HITACHI
Inspire the Next

IGBT

Hitachi Power Semiconductor Device Ltd

Japanese Quality - Worldwide Support

HITACHI
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Japanese design and manufacturing

Local support, delivered worldwide

Distributed manufacturing locations
for security of supply

Hitachi is committed to supplying the highest quality products delivering dependable performance in demanding applications. We have a long history of producing reliable and high performance power modules, developed and manufactured to the highest quality standards in Japan and backed up by a worldwide network providing sales and technical support locally to you. Distributed manufacturing locations and a robust business continuity plan ensure we can meet customer demands whatever happens.

Applications of HV-IGBT Module

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- Automotive
- HVDC
- Induction Heating
- Off Road Vehicles
- Renewables
- Traction

Hitachi Power Semiconductor Devices experience of high reliability, high power applications, stretches back more than twenty years.

Experienced in-house design and manufacturing delivers dependable product solutions with a global network providing customer centric market support.

HV-IGBT versions and features

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D version
800A-2400A

High Speed type
Low switching loss - for Traction, resonant convertor

E version
800A-2400A

Standard type
Low conduction loss - for Traction, HVDC

E2 version
500A-1500A

Standard type
Low conduction loss standard - Tvj, op, Max = 150°C
for Traction, HVDC

E3 version
250A-1500A

Soft switching type
Low spike voltage - Tvj, op, 50~150°C
for Traction with large Ls, series connection of industrial drives

F & G versions
1200A-1800A

Standard type
Highest rated current - Low conduction loss and switching loss
for Traction, industrial drives, HVDC

G2 version
400A-1000A

Soft switching type
Robust short-circuit, low dv/dt with low Eon+Err
for all high voltage application uses

'F' Version key highlights

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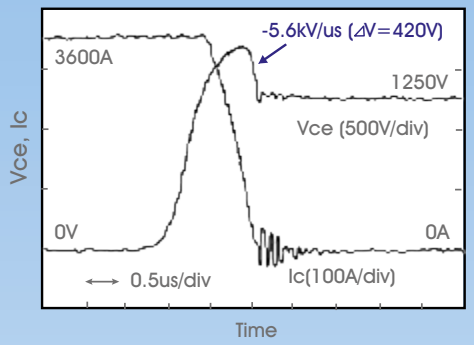
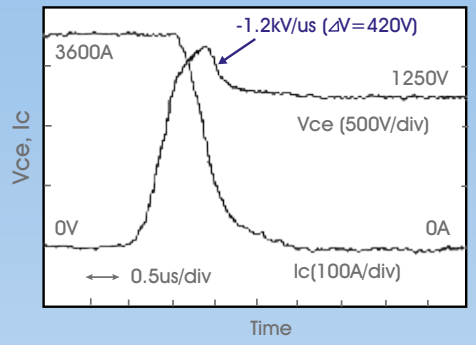
Easy Drive – low overshoot and lower turn off dv/dt

E Version 1700V



IGBT turn-off

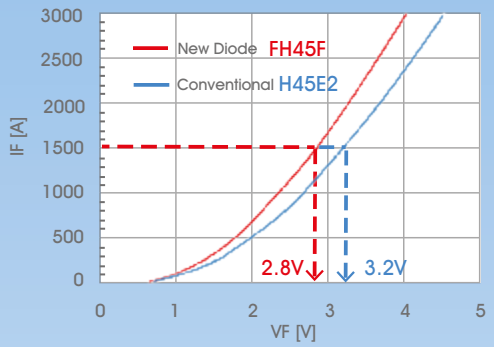
F Version 1700V



IGBT turn-off

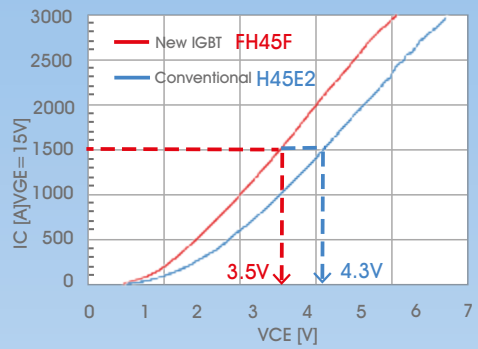
Lower conduction loss

F Version 4500V



VF

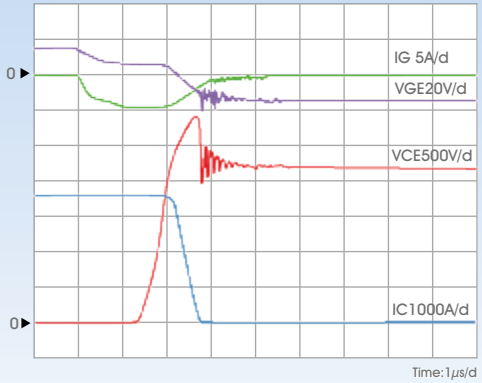
F Version 4500V



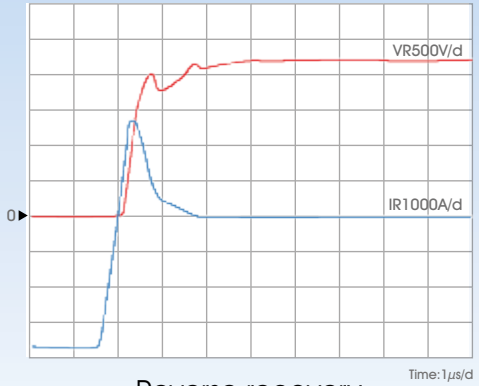
VCE vs. IC

Low temperature durability, -55°C Tvj validation

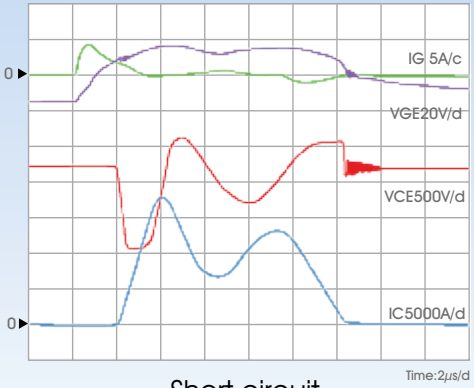
F Version 3300V



IGBT turn-off



Reverse recovery



Short circuit

Advanced Trench "F Version" offers industry leading current density combined with low conduction loss and low temperature capability.

Easy drive makes dV/dt control easy and gives smooth switching with lower voltage overshoot for simple integration into the converter with maximum output power and high reliability.

'G2' Version key highlights

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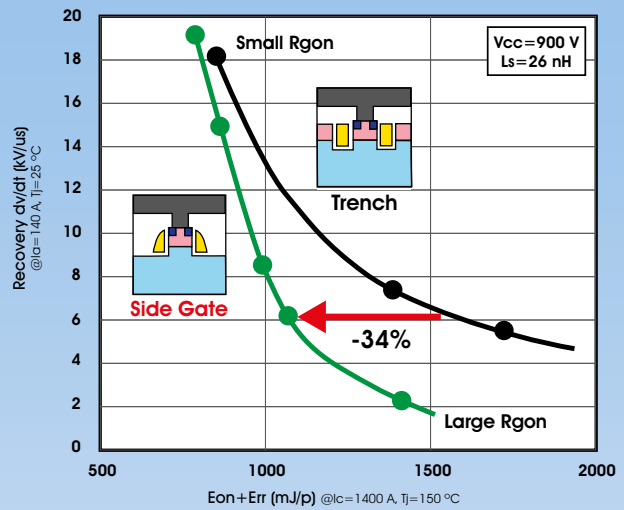
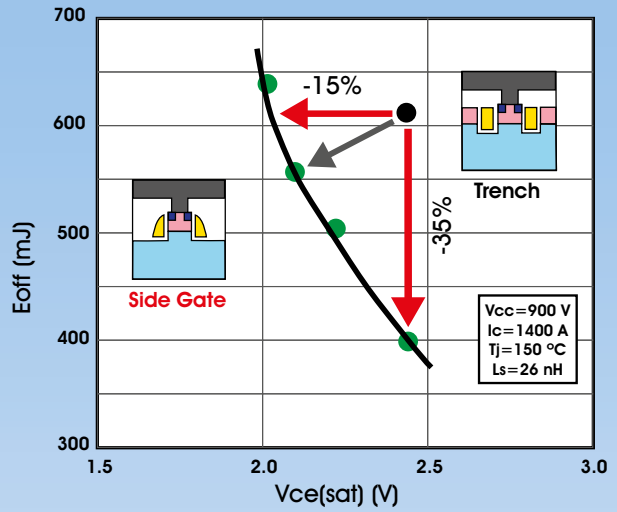
Enhanced Easy Drive – lower recovery dv/dt and Eon+Err



Lower conduction loss



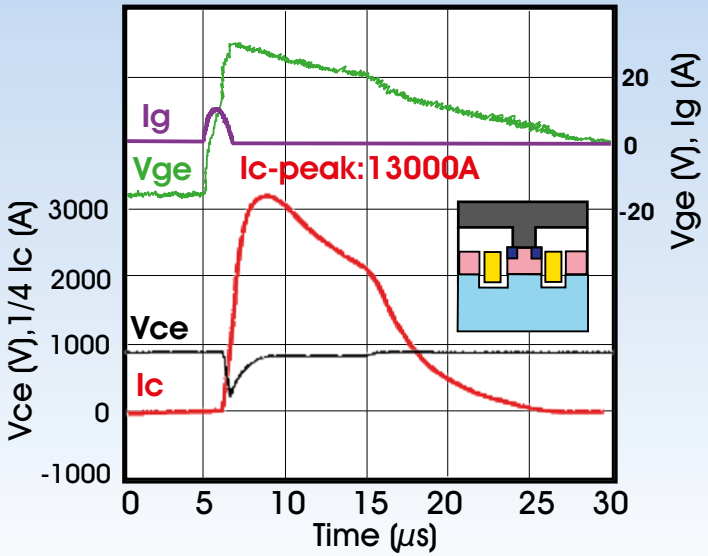
G2 Version 1700V

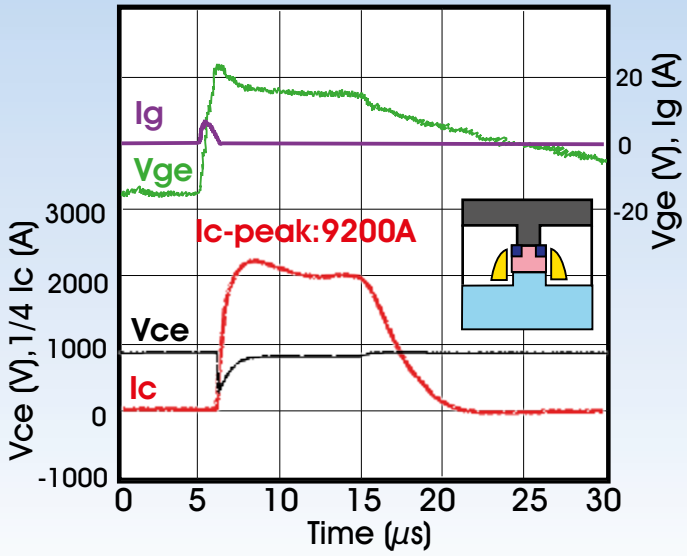
"G2 Version" side gate IGBT improves the conduction loss – Turn-off loss trade-off with lower Vce(sat) and lower Eoff.

Enhanced easy drive offers reduced reverse recovery dV/dt while also decreasing the Turn-on and Reverse recovery loss combination (Eon+Err). Combined with low gate charge and low Reverse Transfer Capacitance (Cres) this simplifies the integration of the module in the converter and reduces the load on the gate driver.

Short Circuit performance is improved with lower peak short circuit currents and lower gate current reducing the stress on the IGBT, Gate Drive and converter during short circuit.

Enhanced Easy Drive – improved durability, low $Ic_{(SC)}$ peak





Feature of “G2” Version IGBT

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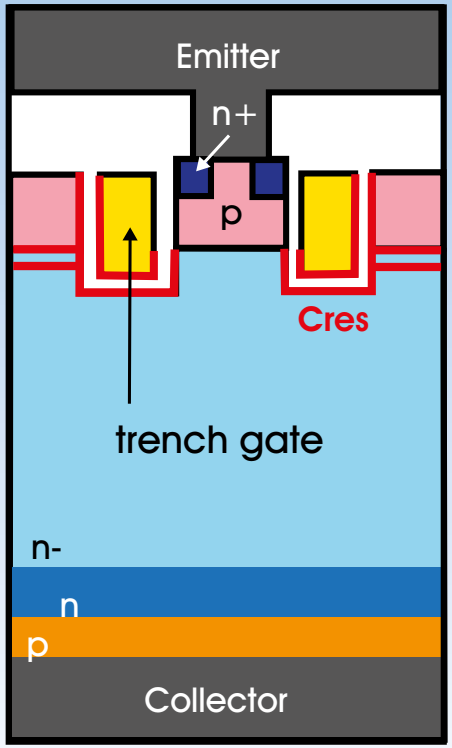
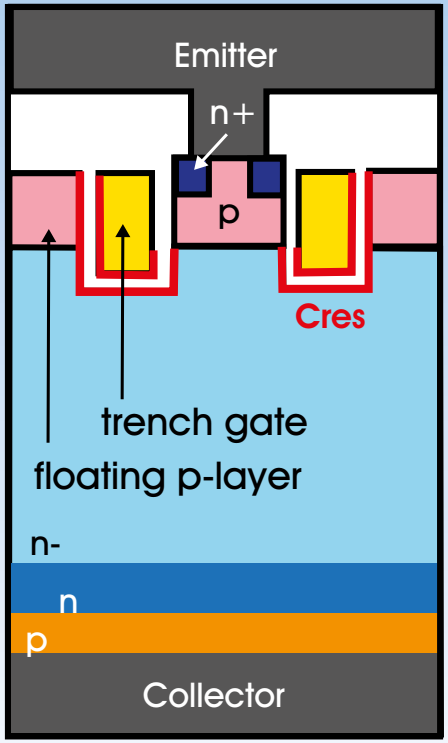
Reducing reverse recovery dV/dt
Suppressing recovery spoke voltage, turn on loss and Qg

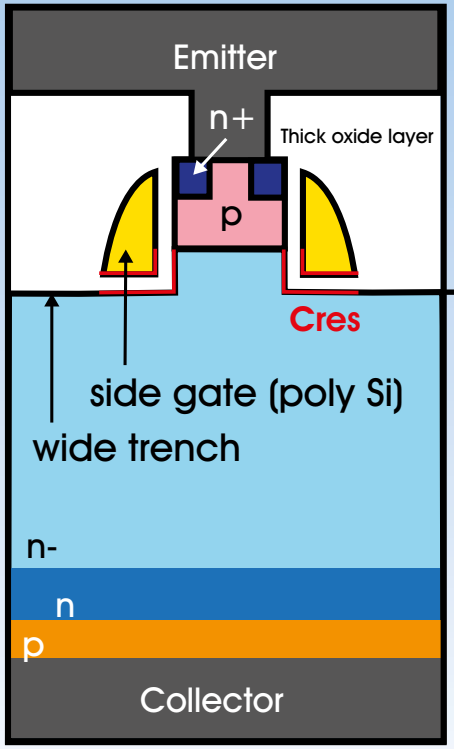
E version
Trench HiGT +LiPT

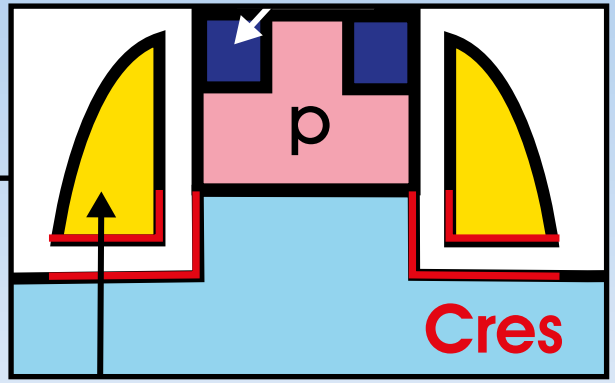


F version
Advanced Trench
HiGT + LiPT



G2 version
Side gate HiGT + LiPT





Cres decrease =
Improved controllability

Package Outline

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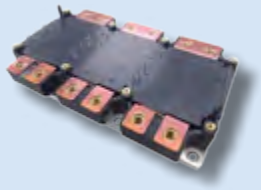
Package type	Viso	~2.5kVrms	~6kVrms	~10.2kVrms
	Height	24.8mm	38mm	48mm
Direct Cooling	98.5 x 163mm			
IHM	73mm x 140mm			
	130mm x 140mm			
	190mm x 140mm			
nHPD²	100mm x 140mm			

Product Line Up by Version

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Voltage Class	Silicon Process (version)	Current Ratings
650V	E	600-800A
700V	E	1000A
1200V	G2	400A
1700V	D E F G G2	800-3600A
2500V	D E	400A-1200A
3300V	MF E2 F	250A-1800A
4500V	E2 E2-H F	200A-1500A
6500V	E2 G2	125A-1000A

HV-IGBT Roadmap

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Version	Technology	kV	2015	2016	2017	2018	2019	2020	2021
G, G2	Super Fine Easy Drive Trench IGBT	1.7	DEVELOPMENT						
		3.3						MP	
		4.5				DEVELOPMENT			
		6.5		DEVELOPMENT				MP	
New package	next High Power Density Dual: nHPD² low inductance	1.7/3.3	DEVELOPMENT					MP	
	Copper Sintering		R&D		DEVELOPMENT nHPD² – 2				MP

SiC Device Development Road Map

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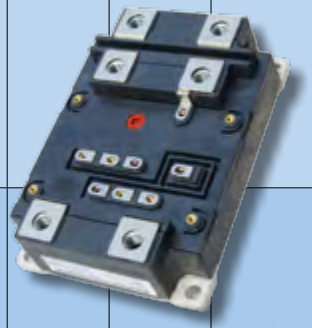
Package	VCE	'15	'16				'17				'18	'19	'20
		4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q			
IHM Std PKG.	3.3kV Si/SiC hybrid 1200A 1800A	ES	Orders Accepted				CS		MP				
nHPD² (LV)	1.7kV Si/SiC hybrid			TS 900A G ver								WS	ES
	3.3kV Si/SiC hybrid				TS 450A							WS	ES
	1.7kV Full SiC								TS 900A		WS 900A	ES 900A	MP
	3.3kV Full SiC					TS 450A SAMPLE			TS 600A		TS 800A WS 600A	WS 800A ES 600A	ES 800A MP

1700V

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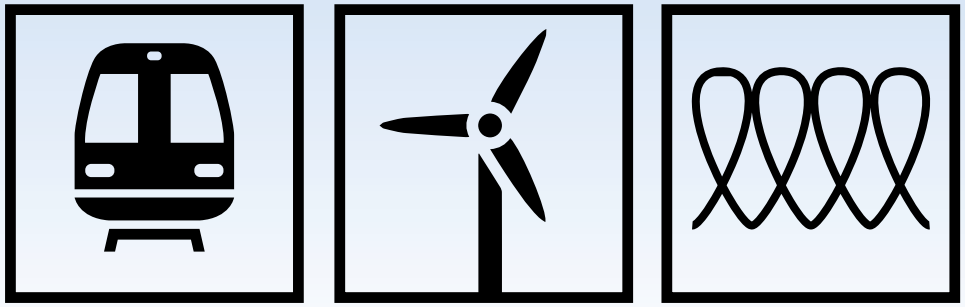
- Higher Current Density
- Wide temperature range
- Low Vce(sat)
- Low noise

Advanced High Conductivity IGBT (HiGT

- Up to 3600A soft switching, low overshoot, low -dv/dt
- Low 2.4V conduction loss
- Low noise (EMI)
- Low temperature operation -50°C to +175°C (Tvj)



Example Applications

PACKAGES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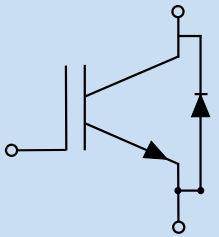
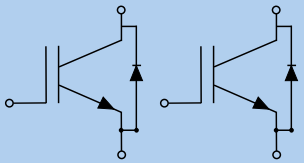
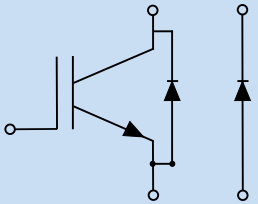
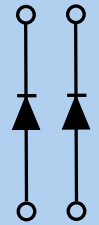
	1200A 1600A 1800A 2400A 3600A
	1200A
	1200A
	1200A

3300V

HITACHI
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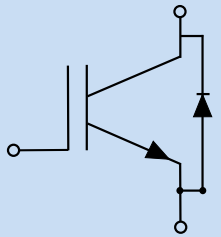
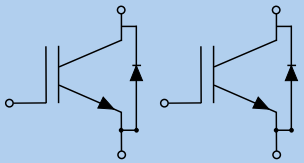
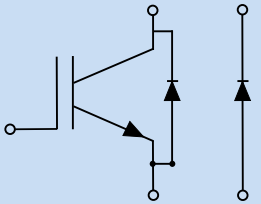
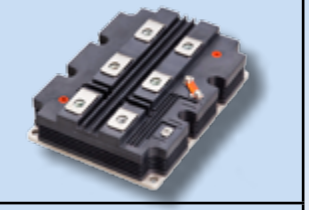
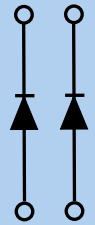
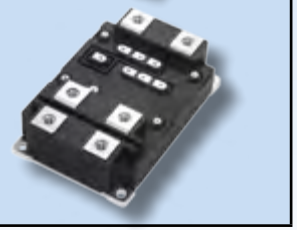
- Ultra Low Conduction Loss
- Very High Current Density
- Low Switching Losses
- Superior Terminal-Terminal Current Sharing
- RoHS Compliant

HITACHI Advanced Trench Gate

High Conductivity IGBT (HiGT) - broaden your expectations.

- Up to 1800A switching
- Improved power cycling and thermal life-time durability
- 20% lower module stray inductance
- 20% reduction of thermal impeadance

Example Applications

PACKAGES	TOPOLOGY	
		800A 1000A 1200A 1500A 1800A
		250A 500A
		400A 800A 1000A
		800A 1000A 1200A
		

2500V

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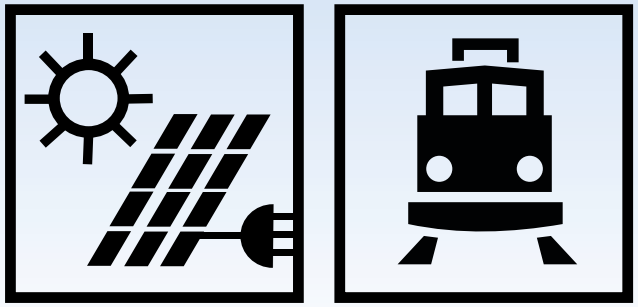
- Higher Current
- Planer Gate
- Low Vce(sat)
- Improved Rth(j-c)

Fine Cell High Conductivity IGBT (HiGT)
Soft LiPT (Low Injection Punch Through

- Suitable for Megawatt Solar Converters, Traction



Example Applications

PACKAGES

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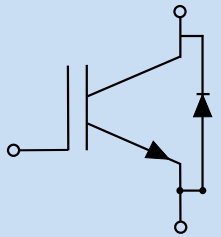
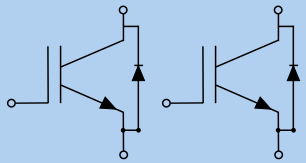
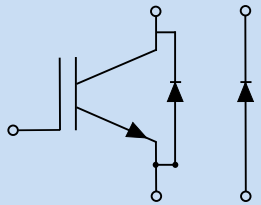
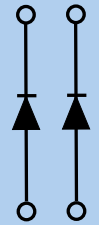
	1200A
	400A
	NA
	NA

4500V F-Version

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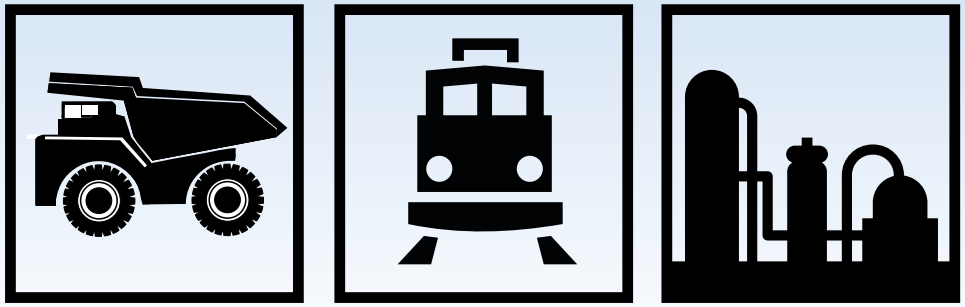
- High TFT metal bonding
- High 150°C Tvj(op)
- Low voltage overshoot
- Higher power density

- Advanced Trench High Conductivity IGBT
- Current rating increased by 25% (vs. E2 version)
- Improved Vf-Err trade off by 17%
- Stray inductance reduction 25%



Example Applications

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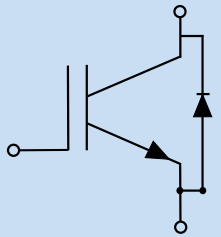
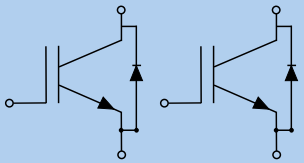
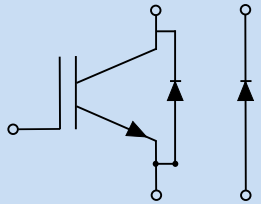
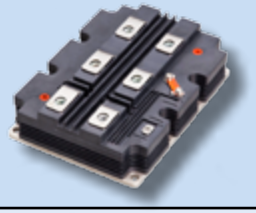
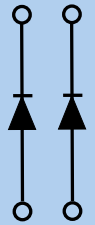
		600A 800A 900A 1200A 1500A
		200A
		NA
		600A 800A 1200A

6500V

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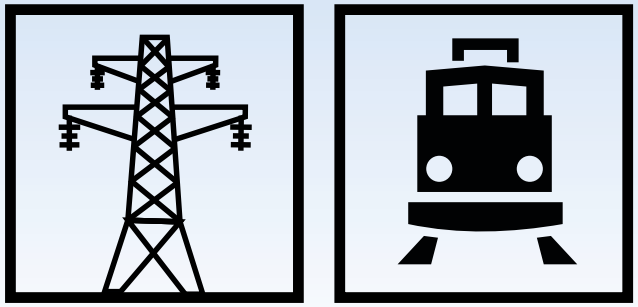
- Higher 750A Current
- High isolation options (10.2kV & 11.6kV)
- Higher frequency operation
- Low driving power

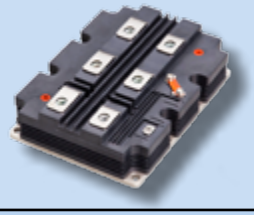
Advanced Soft LiPT & High Conductivity IGBT

- Up to 750A rating
- E2 low loss switching
- Suitable for NPC topologies
- Dual diodes 500A & 750A available
- Locomotive Propulsion, Medium Voltage Converters
- Soft switching - low voltage overshoot & low noise (EMI)



Example Applications

PACKAGES



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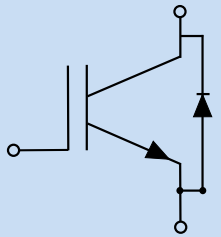
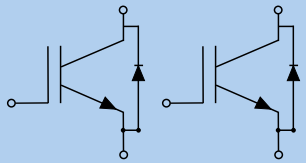
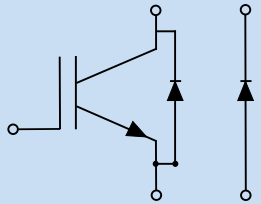
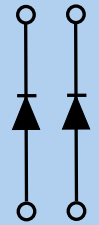
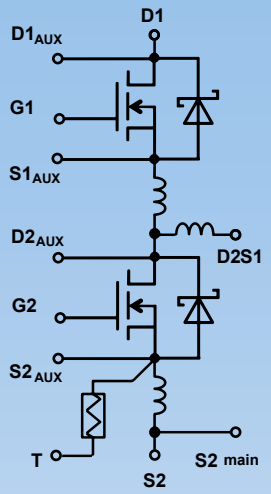
	500A 750A 1000A
	NA
	NA
	500A 750A

nHPD² module

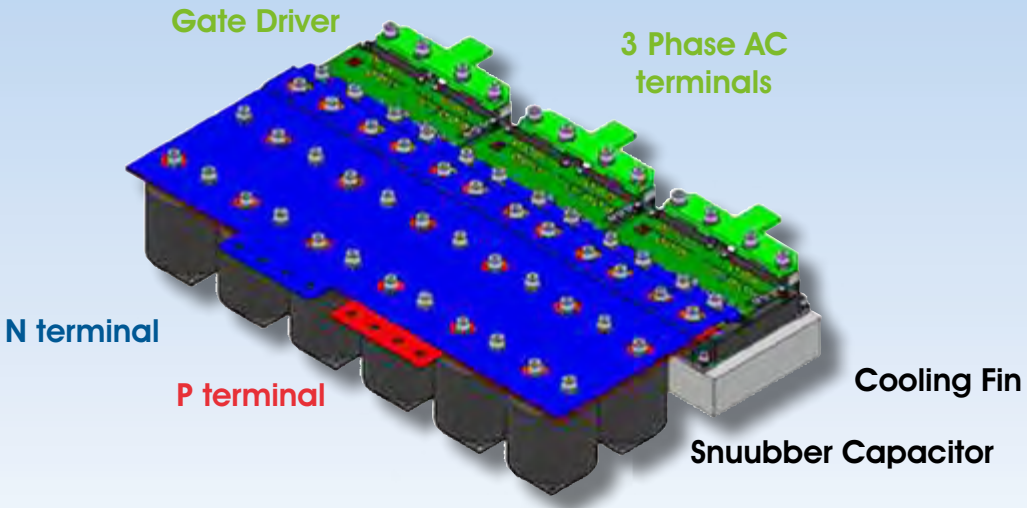
HITACHI
Inspire the Next

Feature of nHPD²

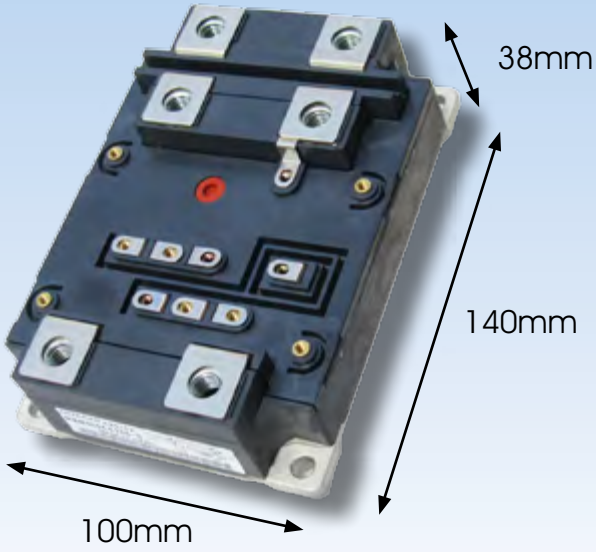
- Low inductance 9nH package … wide band gap technology compatible
- Easy Paralleling … scalable output power
- Current Sensor /Temp Sensor … Supporting robust system level protection



ISOLATION	VOLTAGE	CURRENT	TYPE	TYPE NAME
4.0kVrms (LV)	1700V	1000A	Dual IGBT	MBM1000FS17G
6.0kVrms (LV)	3300V	450A	Dual IGBT	MBM450FS33F



2 level inverter configuration

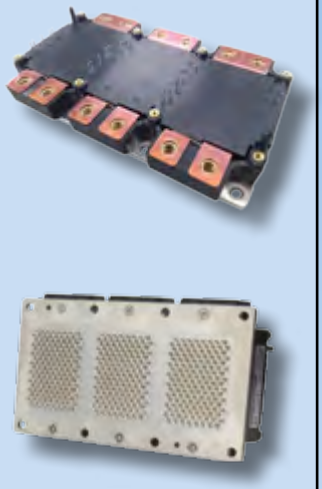


650-1200V SUIJIN Series

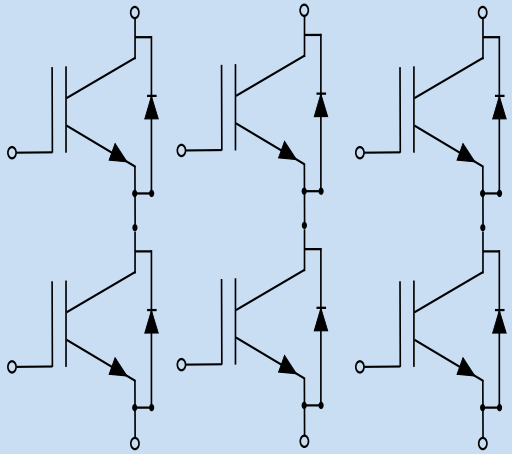
HITACHI
Inspire the Next

- Common Footprint
- Low Thermal Impedance
- Excellent Mission Profile Lifetime
- Compact Inverter Designs

PACKAGE



TOPOLOGY



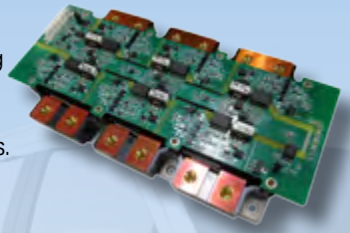
Helping to improve the initial testing and validation phases, compatible supplementary components have been prepared by external partners.

Broadcomm offer a range of suitable gate drivers featuring optical isolation, UVLO, miller clamping and PN voltage sensing.

Similarly, capacitors from Nissei Electric are available for applications up to 750V.

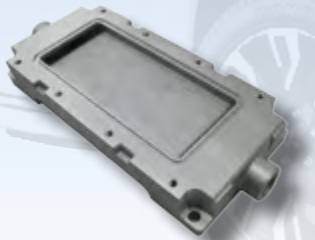
Water jackets to allow out of the box operation are also available in sample quantities directly from Hitachi.

More details available from your Hitachi representative.



Gate driver (GD) board
MBB800TW6A

DC link capacitor
available for MBB600TV6A
& MBB800TW6A



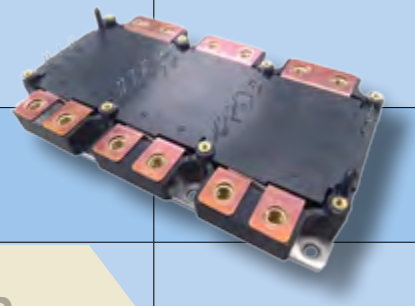
Mindful of recurring engineering costs, Hitachi delivers a range of high performance direct water cooled IGBT power modules, from 650V to 1200V, with a common footprint, reducing the need for system level mechanical changes and client reworking. Package features offer, thermistor and on-chip temperature sensing, providing capable protection, as well as a range of soft switching chip technologies to ensure robust reliable switching even at minus temperatures.

Roadmap of IGBT for EV

HITACHI
Inspire the Next

Module (6 in1)

Voltage/ Current	IGBT chip type	2017	2018	2019	2020	2021
650V 600A	Trench HiGT	MP				
700V 800A	Trench HiGT	WS DEVELOPMENT	ES MP			
700V 1000A	Side Gate HiGT Temp sensor on IGBT chip	DEVELOPMENT		WS ES	MP	
1200V 400A	Side Gate HiGT Temp sensor on IGBT chip	WS DEVELOPMENT	ES MP			
750V 800A	Side Gate HiGT Temp sensor on IGBT chip		DEVELOPMENT	WS	ES MP	



Chip

1200V 200A	Side Gate HiGT Temp sensor on IGBT chip	WS DEVELOPMENT	ES MP			
750V 400A	Side Gate HiGT Temp sensor on IGBT chip	DEVELOPMENT		WS ES	MP	

Copper Sintering

HITACHI
Inspire the Next

Selection of Die Attachment

Cu is suitable because of low material cost, low CTE and high Yield stress.
Thermal strain can be reduced (= more reliable).

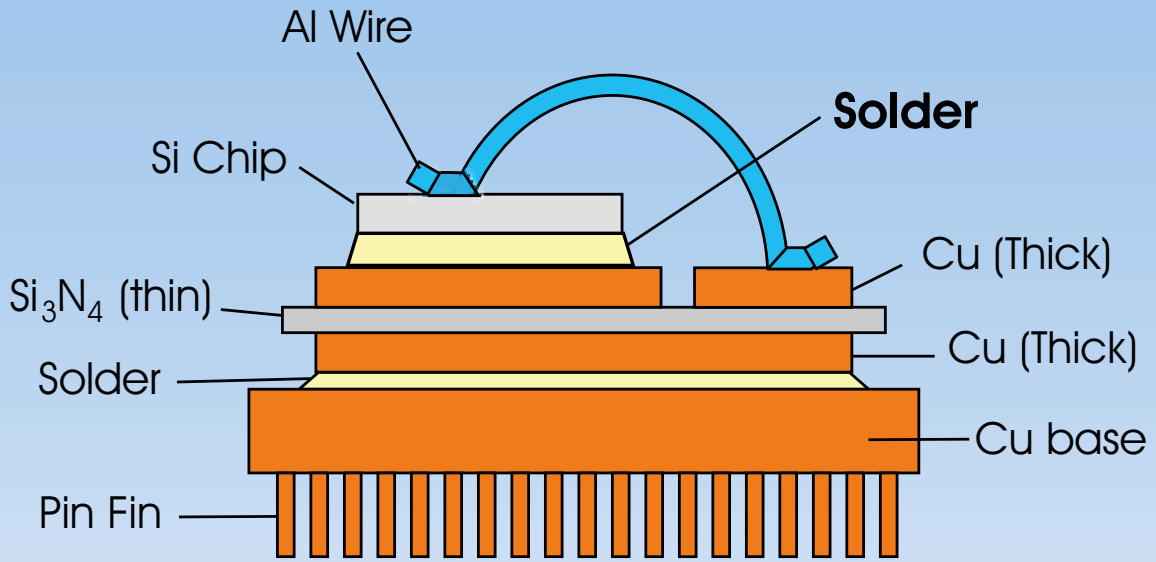
Comparison among die attachment materials

Die Bond Material	Coefficient of thermal expansion (ppm/k)	Yield stress (MPa)	Thermal condutivity (W/mk)	Melting point (°C)	Interconectable die electrode	Cost
Cu	16.6	310	398	1083	Cu,Ni	Low
Ag	19.7	262	427	960	Ag,Au	High
Pb-rich solder	17	5.9	24	280	Ni,Cu Au,Ag	Low

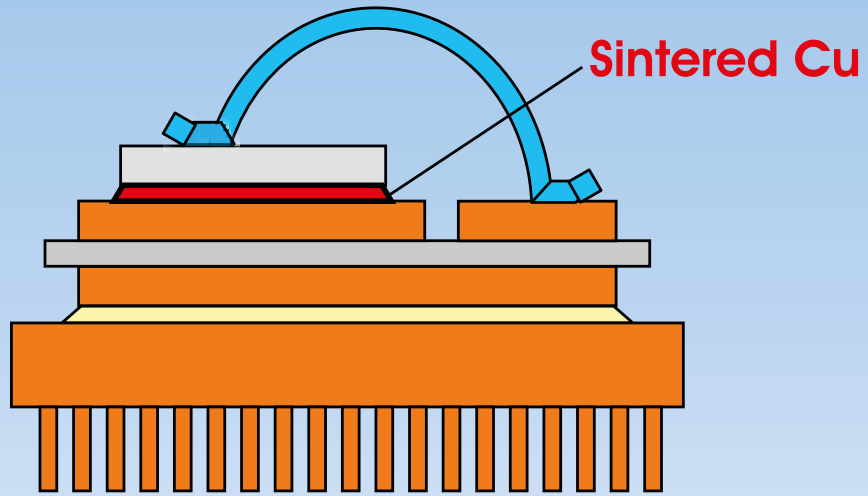
Copper Sintering

HITACHI
Inspire the Next

Improved die attachment structure



Hitachi Conventional Structure



Improved Structure

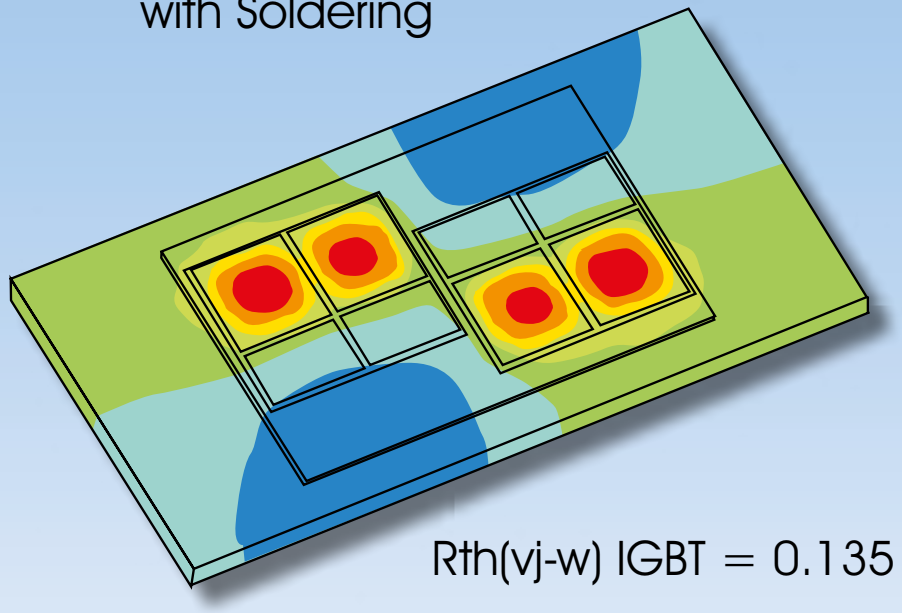
Sintered Cu is applied to improve operating junction temperature and power cycling capability.

Copper Sintering

HITACHI
Inspire the Next

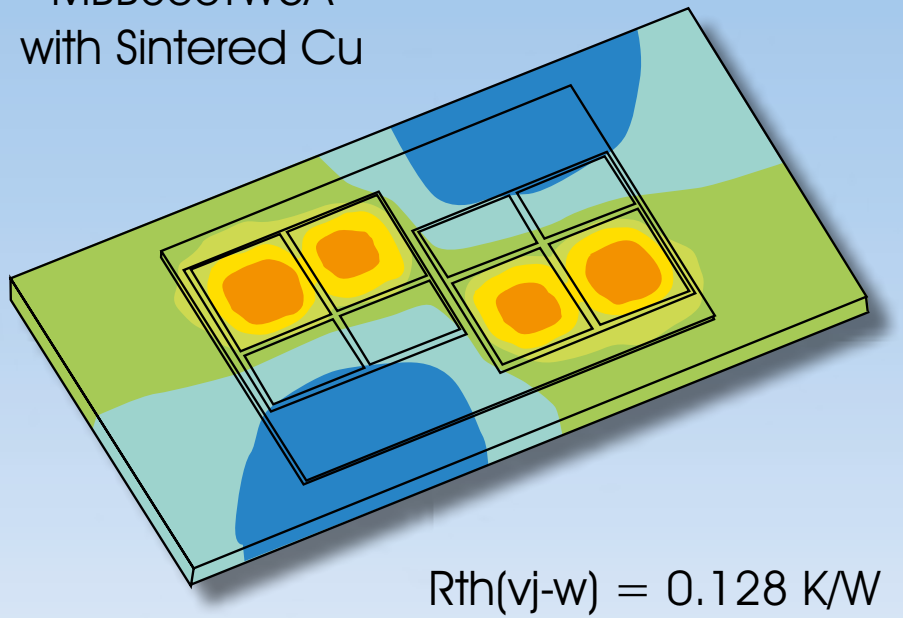
Thermal resistance improvement

MBB800TW6A
with Soldering



Rth(vj-w) IGBT = 0.135 K/W

MBB800TW6A
with Sintered Cu



Rth(vj-w) = 0.128 K/W

Improvement of cooling performance
applying sintered Cu is approx. 5%

Copper Sintering

HITACHI
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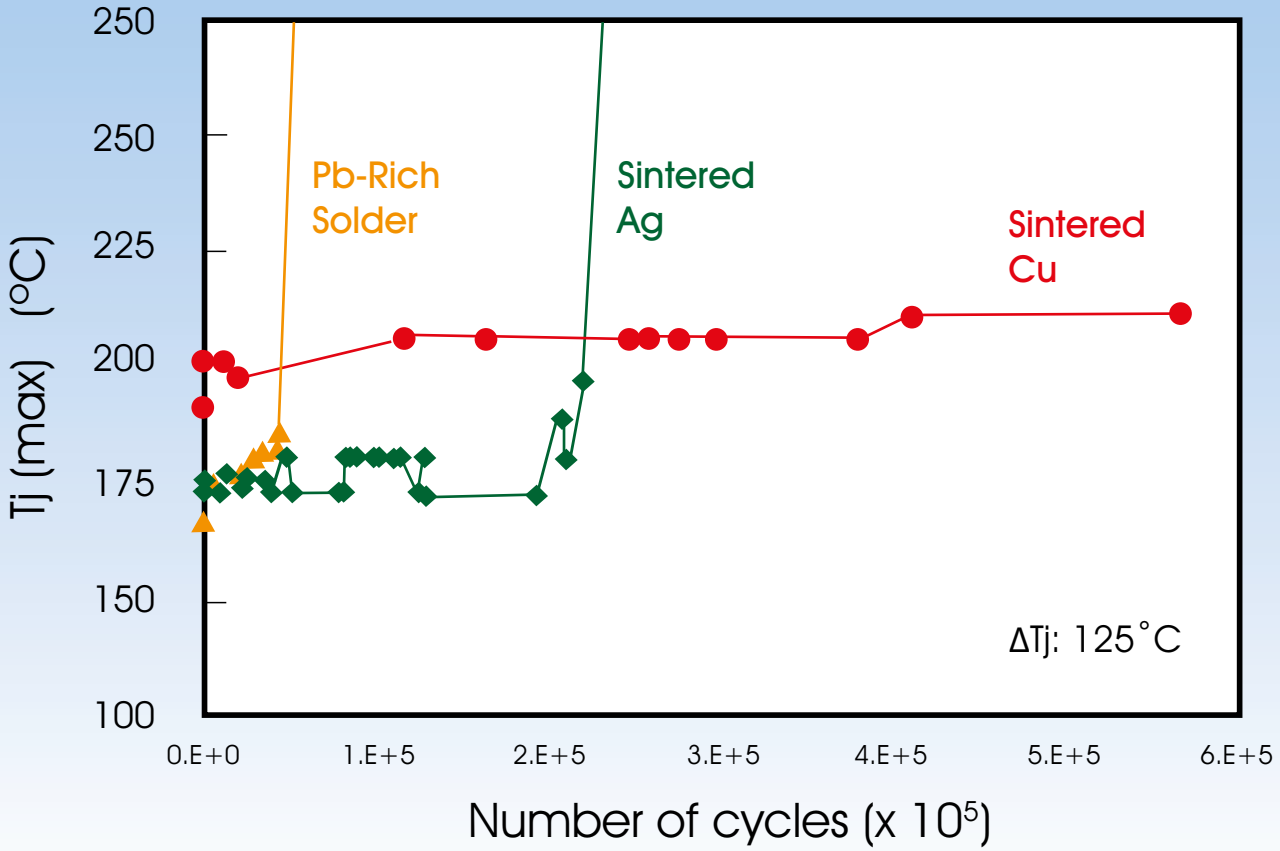
Power cycle durability

Power cycling durability of Sintered Cu is more than twice that of Sintered Ag.

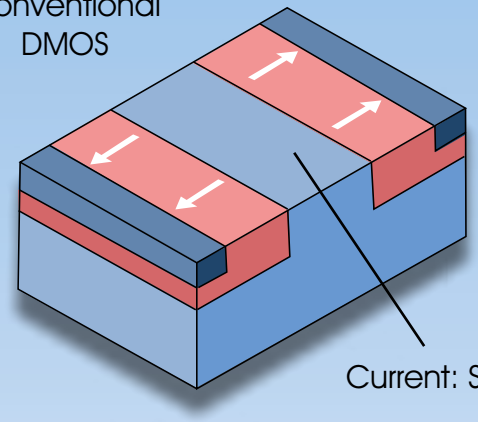


SiC TEDMOS

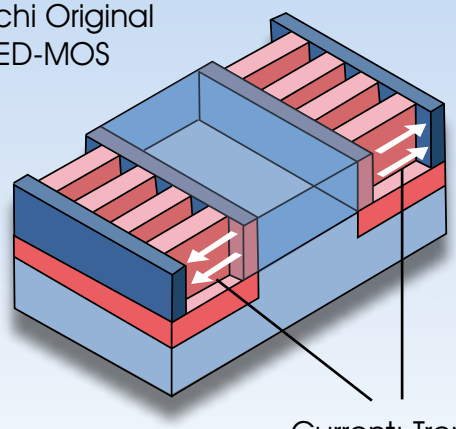
HITACHI
Inspire the Next

Hitachi Original Trench-MOSFET (TED-MOS) achieves
(i) Lower R_{on} (ii) Lower C_{gd} (iii) Short-circuit Protection (iv) Lower Switching Loss

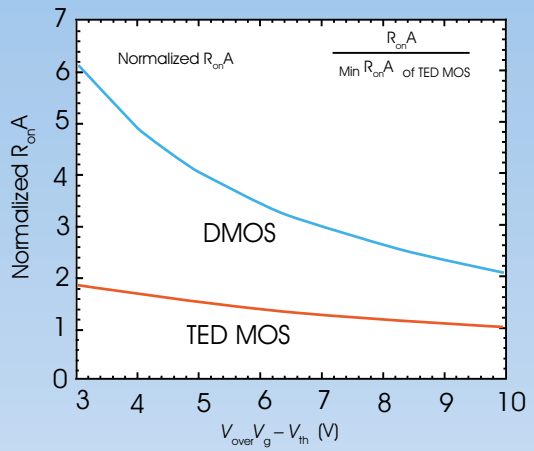
Conventional DMOS



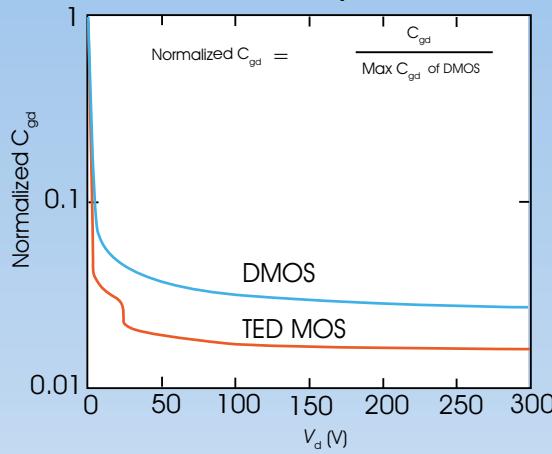
Hitachi Original TED-MOS



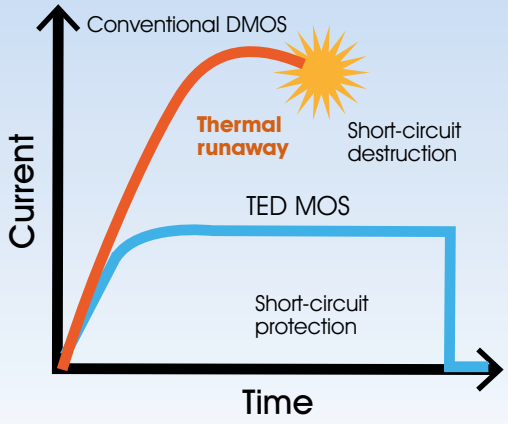
Lower On-Resistance



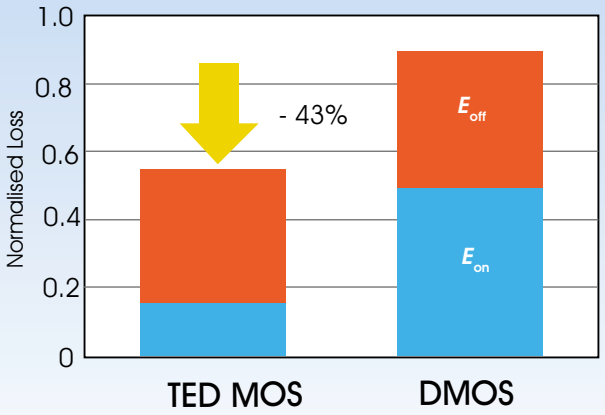
Lower G-D Capacitance



Short-circuit Protection



Lower Switching Loss



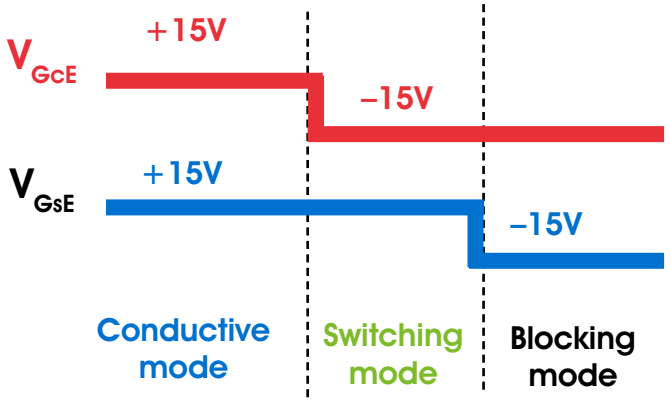
Dual Side Gate – Next Generation Silicon IGBT

HITACHI
Inspire the Next

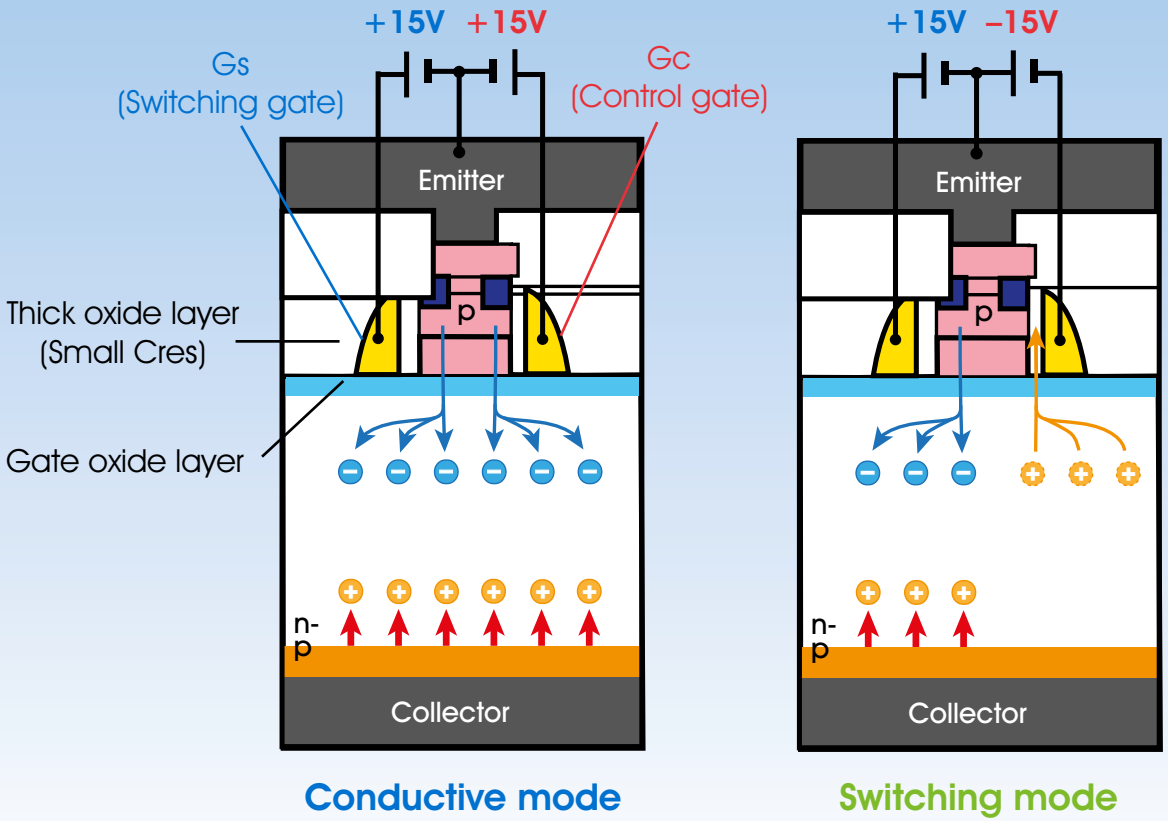
Advanced Side Gate HiGT

Dual side-gate HiGT based on dynamic carrier control method with a small Cres side-gate structure enabling easy gate drive was proposed.

Gate drive signals



Device Structures

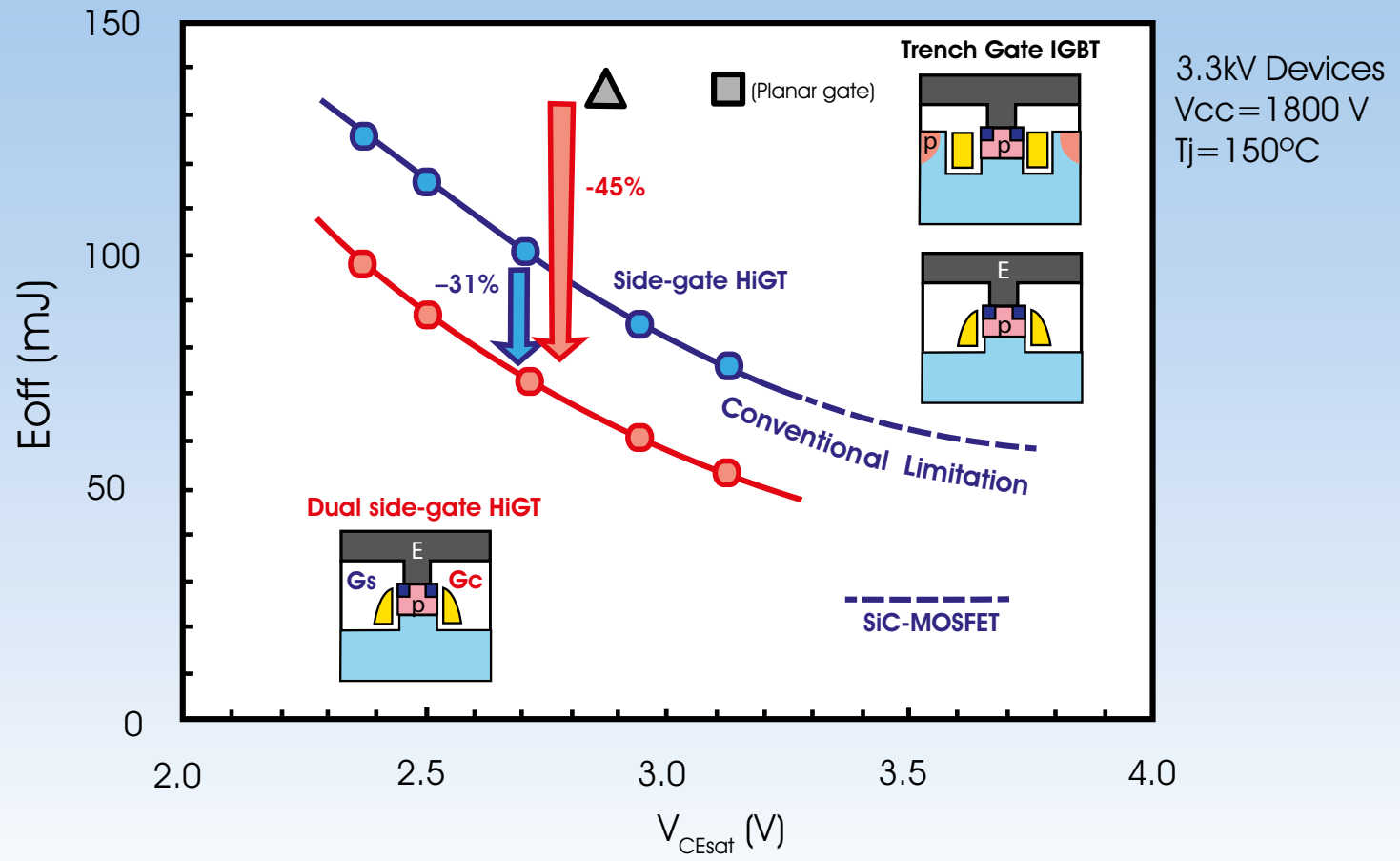


Dual Side Gate – Next Generation Silicon IGBT

HITACHI
Inspire the Next

Advanced Side Gate HiGT

Dual Side-gate HiGT broke through the limitation of conventional IGBTs, and achieved Eoff of -31% compared to the leading-edge side-gate HiGT.



nHPD² module Portfolio

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MSM900FS17AL	MSM900FS17AL	1700V	900A	SiC MOS	WS 6/18	Full SiC
MBM1000FS17G	Dual	1700V	1000A	G	MP	
MBM1000FS17G2	Dual	1700V	1000A	G2	WS	Side Wall HIGT
MBM1200GS17G2	Dual	1700V	1200A	G2	WS	Side Gate HIGT Cu Sinter
MBM450FS33F	Dual	3300V	450A	F	MP	
MBM450FS33F-C	Dual	3300V	450A	F with SiC Diodes	WS 6/19	Hybrid

IHM Portfolio 1700V and 2500V

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MDM900E17D	2 in 1 Diode	1700V	900A	D	MP	IHM 130*140
MDM1200E17D	2 in 1 Diode	1700V	1200A	D	MP	IHM 130*140
MBM1200E17F	2 in 1	1700V	1200A	F	MP	IHM 130*140
MBL1200E17F	Chopper	1700V	1200A	F	MP	IHM 130*140
MBL1600E17F	Chopper	1700V	1600A	F	MP	IHM 140*190
MBN1600E17F	1 in 1	1700V	1600A	F	MP	IHM 130*140
MBN3600E17F	1 in 1	1700V	3600A	F	MP	IHM 140*190

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MBM400E25E	2 in 1	2500V	400A	E	MP	IHM 130*140
MBN1200E25C	1 in 1	2500V	1200A	C	MP	IHM 140*190

IHM Portfolio 3300V (1)

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MBM250H33E3	2 in 1	3300V	250A	E3	MP	73mm high iso
MBN400E33D-MFR	2 in 1	3300V	400A	D	MP	For High freq.
MBL400E33D	Chopper	3300V	400A	D	MP	IHM 130*140
MBM500E33E2-R	2 in 1	3300V	500A	E2	MP	IHM 130*140
MBN800E33D	1 in 1	3300V	800A	D	MP	IHM 130*140
MBN800E33D-AX	1 in 1	3300V	800A	D	MP	IHM 130*140
MBN800E33E	1 in 1	3300V	800A	E	MP	IHM 130*140
MBL800E33C	Chopper	3300V	800A	C	MP	IHM 140*190
MBL800E33D	Chopper	3300V	800A	D	MP	IHM 140*190
MBL800E33E	Chopper	3300V	800A	E	MP	IHM 140*190
MDM800E33D	2in1Diode	3300V	800A	D	MP	IHM 130*140
MBN1000E33E2	1 in 1	3300V	1000A	E2	MP	IHM 130*140
MBL1000E33E2-B	Chopper	3300V	1000A	E2	MP	IHM 140*190
MBN1200E33C	1 in 1	3300V	1200A	C	MP	IHM 140*190

IHM Portfolio 3300V (2)

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MBN1200H33D	1 in 1	3300V	1200A	D	MP	IHM 140*190 h.iso
MBN1200E33E	1 in 1	3300V	1200A	E	MP	IHM 140*190
MBN1200F33F	1 in 1	3300V	1200A	F	MP	IHM 130*140
MBN1200F33F-C	1 in 1	3300V	1200A	F +SiC	WS	IHM 130*140
MBN1200E33D	1 in 1	3300V	1200A	D	MP	IHM 140*190
MDN1200D33	1in1 Diode	3300V	1200A	D	MP	113*96
MDM1200FH33F	2in1 Diode	3300V	1200A	F	MP	IHM 140*190 h.iso
MDM1200E33D	2in1 Diode	3300V	1200A	D	MP	IHM 130*140
MBN1500E33E2	1 in 1	3300V	1500A	E2	MP	IHM 140*190
MBN1500E33E3	1 in 1	3300V	1500A	E3	MP	IHM 140*190
MBN1800F33F	1 in 1	3300V	1800A	F	MP	IHM 140*190
MBN1800FH33F	1 in 1	3300V	1800A	F	MP	IHM 140/*190 h. iso
MBN1800F33F-C	1 in 1	3300V	1800A	F+SiC	WS	IHM 140*190

IHM Portfolio 4500V (1)

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MBM200H45E2-H	2 in 1	4500V	200A	E2-H	MP	IHM 73 mm h. iso
MBN200H45E2-H	2 in 1	4500V	200A	E2-H	MP	IHM 73mm h.iso
MDM400H45E2	2in1 Diode	4500V	400A	E2	MP	IHM 130*140 h.iso
MBN600E45A	1 in 1	4500V	600A	D	MP	IHM 130*140
MDM600E45A	2 in 1 Diode	4500V	600A	D	MP	IHM 130*140
MBN800H45E2-H	1 in 1	4500V	800A	E2-H	MP	IHM 130*140 h. iso
MBN800H45E2	1 in 1	4500V	800A	E2	MP	IHM 130*140 h. iso
MDM800H45E2-H	2in1 Diode	4500V	800A	E2-H	MP	IHM 130*140 h. iso
MDM800H45E2	2in1 Diode	4500V	800A	E2	MP	IHM 130*140 h. iso

IHM Portfolio 4500V (2)

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MBN900D45A	1 in 1	4500V	900A	D	MP	IHM 140*190
MBN1000FH45F-H	1 in1	4500V	1000A	FH	MP	IHM 130*140 h. iso
MBN1000FH45F	1 in 1	4500V	1000A	F	WS	IHM 130*140 h. iso
MBN1200H45E2	1 in 1	4500V	1200A	E2	MP	IHM 140*190 h.iso
MBN1200H45E2-H	1 in 1	4500V	1200A	E2-H	MP	IHM 140*190 h. iso
MDM1200H45E2-H	2in1 Diode	4500V	1200A	E2-H	MP	IHM 130*140 h. iso
MDM1200H45E2	2in1 Diode	4500V	1200A	E2	MP	IHM 130*140 h. iso
MBN1500FH45F-H	1 in 1	4500V	1500A	FH	MP	IHM 140*190 h. iso
MBN1500FH45F	1 in 1	4500V	1500A	F	MP	IHM 140*190

IHM Portfolio 6500V

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MDM250H65E2	2in1 Diode	6500V	250A	E2	MP	IHM 130*140 h. iso
MBN500H65E2	1 in 1	6500V	500A	E2	MP	IHM 130*140 h. iso
MDM500H65E2	2in1 Diode	6500V	500A	E2	MP	IHM 130*140 h. iso
MBN750H65E2	1 in 1	6500V	750A	E2	MP	IHM 140*190 h. iso
MDM750H65E2	2in1 Diode	6500V	750A	E2	MP	IHM 130*140 h. iso
MBN1000FH65G2	1 in 1	6500V	1000A	G2	WS E/18	IHM 140*190 h. iso

Automotive Portfolio

HITACHI
Inspire the Next

Type Name	Topology	Voltage	Current	Chip	Status	Feature
MBB600TV6A	6 in 1	650V	600A	Trench HIGT	MP	
MBB800TW6A	6 in 1	650V	800A	Trench HIGT	MP	T-Sensor on IGBT Chip
MBB400TX12A	6 in 1	1200V	400A	Side Gate HIGT	MP	T-Sensor on IGBT Chip
MBB1000UV7A	6 in 1	700V	1000A	Trench HIGT	WS E/18	3 NTC for T-Measurement Copper sintering
MBB1000UW7A	6 in 1	750V	1000A	G2		Copper sintering T-sensor on IGBT Chip

HITACHI
Inspire the Next

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