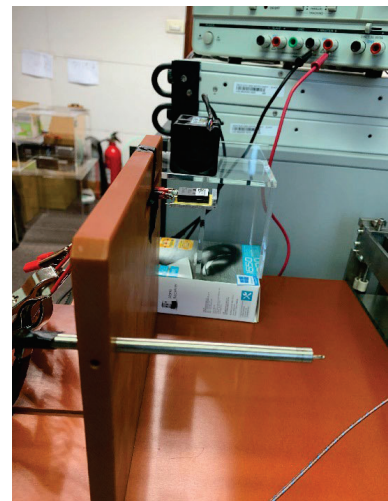
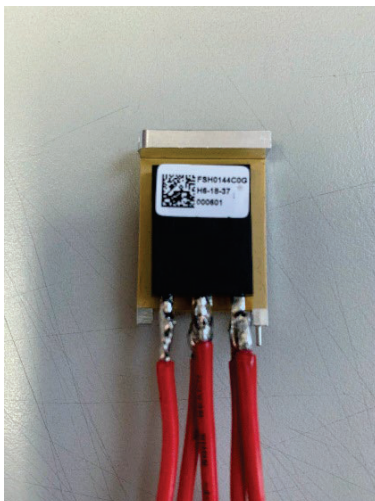
Procedure specified in the JEDEC standard JESD51-1



R_{thja} 進行Flotherm模擬



- 利用 T3Ster 量測 R_{thja}
- 遵照JEDEC JESD 51-2A 規範于自然對流箱中進行測試
- 按照其終端產品的設置，於元件左邊增加一風扇增加風流，確保及增加準確度於元件在產品使用上的熱特性

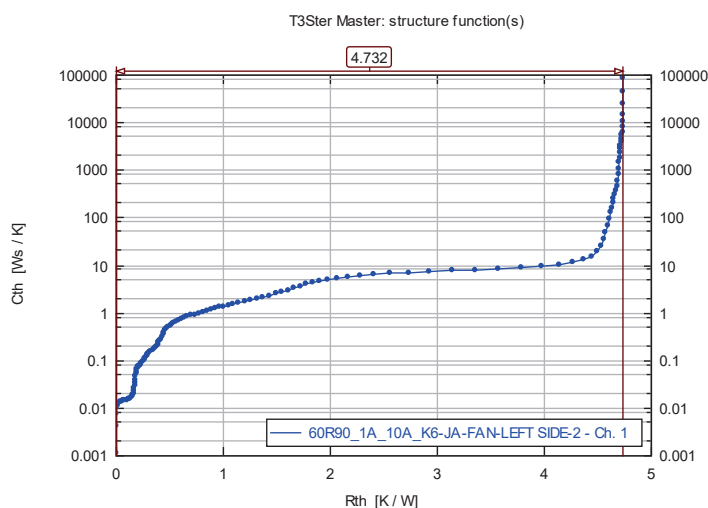


R_{thja} 進行Flotherm模擬

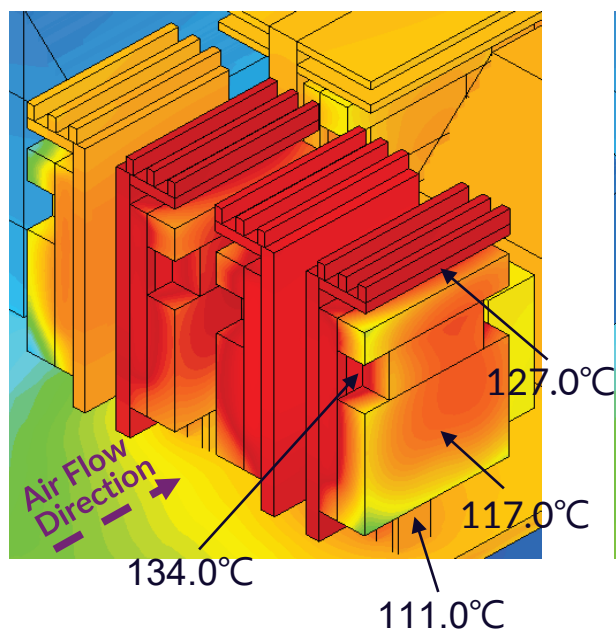


- Use JESD 51-2A
- Add Fan on left side of DUT
- $R_{thja} = 4.732 \text{ K/W}$

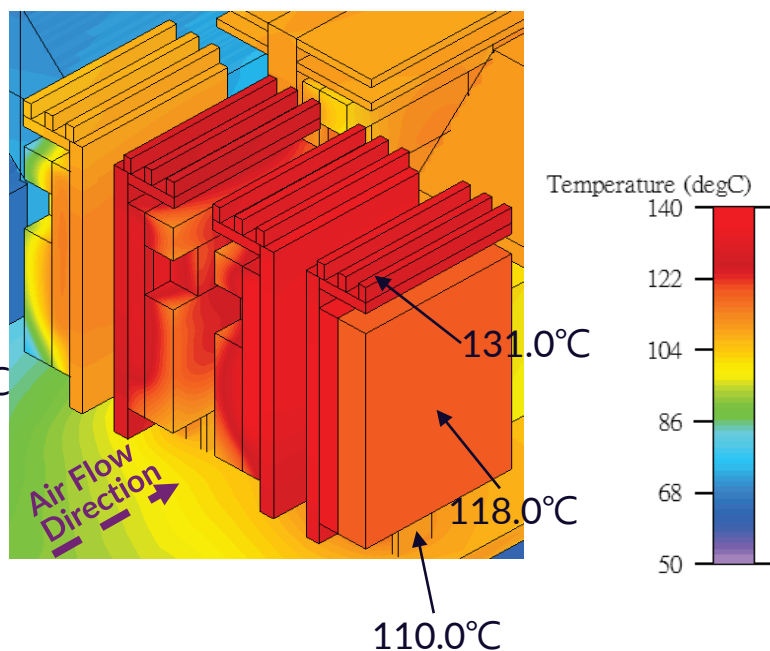
Set Parameter	60R090F7 MOSFET
I_m	1A
I_d	10A
Power dissipation	15.553 W
Ambient Temp.	23.2 °C



R_{thja} 進行Flotherm模擬



原始模型



T3Ster

Case 4

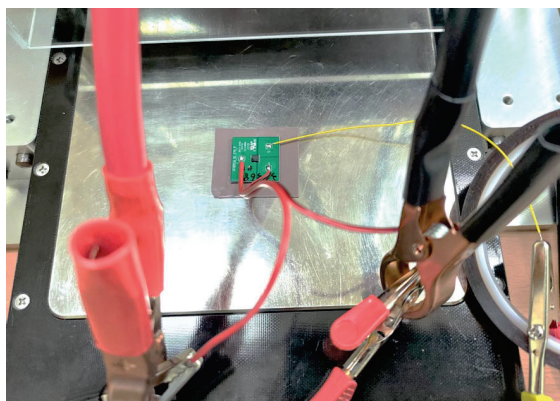
100°C控溫板的Rthjc量測

Device Description-Rthjc

- ∞ DUT put on **Cold plate(水冷板)** and measurement
- ∞ Measurement Parameter as bellow:

Set Parameter	MOSFET
V_{gs}	10V
I_M	100mA
I_H	10 A
Ambient Temp.	100 °C

※Remark: I_M is measurement current and I_H is heating current.



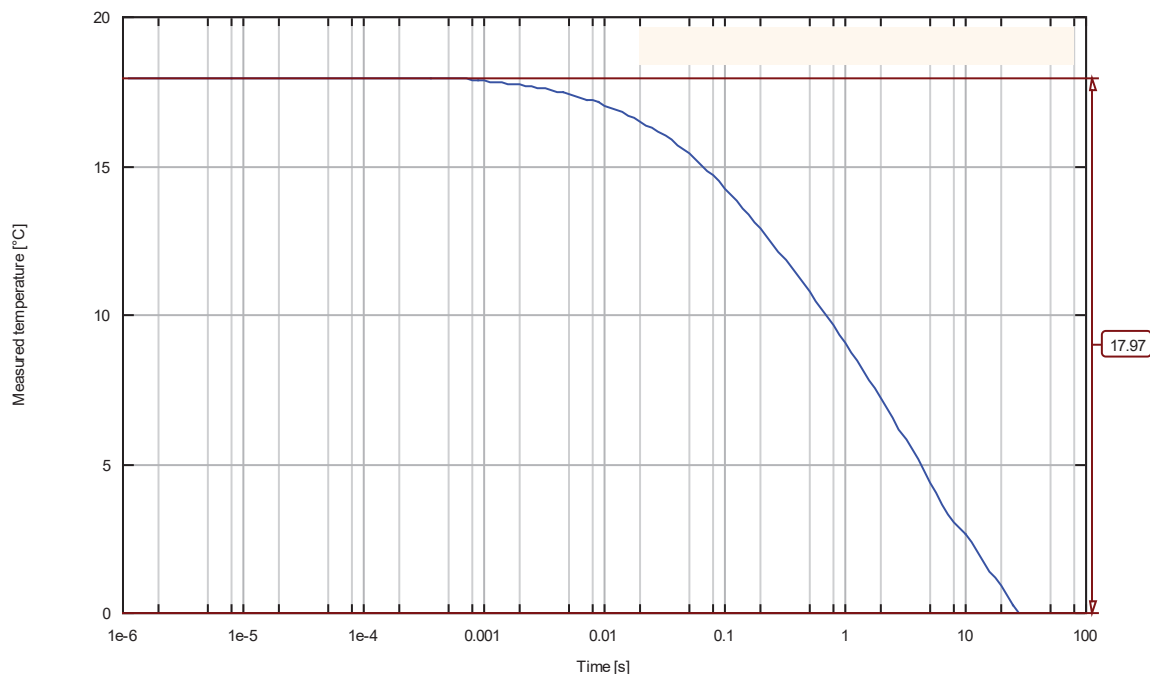
T3Ster Measurement Results_Rthjc_

ΔT_j and T_j _MOSFET



- ΔT_j @ 100°C is 17.97°C
- $T_j = \Delta T_j + T_{ref.} = 17.97 + 100 = 117.97^\circ\text{C}$

T3Ster Master: Smoothed response



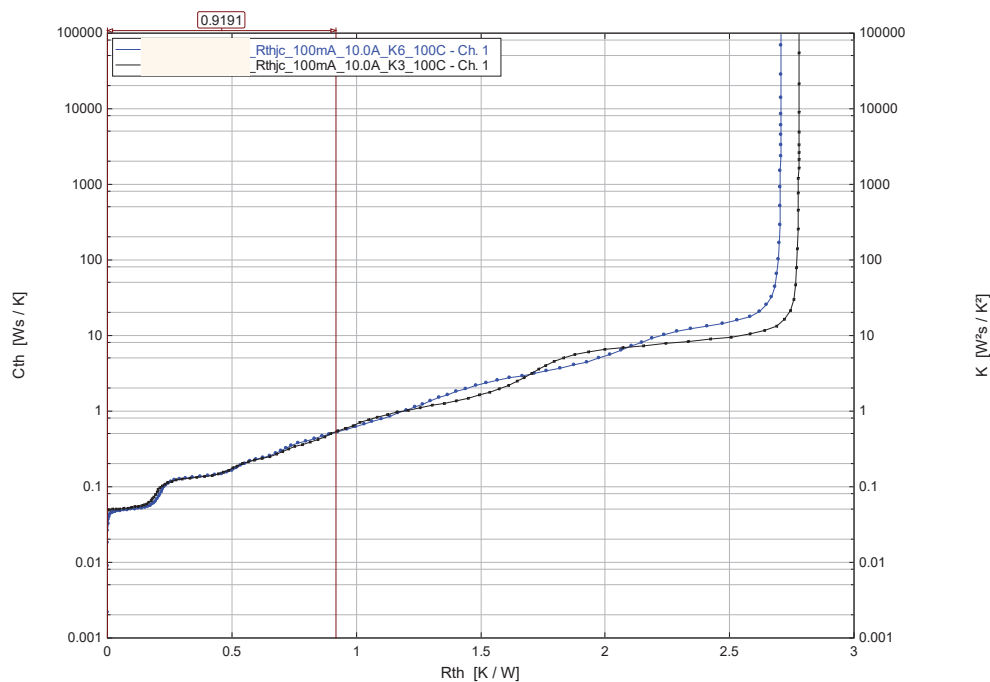
T3Ster Measurement Results_Rthjc_

Structure Function_ MOSFET



- Integral Structure Function @ 100°C
- Use JESD 51-14
- $R_{thjc} = 0.9191^\circ\text{C/W}$

T3Ster Master: structure function(s)



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➤ Power Tester 600A
➤ Power Tester 2400A
功率迴圈之可靠度測試



➤ T3Ster S



