



Bipolar device introduction

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Part 1 Product general view

Bipolar device-diode/thyristor

- ◆ Based on full press pack technology, company developed 5,6,7-inch high current thyristor, representing the most advanced product
- ◆ All types of devices pass the rigorous test verification and engineering application assessment
- ◆ A wide range of products to meet the customer's different capacity selection requirements



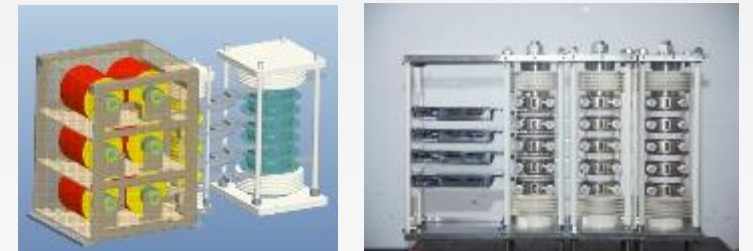
Self turn-off device-IGCT

- ◆ With 4, 6-inch IGCT device design and manufacturing capabilities
- ◆ The parameter level is world-class, and the single device has a shutdown capacity of more than 10kA.
- ◆ Can provide matching freewheeling and absorption diodes according to customer's requirements



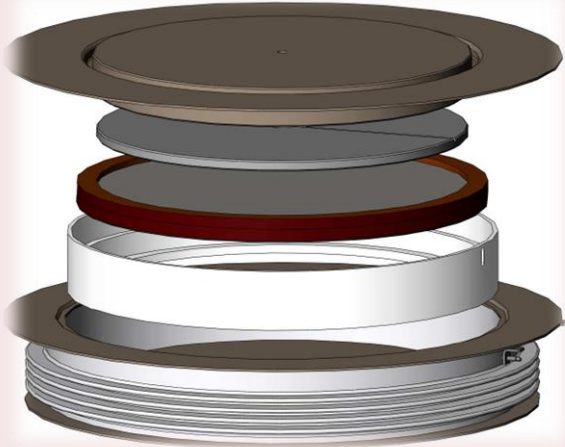
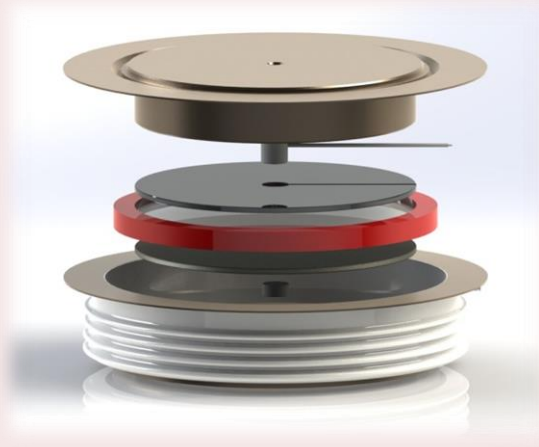
Bipolar power stack

- ◆ With 5-inch, 6-inch thyristor stack overall design and manufacturing capabilities
- ◆ Has professional electrical, structural design, a variety of series and parallel forms according to customer technical requirements,
- ◆ With high voltage and high current test capability, it can be used in power frequency, medium frequency and pulse, etc.
- ◆ Through high-end fields (HVDC, medium voltage drive inverters, locomotive converters, etc.) application verification





Part 1 Product general view

	Alloying device	Free-floating device
Outline		
Characteristic	Si-Molly sintering, low cost, mature process	Less wafer deformation, better uniform
Dimension	1~4 inch	1.5~6 inch
Current	300A~3300A (thyristor) 500A~6000A (diode)	300A~7000A (thyristor) 2200A~10000A (diode)
Voltage	600V~5200V (thyristor) 600V~8500V (diode)	1400V~8500V (thyristor) 1600V~8500V (diode)

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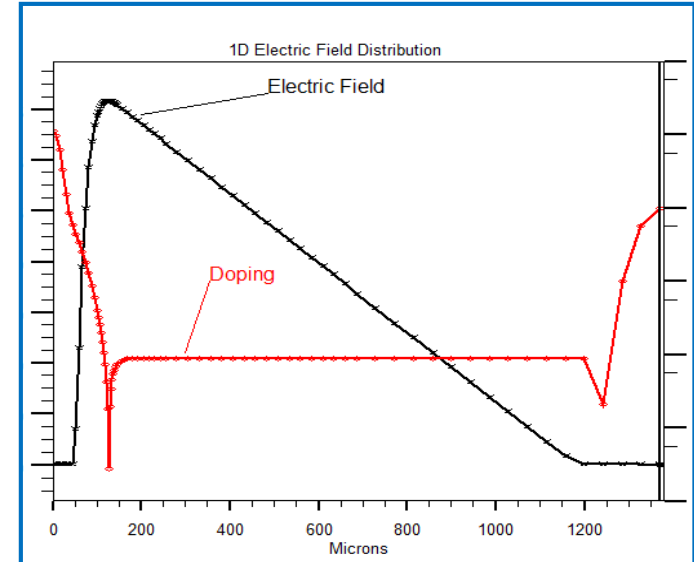
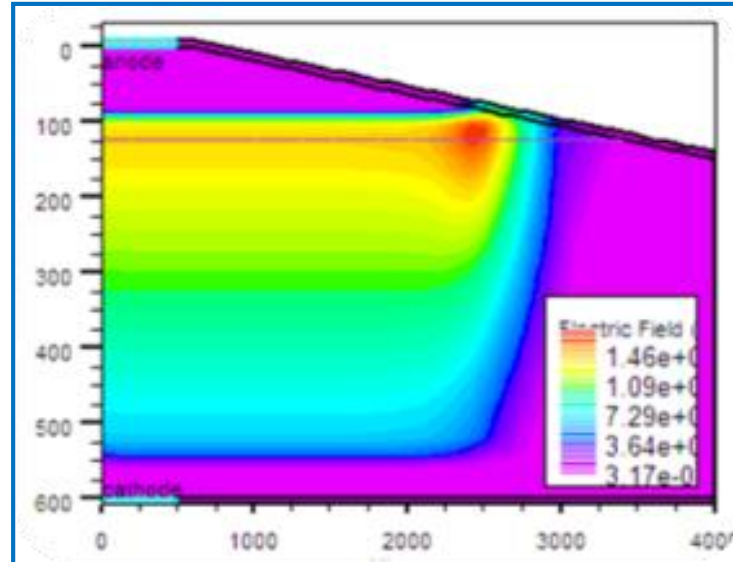
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R&D plan and new product



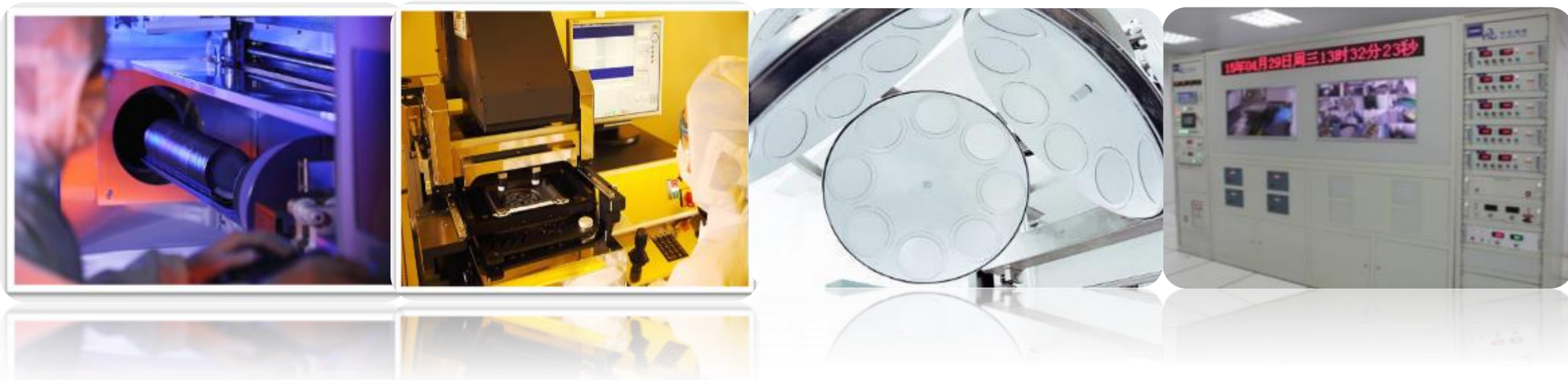
Part 2 Technology platform improvement

2.1 Design



- In 2012, R&D center was formed in both Lincoln and Zhuzhou, designing and developing jointly.
- In 2012, Apply simulation tools SILVACO into process and device simulation.
- In 2013, simulation lab was built to optimize design, process and characteristic in full dimensions.

2.2 Process



- **Diffusion system** make the single process with large batch processing capacity and good parameter uniformity.
- Control the gel, baking and high-precision **alignment** exposure equipment automatically, and high chip line alignment precision.
- High-vacuum thick-film aluminum **electron beam evaporation** equipment ensure the adhesion and uniformity of the aluminum layer, fatigue resistance.
- A 12MeV **electron irradiation** linear accelerator with high control precision to optimize the matching and coordination relationship of various parameters of the device to ensure high reliability of high-voltage series-parallel application.
- The annual production capacity of bipolar production line devices is **600,000pcs**.

2.3 Test



- Test capability of thyristors (diode) with power ratings of 6-inch, 1.2kV and below
- Test capability for 6-inch, 6kV and below power range IGCT
- Full-scale test capability for high-power semiconductor devices (IEC60747-2、IEC60747-6)
- Complete reliability and life test platform

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Part 3 Application and performance

3.1 HVDC

- ◆ Thyristor
- ◆ multiple device in series
- ◆ AC-DC,DC-AC
- ◆ High-voltage system , need multi-devices in series,e.g. $\pm 500\text{kV}$, $\pm 800\text{kV}$, $\pm 1100\text{kV}$
- ◆ Long-distance transmission



Symbol	Parameters Name	Unit	Requirement
t_{on}	Turn-on Time	us	± 1
Q_{rr}	Reverse Recovery Charge	uc	± 200
I_{GT}	Gate Trigrer Current	mA	± 50
di/dt	On-state Current Critical Rising Rate	A/us	High di/dt demand





Part 3 Application and performance

3.1 LCC-HVDC

Project	Size	Part number
高岭背靠背工程	5-inch	KP _D 3600-72
灵宝II期扩建工程	6-inch	KP _E 4500-72
葛南工程葛洲坝换流站项目	3.5-inch	KP _B 1200-65
宁夏-山东高压直流工程	5-inch	KP _D 3000-72
三沪二回直流工程	5-inch	KP _D 3000-72
锦屏-苏南特高压直流输电工程	6-inch	KP _E 4500-72
哈密-郑州特高压直流输电工程	6-inch	KP _E 5000-85
溪洛渡-浙江金华特高压直流输电工程	6-inch	KP _E 5000-85
灵州-绍兴特高压直流输电工程	6-inch	KP _E 5000-85
酒泉-湖南特高压直流输电工程	6-inch	KP _E 5000-85
上海庙-临沂特高压直流输电工程	6-inch	KP _E 6250-75
扎鲁特-青州特高压直流输电工程	6-inch	KP _E 6250-75
昌吉-古泉特高压直流输电工程	6-inch	KP _E 5500-85

Project	Power range
Cross Channel	2000MW
McNeill (Back-to-Back)	150MW
Nelson River	1620MW
Korea - Cheju Island	300MW
Chandrapur	2x500MW
Visakhapatnam	500MW
Rivera (Back-to-Back)	70MW
Sassaram	500MW
巴西美丽山II期	11GW



3.1 VSC-HVDC

Project	Size	Current/Voltage
上海南汇风电场柔性直流输电示范工程	2-inch	1000A/4200V
舟山五端柔性直流输电科技示范工程	3-inch	2000A/3600V
	3-inch	2000A/3600V
	3.5-inch	3200A/3400V
广东汕头南澳多段柔性直流输电工程	3-inch	2000A/3600V
云南鲁西背靠背柔性直流输电工程	3.5-inch	3000A/4500V
厦门柔性直流输电工程	3.5-inch	3200A/3400V
渝鄂柔性直流输电工程	3.5-inch	3200A/3400V
张北柔性直流输电工程	5-inch	5000A/5200V





Part 3 Application and performance



3.2 DC diesel locomotive traction & transmission

- ◆ Diode
- ◆ Three-phase rectifier
- ◆ Complex working conditions, e.g. abrupt & long slope, long tunnel, high altitude etc.

Symbol	Parameters name	Unit	Requirement
VRRM	Repetitive Peak Reverse Voltage	V	Enough Allowance
IF(AV)	Peak Forward Current	A	Enough Allowance
	Heat sink		Meet working condition and thermal dissipation requirement
	Wind Speed	m/s	≥6m/s





Part 3 Application and performance



3.3 DC locomotive

- ◆ Thyristor
- ◆ AC-DC
- ◆ Complex working conditions, e.g. abrupt & long slope, long tunnel, high altitude etc.

Symbol	Parameters name	Unit	Requirement
VRRM	Repetitive Peak Reverse Voltage	V	Enough Allowance
IF(AV)	Peak Forward Current	A	Enough Allowance
	Heatsink		Meet working condition and thermal dissipation requirement
	Wind Speed	m/s	≥6m/s





Part 3 Application and performance

- ◆ The company holds 70%+ market share of power semiconductor device in domestic traction application.
- ◆ The company served for China railway more than 50 years, and supplied 1000,000pcs device.
- ◆ The company exported 30,000+ pcs device to world wide countries with locomotive.





Part 3 Application and performance

3.4 SVC

- ◆ Thyristor, IGCT
- ◆ AC-DC, DC-AC
- ◆ Control the conduction angle to get the different output current
- ◆ Three-phase reversed in parallel
- ◆ High harmonic voltage

symbol	Parameters Name	Unit	Requirement
V_{RRM}	Repetitive Peak Reverse Voltage	V	6 times higher of input line voltage
V_{DRM}	Repetitive Peak off-state Voltage	V	6 times higher of input line voltage
di/dt	Current Rising Rate	A/us	high criteria for di/dt
Qrr	Reverse Recovery Current	uC	TBD



Part 3 Application and performance

- ◆ The company has provided high-voltage series thyristors for domestic and international SVC devices since 2005.
- ◆ The company is a major supplier of thyristors for SVC devices worldwide.
- ◆ The company has provided more than 100,000 pcs 6.5kV series high voltage thyristors to customers.





Part 3 Application and performance



3.5 Induction heating

- ◆ Fast switching thyristor, FRD
- ◆ DC-AC, free-wheeling

Type	Symbol	Parameters Name	Unit	Requirement
Parallel resonance	di/dt	On-state Current Critical Rising Rate	A/us	high di/dt
	tq	Circuit Commutated Turn-off Time	us	controlling depend on frequency
Series Resonance	dV/dt	Off-state Voltage Ctitical Rising Rate	V/us	high demang for dv/dt ≥ 2000
	tq	Circuit Commutated Turn-off Time	us	controlling depend on frequency

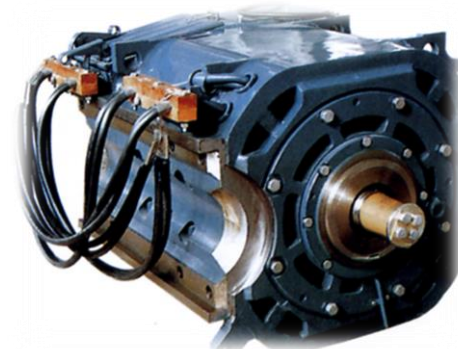




3.6 Soft starter

- ◆ Thyristor
- ◆ 3-phase in reverse parallel connection
- ◆ the input voltage of the controlled motor change with the phase of the conduction angle
- ◆ LV starter: 380V,660V,1100V
- MV starter: 6kV
- HV starter: 10kV

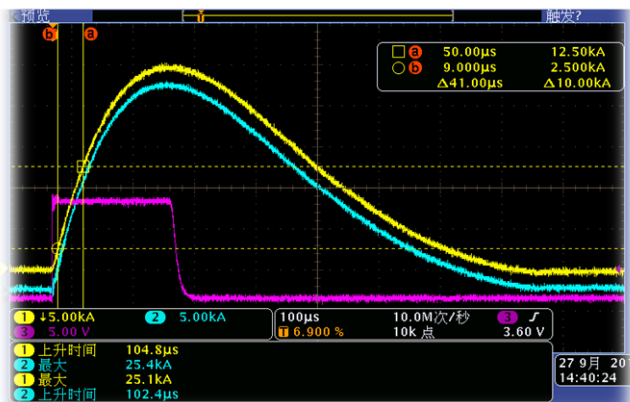
	Symbol	Parameters Name	Unit	Requirement
LV MV	I _H	Holding Current	mA	±10
	I _L	Latching Current	mA	±30
	t _{on}	Turn-on Time	us	±1
HV	Q _{rr}	Reverse Recovery Charge	uc	±200
	I _{GT}	Gate Trigrer Current	mA	±50
	di/dt	On-state Current Critical Rising Rate	A/us	High di/dt





3.7 High current power supply

- ◆ Pulse power device (thyristor, IGCT)
- ◆ Serial / parallel connection
- ◆ AC-DC



symbol	Parameters Name	Unit	Requires
V_{TM}	Peak On-state Voltage	V	matching depend on Circuit Layout
V_{FM}	Peak Forward Voltage	V	matching depend on Circuit Layout



3.8 DC ice-melting

No.	Project	Power	Type
1	贵州电网福泉变 电站	500kV/60MW	3~5" 6.5kV
2	竹东变电站	220kV/25MW	
3	息丰变电站	500kV/40MW	
4	安顺变电站	500kV/60MW	
5	云南大关变电站	220kV/20MW	
6	广西南塘变电站	220kV/25MW	



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Part 4 R&D plan

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Breakdown thyristor technology

Monochip thinning technology

High frequency pulse technology

Ultra High voltage thyristor technology

High temperature junction technology

Local p-type doping technology

Ultra high surge current technology

Device low loss technology

High junction temperature thyristor technology

Reverse recovery period control technology





Part 4 R&D plan

Improvement of Reliability

- Precision machining technology
- Terminal protection material improvement
- High junction temperature thyristor technology
- Device limit capability

Reduction of Losses

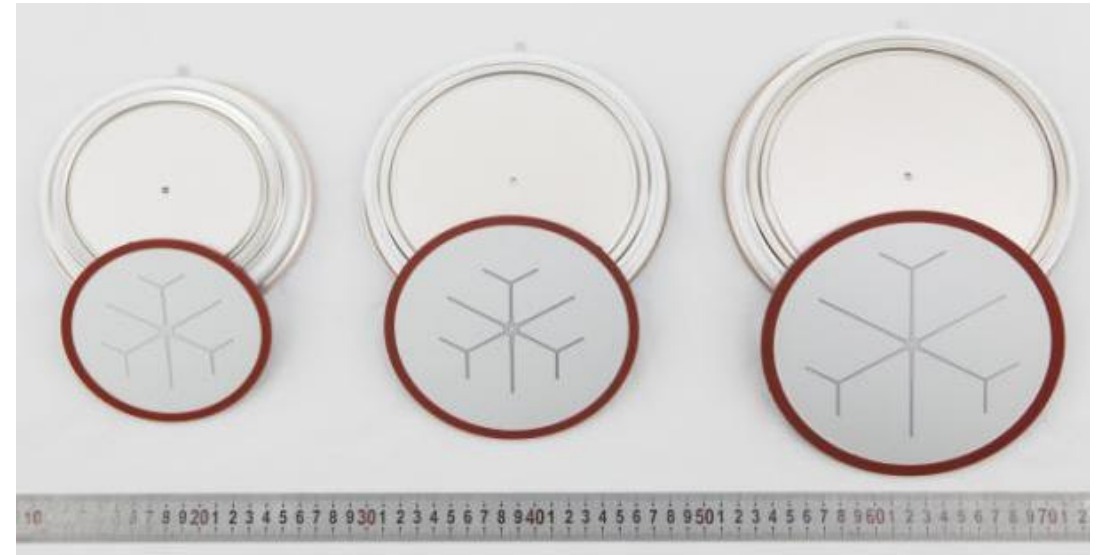
- Short base technology
- Junction terminal finish process
- Monochip thinning technology

Construction of Platform

- High energy and High frequency testing capability;
- Complete bipolar product types and fields;
- complete products simulation library of application;

▶ Up to 7 inch HVDC thyristor

Part number	$V_{DSM}/V_{RSM}(V)$	Condition
KP _F 6500-85	8500	$T_{vj} = 25, 125\text{ }^{\circ}\text{C}$ $I_{DRM}, I_{RRM} \leq 400\text{mA}$ $V_{DRM} = V_{DSM}$ $V_{RRM} = V_{RSM}$



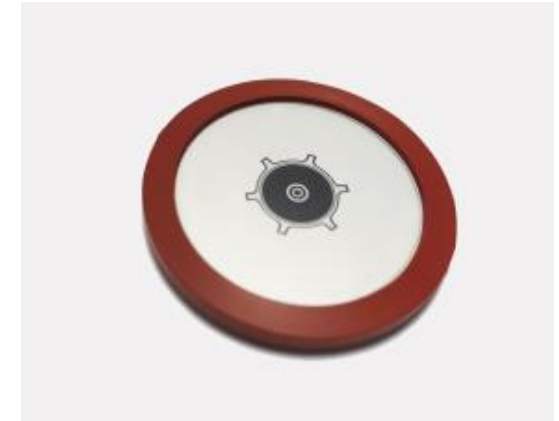
▶ Smaller HVDC thyristor

Part number	$V_{DSM}/V_{RSM}(V)$	Condition
KP _A 700-85 KP _X 1200-85 KP _B 1400-85 KP _C 1800-85	8500	$T_{vj} = 25, 125\text{ }^{\circ}\text{C}$ $I_{DRM}, I_{RRM} \leq 400\text{mA}$ $V_{DRM} = V_{DSM}$ $V_{RRM} = V_{RSM}$



▶ **Breakdown thyristor:** with overvoltage breakover or breakdown function

Part number	$V_{DSM}(V)$	$V_{BO}(V)$	Condition
1000A/4200V	4200	4000-4300	$T_{vj} = 25, 125 \text{ } ^\circ\text{C}$ $I_{DRM} \leq 300\text{mA}$ $t_p = 10\text{ms}$ $V_{RRM} = V_{RSM} - 100\text{V}$



▶ **Integrated breakdown thyristor:** the wafer has an electrical trigger turn-on function in the forward direction and an overvoltage breakover or breakdown function in the reverse direction.

Part number	$V_{DSM}(V)$	$V_{BO}(V)$	Condition
5000A/4200V	4200	4000-4300	$T_{vj} = 25, 125 \text{ } ^\circ\text{C}$ $I_{DRM} \leq 400\text{mA}$ $t_p = 10\text{ms}$ $V_{RRM} = V_{RSM} + 100\text{V}$



Low voltage bidirectional thyristor

Part number	$V_{DSM}/V_{RSM}(V)$	Condition
KB ₉ 1500 -14 KB _A 2600 -14 KB _X 2600 -14	1400	$T_{vj} = 25, 125\text{ }^{\circ}\text{C}$ $I_{DRM}, I_{RRM} \leq 300\text{mA}$ $V_{DRM} = V_{DSM}$ $V_{RRM} = V_{RSM} - 100\text{V}$
KB ₉ 1500 -18 KB _A 2500 -18 KB _X 2500 -18	1800	



5-inch FRD device

Part number	$V_{RRM}(V)$	Condition
FY _D 4600 -45	4500	$T_{vj} = 25, 125\text{ }^{\circ}\text{C}$ $I_{RRM} \leq 100\text{mA}$ $t_p = 10\text{ms}$ $V_{RSM} = V_{RRM} + 100\text{V}$





Thank you !