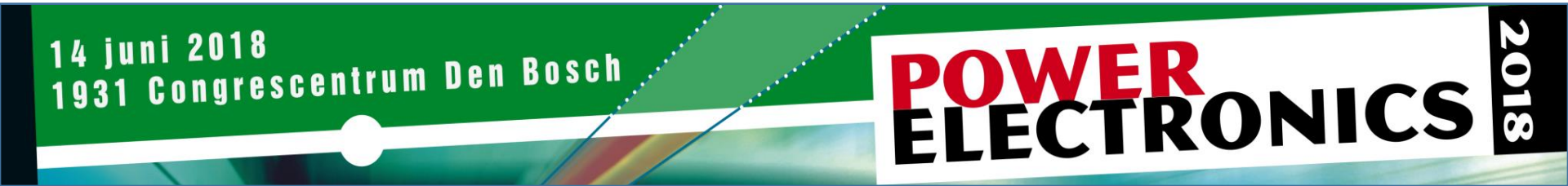
Mitsubishi Electric Semi-Conductors Division

IGBT Module 7th Generation T-Series

June 14, 2018



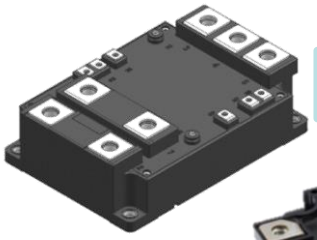
7th generation IGBT module

SLC-Technology

(SoLid Cover Technology)

- Optimized structure with resin insulation
- Direct potting resin
- PC-TIM / PressFit available

LV100 package type



NX package type

std package type

7th chip technology

Improved trade-off

◆IGBT (CSTBT) ◆Diode (RFC)

V_{CEsat} vs E_{off} V_{EC} vs E_{rr}

dv/dt vs E_{off} dv/dt vs E_{rr}

Low loss & Low dv/dt device

TMS-Technology

(Thick Metal Substrate)

- Optimized structure with Si_3N_4 ceramic insulation
- Terminal US bonding
- PC-TIM available

IGBT Module T Series with 7th Gen. IGBT 【NX type】

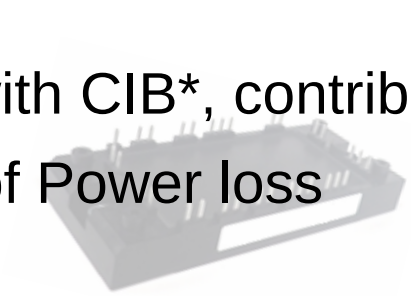
NEW

Some products are under development

Point

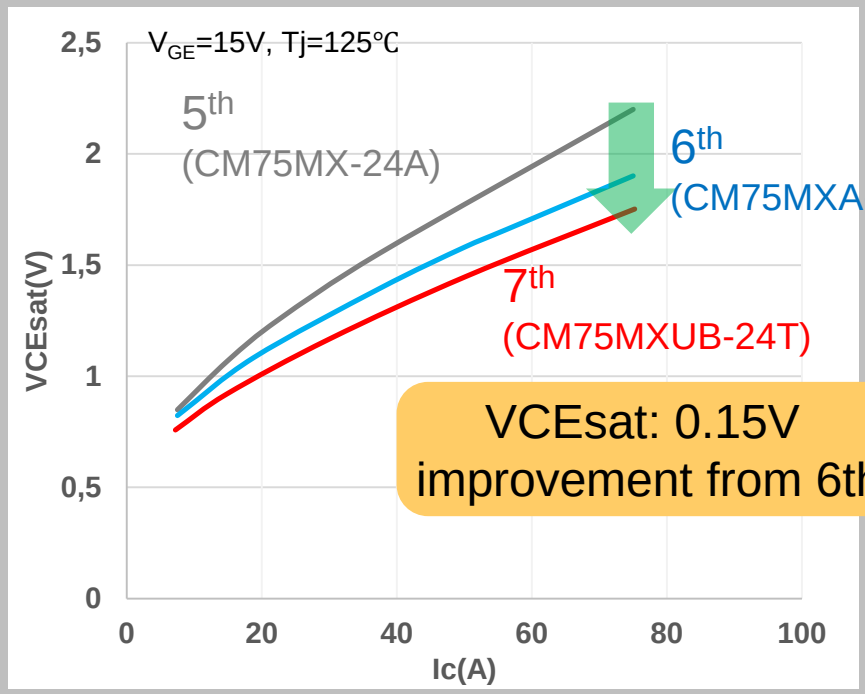
- New modules equipped with CIB*, contributes to simplifying design.
- Significant improvement of Power loss
- High reliability
- Simplified assembly process

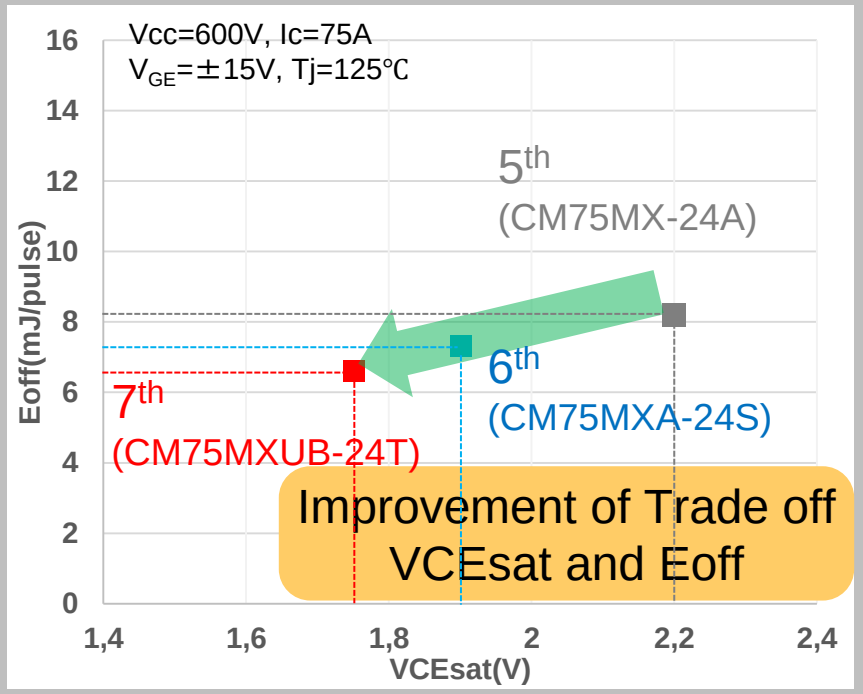
* CIB: Converter, Inverter, and Brake circuit



VCES(V)	Connection	CurrentRating(A)										
		35A	50A	75A	100A	150A	200A	225A	300A	450A	600A	1000A
650V	2 in1								●	●	●	
	6 in1				●	●	●					
	7 in1					●	●					
	CIB		●	●	●	●						
1200V	2 in1							●	●	●	●	●
	6 in1				●	●	●					
	7 in1				●	●						
	CIB	●	●	●	●	●						
1700V	2 in1							●	●	●	●	
	6 in1				●	●						

Significant improvement of Power loss





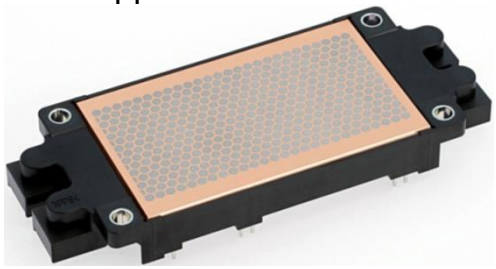
Power loss is reduced with 7th-Gen. IGBT

High reliability

- 7th -generation chips lead better trade-off characteristics and lower loss
- New package technologies realize High reliability and Light weight
- Press-Fit pins and PC-TIM* achieve easy mounting

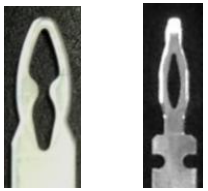
■Outlook

■Pre-applied PC-TIM*



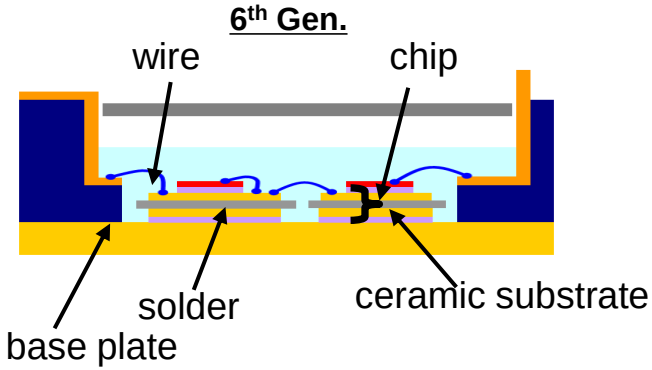
■Features

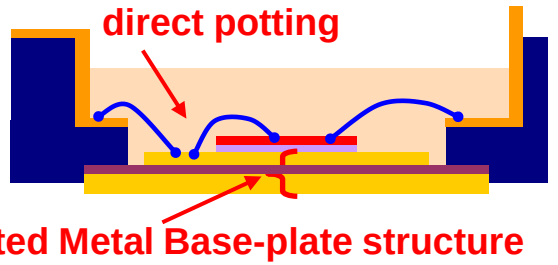
- High Reliability
- Compatible with 6th Gen. NX type
- Press-Fit pins available



Power terminals　Auxiliary terminals

■Package structure comparison



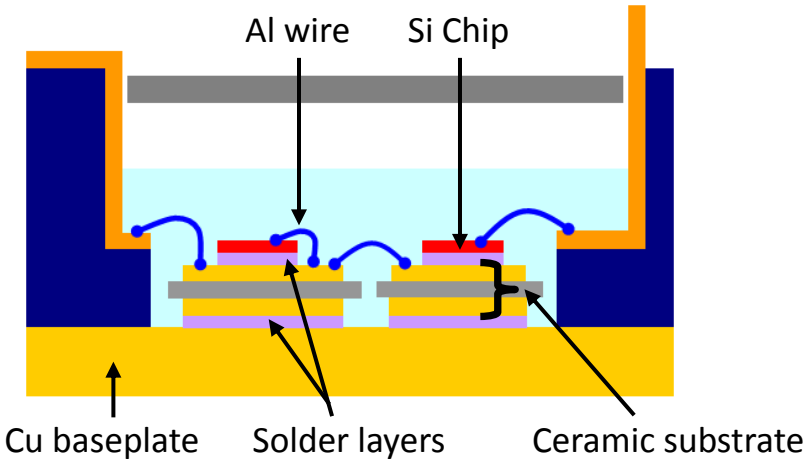


*PC-TIM: Phase Change - Thermal Interface Material

Matched Thermal Expansion

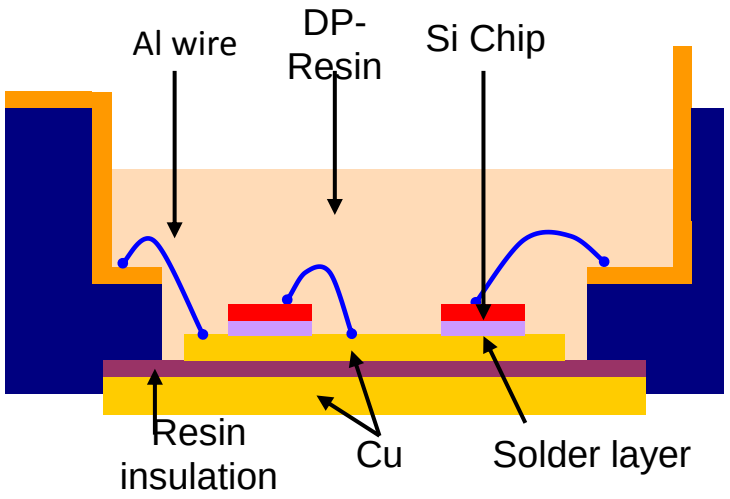
NX/LV100 type

Conventional



Material	CTE* [ppm/K]
Al wire	23
Si Chip	2.3
Ceramic substrate	4.5 ~ 7.0
Cu baseplate	≈17

SLC-Technology



Material	CTE* [ppm/K]
Al wire	23
Si Chip	2.3
Cu, Resin	≈17

CTE*= Coefficient of Thermal Expansion

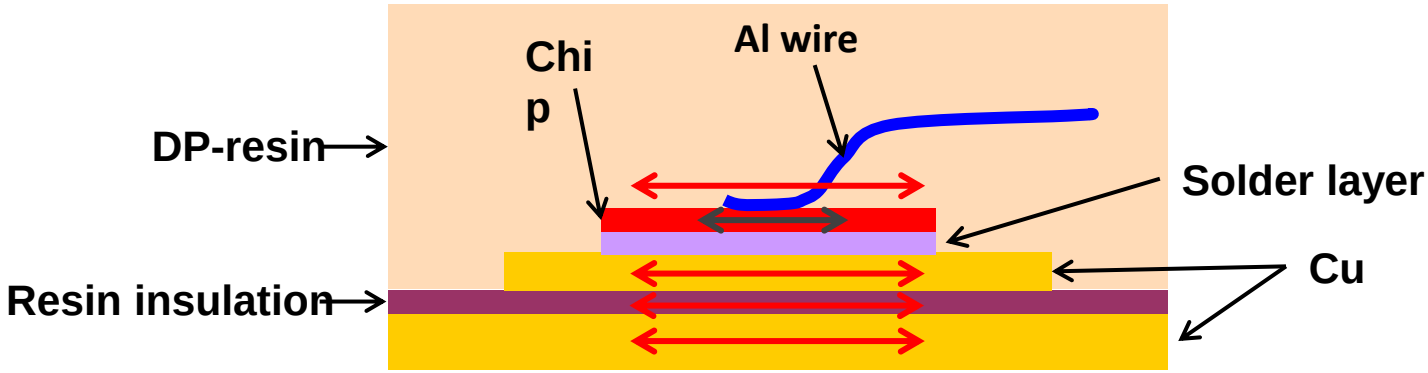
➢ **Matching thermal expansion of copper and resin**

Matched Thermal Expansion

NX type

SLC-Technology

CTE*= Coefficient of Thermal Expansion



CTE*: Copper ≈ Resin

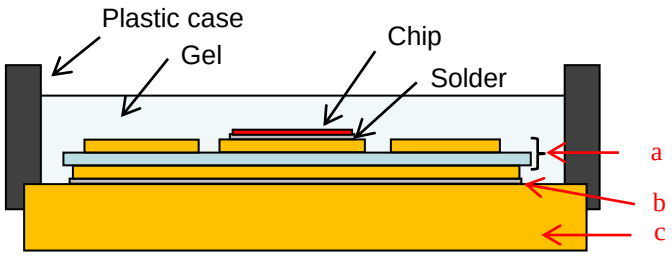
SLC-Technology structure stress concentrates between different CTE of chip, solder, Al wire and decreases strain of each elements

- **Reduced baseplate warpage**
  → reduced pumping out

Warpage

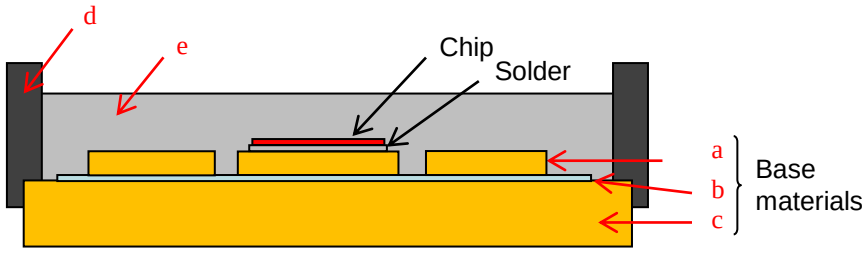
NX type

Conventional



Symbol	a	b	c
Material	DBC	Solder	Copper
CTE(10^{-6}/K)	6.9	26	16.7

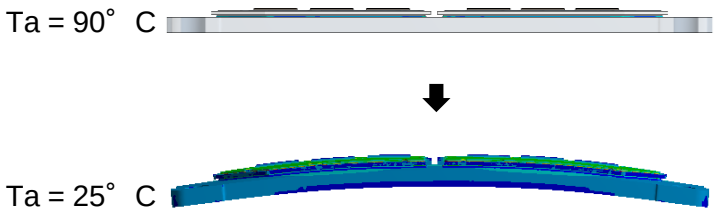
SLC-Technology

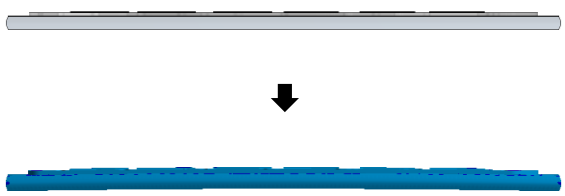


Symbol	a	b	c	d	e
Material	Copper	Insulator	Copper	Plastic	Resin
CTE (10^{-6}/K)	16.7	16.7	16.7	16.5	16.0

CTE of components

Simulation





*10 times amplified image

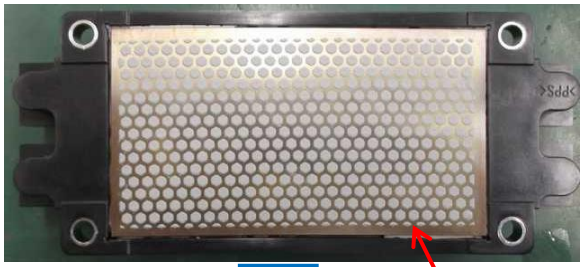
- Practically no pumping out of thermal interface material
- Improved reliability of Rth(c-s) which results in improved overall reliability

Simplified assembly process (NX type/std type)

PC-TIM support

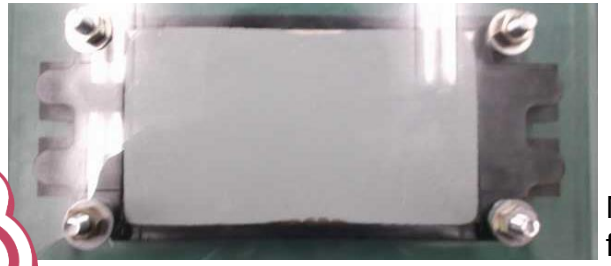
■ Delivered product

Solid in room temp.



■ After phase changed (during operation)

Get softened and expand same as thermal grease



Mounted on glass for observation

<ADVANTAGES>

- Easier to handle than thermal grease
- Save grease applied process at assembly
- Superior thermal conductivity owing to high heat dissipation material and strict thickness control

※ Pre-application of PC-TIM is applicable to both std-type and NX-type products.

PC-TIM: **P**hase **C**hange – **T**hermal **I**nterface **M**aterial

PC-TIM contribute to simplifying the assemble process

Converter + Brake + Inverter

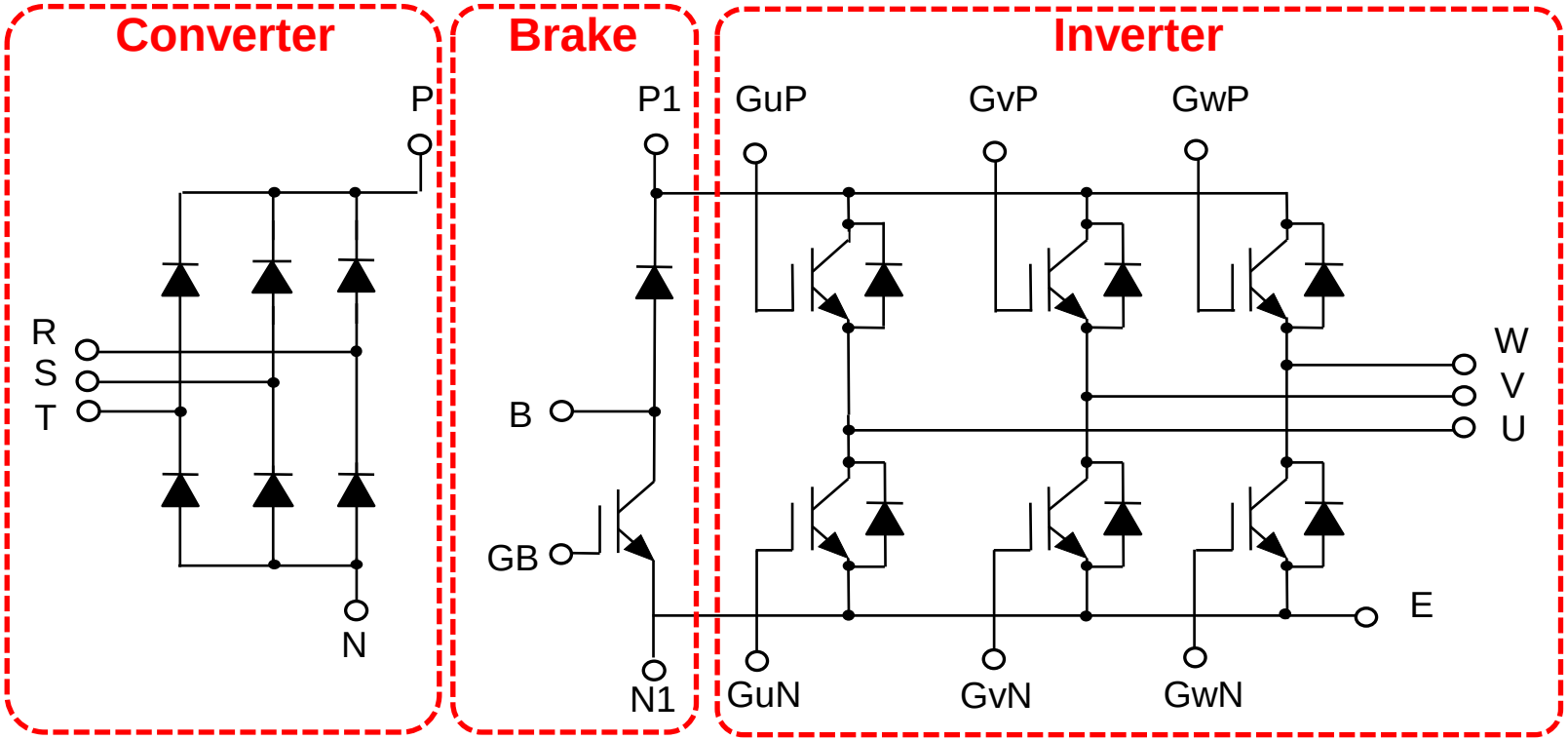
Approx. 36% size reduction

CIB Module
(75A/1200V CIB-S package)

IGBT Module S/S1series
(75A/1200V CIB-M package)

Smaller, simpler design for inverter systems

Converter + Brake + Inverter



Smaller, simpler design for inverter systems

IGBT Module T Series with 7th Gen. IGBT【std type】

NEW

Some products are under development

Point

- Significant improvement of Power loss
- High reliability/Compact and Light weight
- Simplified assembly process

VCES (V)	conecction	Current Rating (A)							
		75A	100A	150A	200A	300A	400A	450A	600A
650V	2 in1		●	●	●	●	●		●
1200V			●	●	●	●		●	●
1700V		●	●	●	●	●	●		

High reliability/Compact and Light weight

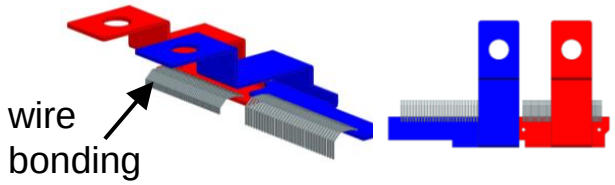
- New package technologies realize Low internal inductance, High reliability, Compact, and Light weight

■Outlook

■Pre-applied PC-TIM*

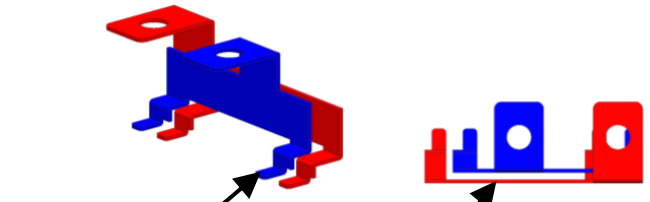
■Package inductance

Main terminals of 6th Gen.



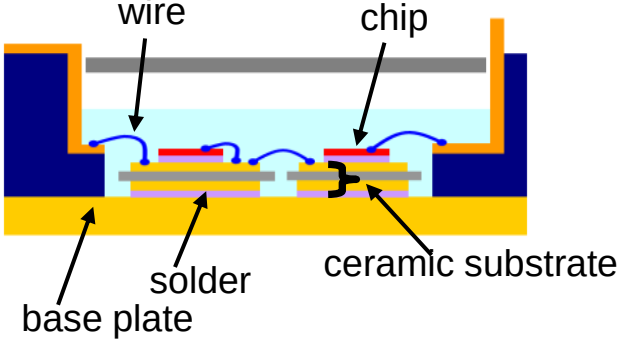
Approx. 30% reduction

Main terminals of 7th Gen.

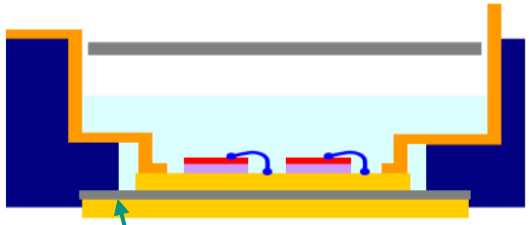


■ Package structure comparison

6th Gen.



7th Gen.



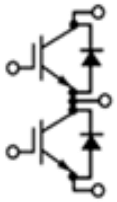
Solderless structure
at the bottom side of substrate
(TMS ** technology)

*PC-TIM: **P**hase **C**hange - **T**hermal **I**nterface **M**aterial

**TMS: Thick Metal Substrate

7th gen LV100 type line-up

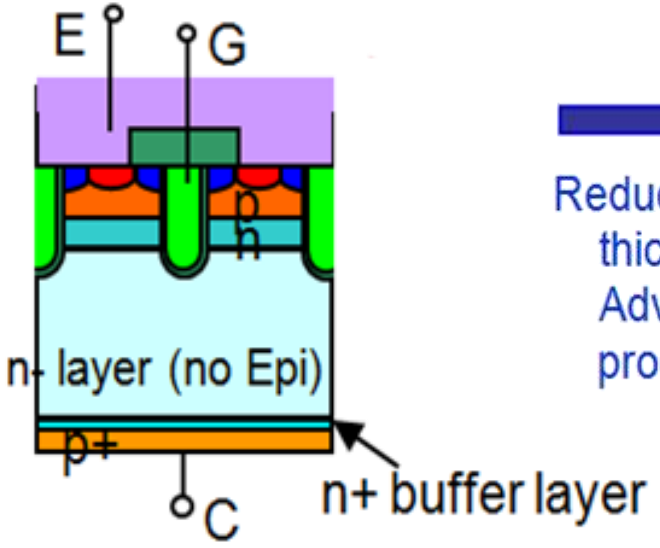
LV100-type

Circuit	Topology	Package outline	Package size	Rated Curent Ic [A] 1200V	Rated Curent Ic [A] 1700V
2in1	D 		100mm x 140mm	t.b.d.	800A
					1200A

IGBT chip feature

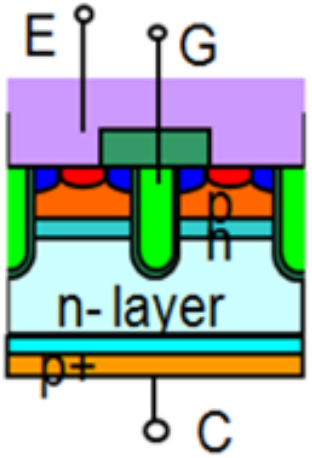
■Cross sectional structure

Conventional



Reduced wafer thickness, Advanced processes

7th generation



Keys

1. Thinner N^- drift layer

Low V_{CEsat}

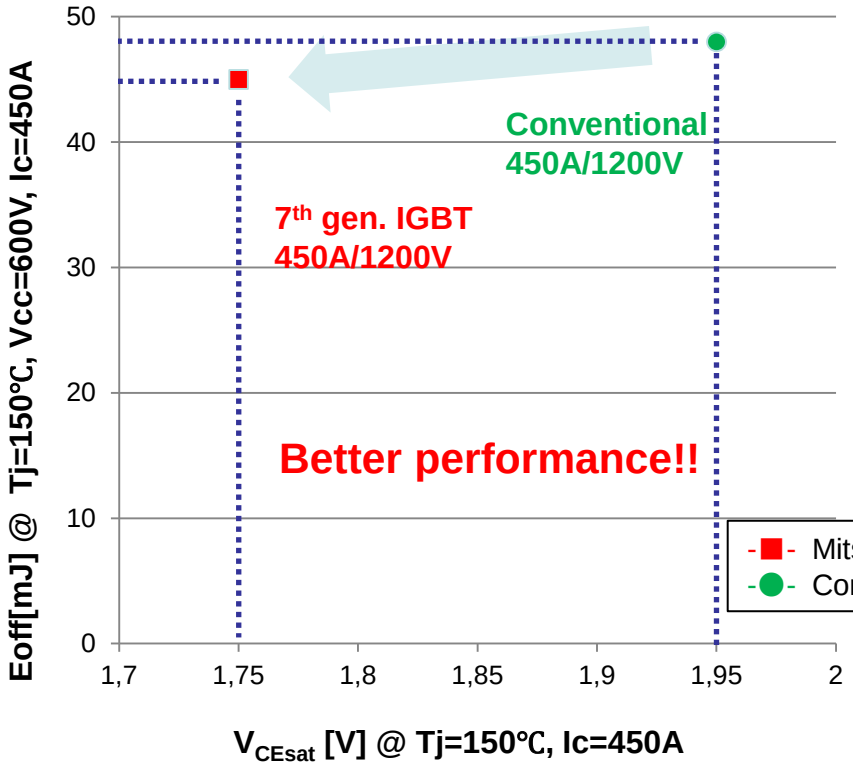
Low E_{off}

2. Optimized cell design

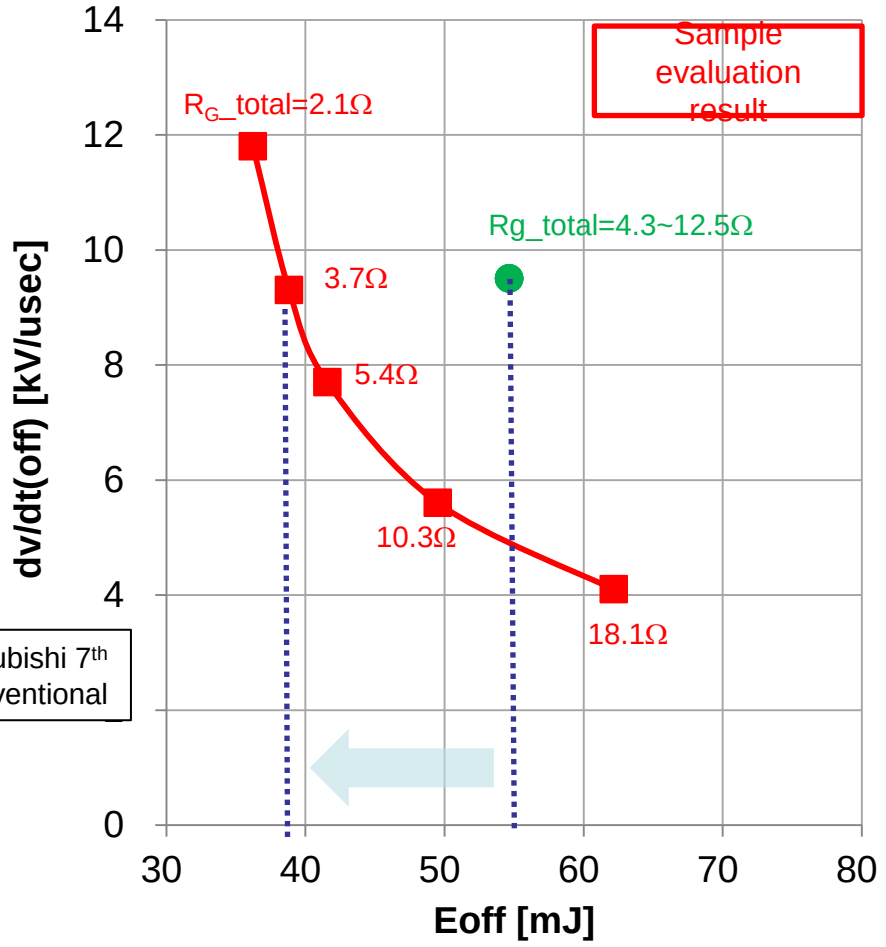
Better controllability of dv/dt with R_G

1200V IGBT chip characteristics

■V_{CEsat} vs E_{off} trade-off



■E_{off} vs dv/dt (off) trade-off

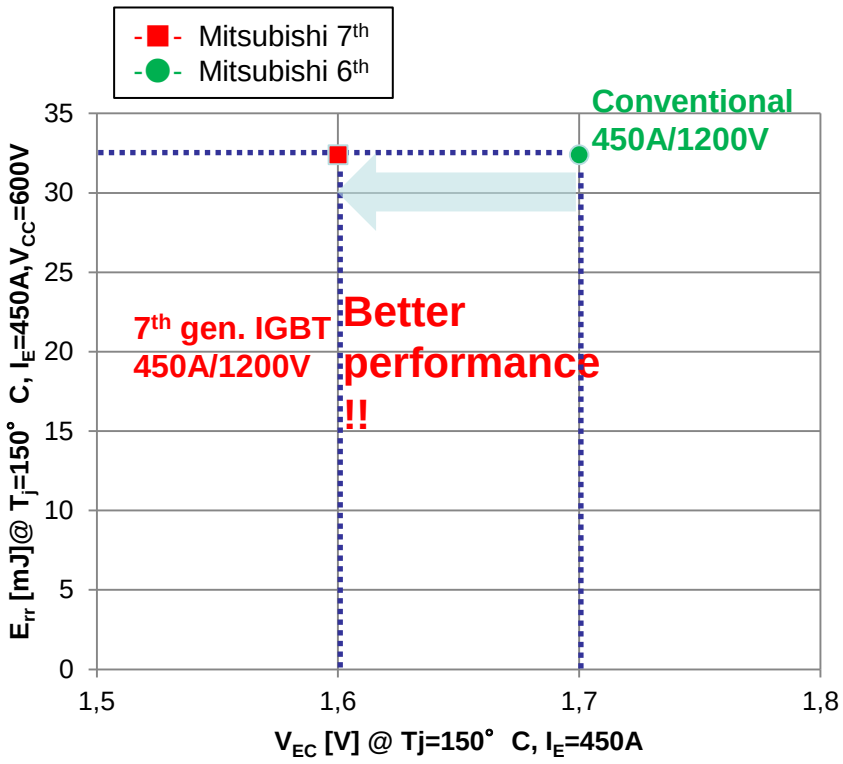


7th gen. IGBT has better static and dynamic characteristics.
It also has better controllability of dv/dt with R_G.

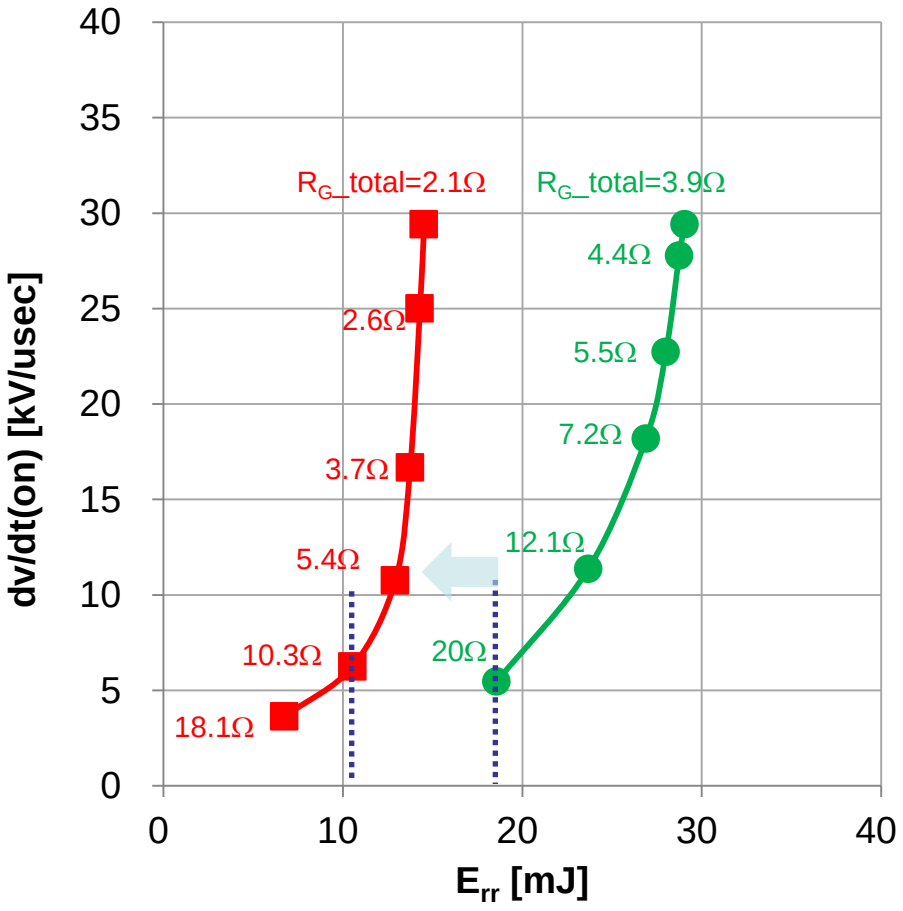
1200V Diode chip characteristics

Sample evaluation result

V_{EC} vs E_{rr} trade-off



E_{rr} vs dv/dt (rec) trade-off

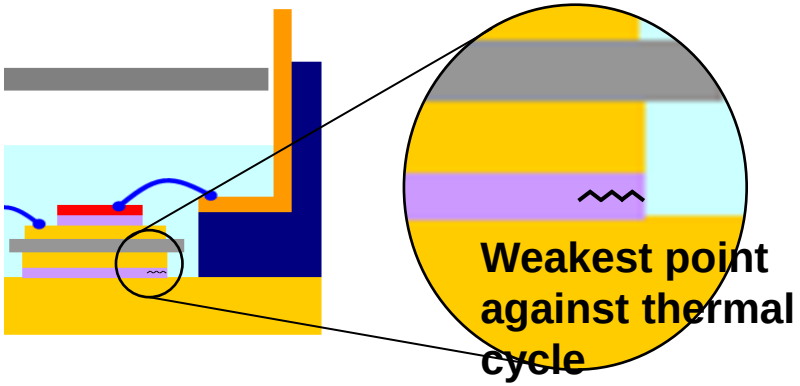


RFC diode improves the E_{rr} vs. V_{EC} trade-off from 6th gen. Diode.
Err against dv/dt is further reduced than the other diodes.

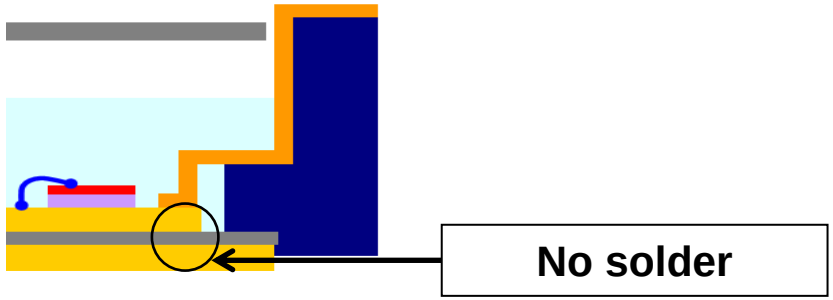
Thermal cycling capability

std type

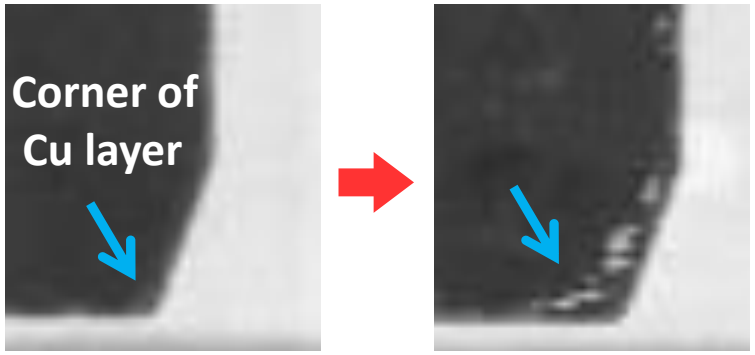
Conventional



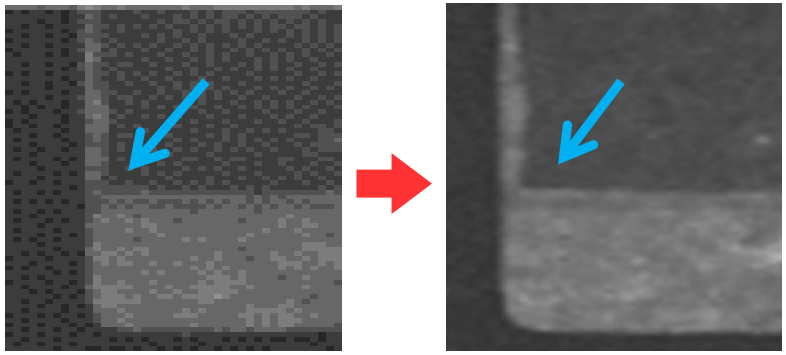
TMS



■ Temperature cycling test **(-40℃ ~ 125℃)**



Before test　　After 300cyc.



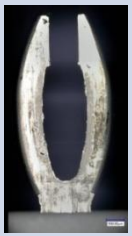
Before test　　After 1000cyc

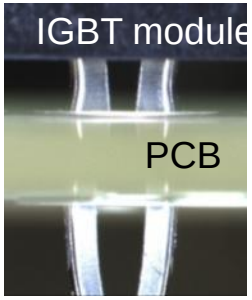
➢ **No crack until 1000cyc. → more than 3 times higher capability**

PressFIT

NX type

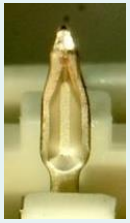
Main terminals

	Market standard	MITSUBISHI (6in1)
Shape		
Press-in force	75-81N/pin	76N/pin
Press-out force	59-64N/pin	50N/pin

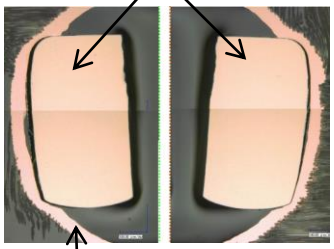


Press fit main terminal

Auxiliary terminals

	Market standard	MITSUBISHI (2in1)
Shape	 	
Press-in force	110N/pin (typ.)	100N/pin (typ.)
Press-out force	n/d	40N/pin

Press fit terminals



Plated through-hole

- **The same requirement as market standard** (PCB material, thickness and hole diameter)
- **Improved reliability** and **reduced contact resistance**

MITSUBISHI ELECTRIC

Changes for the Better

GLYN

14 juni 2018
1931 Congrescentrum Den Bosch

POWER ELECTRONICS 2018