

SBR Product Presentation
Solar PV Module



SBR Business Unit

Super Barrier Rectifier SBR®

SBR is a proprietary and patented Diodes Inc technology that utilizes a MOS mfg'ing process (compared to bipolar process) to create a superior 2 terminal device

Lower forward voltage (V_f) than comparable Schottky diodes with thermal stability and high reliability characteristics of PN epitaxial diodes

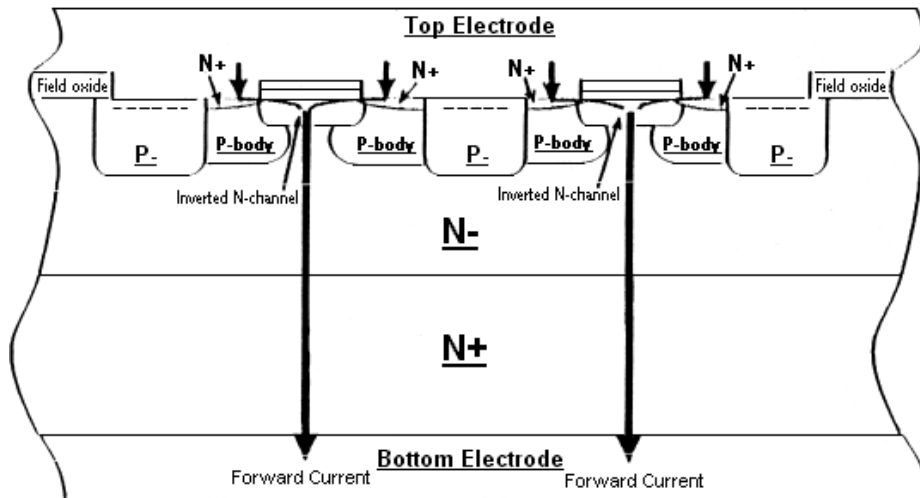
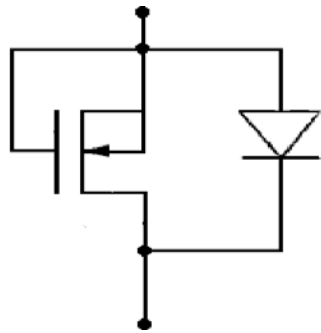
SBR's forward bias operation at low voltage is similar to Schottky diode but the leakage current is lower than Schottky diode in reverse bias



Super Barrier Rectifier

Device Structure and Operation

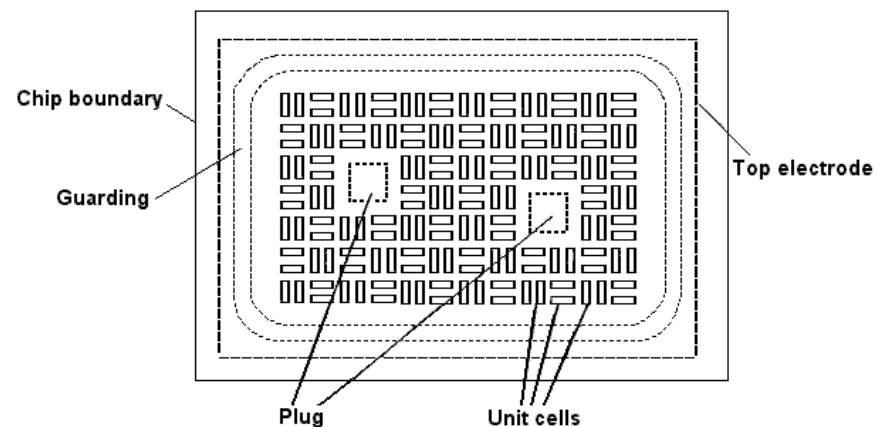
SBR[®](Super Barrier Rectifier)



Diodes Patented & Proprietary

Device Structure Operation of SBR[®]

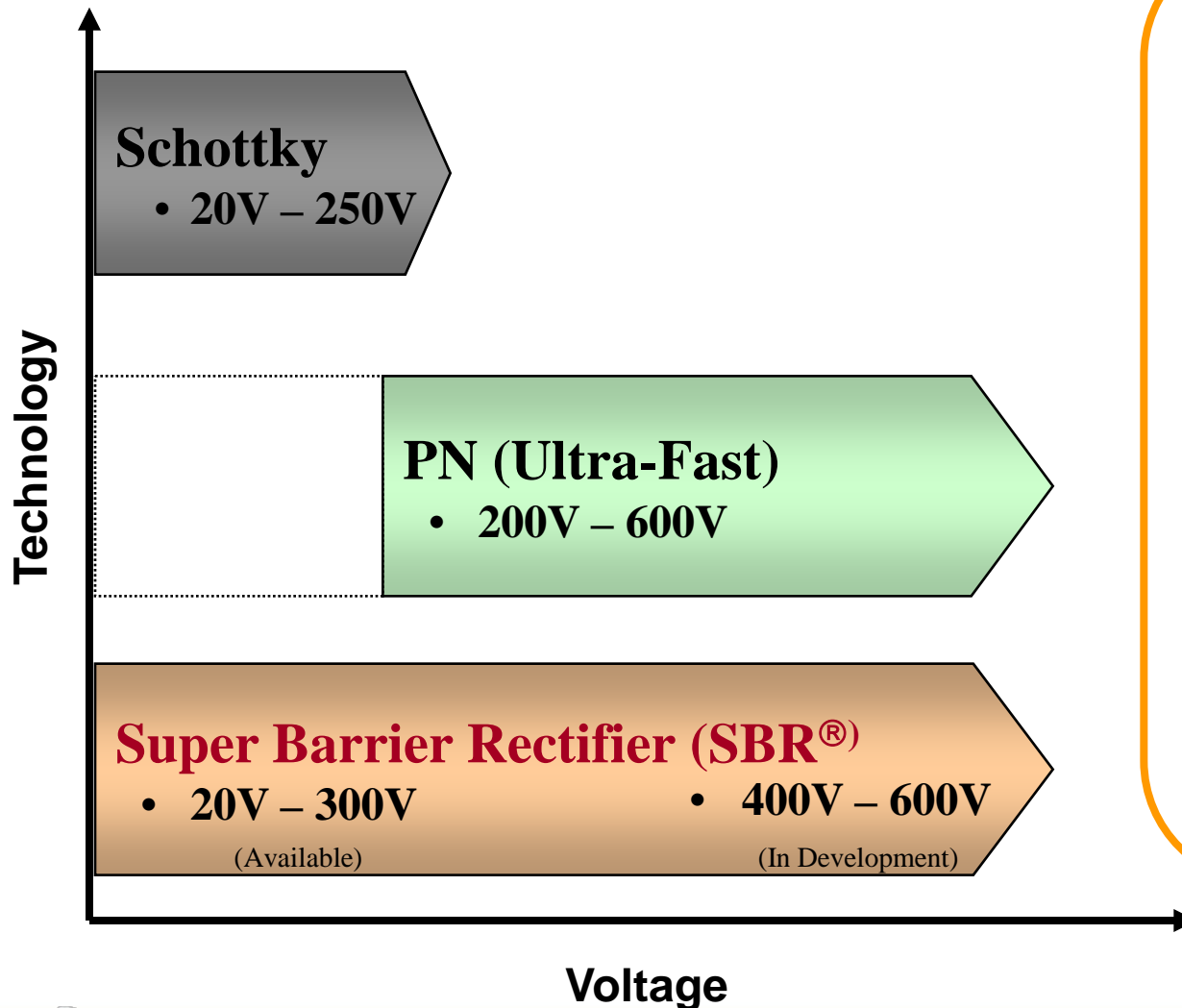
- Traditional (two terminal) device by shorting the gate and source, $V_{GS} = 0$
- In forward mode, device operates as majority carrier (MOS) with low V_F and fast switching
- In reverse mode, electrostatic behavior causes depletion mode, substantially reducing leakage current
- Cellular design operates as thousands of individual (unit) working in parallel



SBR is a registered trademark of Diodes Incorporated



Scalability of SBR[®] Technology



Scalability of SBR[®] technology

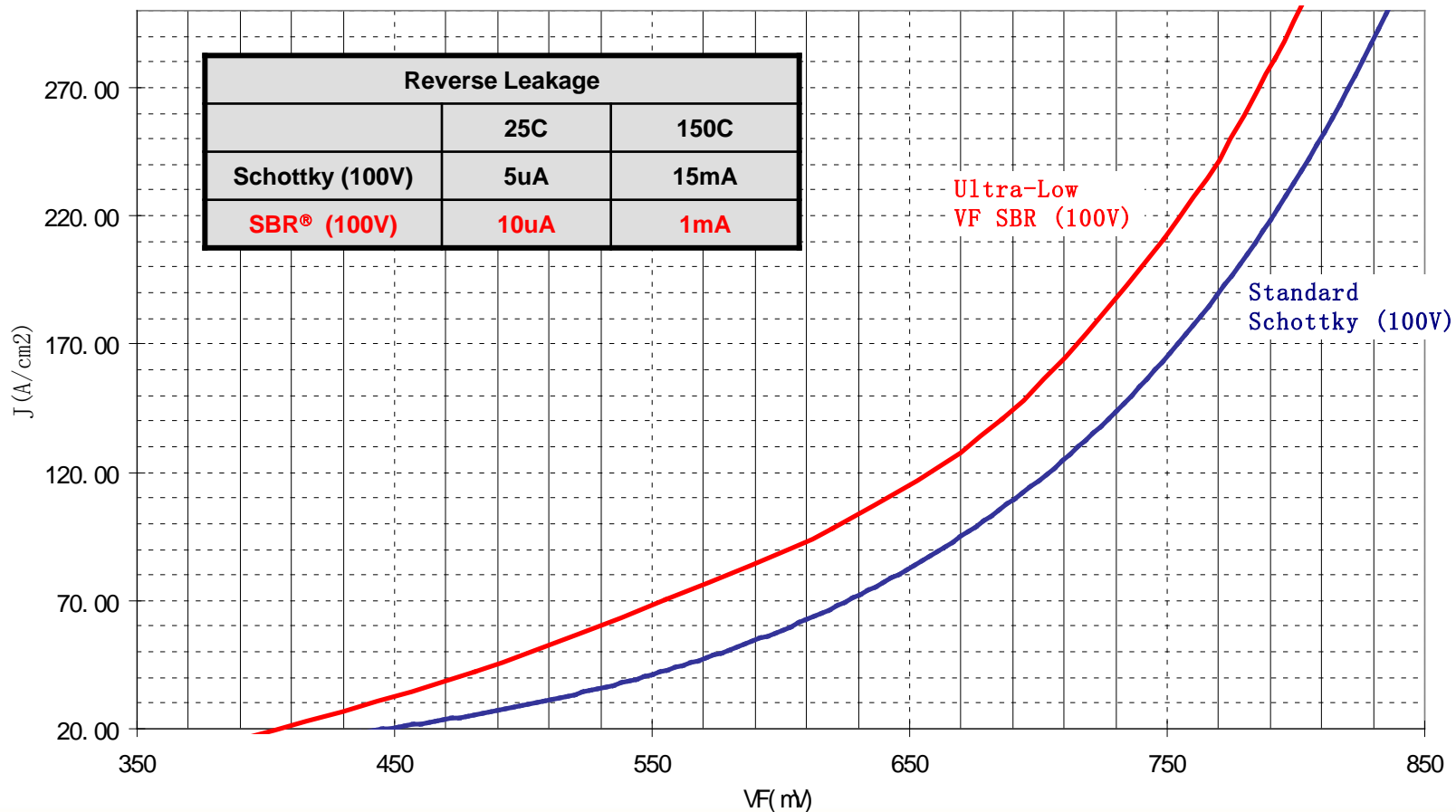
- ✓ SBR[®] is the only technology that can be scaled from 20V to 600V without any loss in performance
- ✓ Technology can be scaled by current from 0.1A to 60A without loss in performance
- ✓ One simple solution to cover all range of voltage application requirements
- ✓ High voltage SBR[®] (>200V) has significantly lower V_F and comparable switching speed (T_{RR}) than Ultra-Fast PN junction diodes



SBR[®] Forward Voltage (V_F) Benchmark Performance

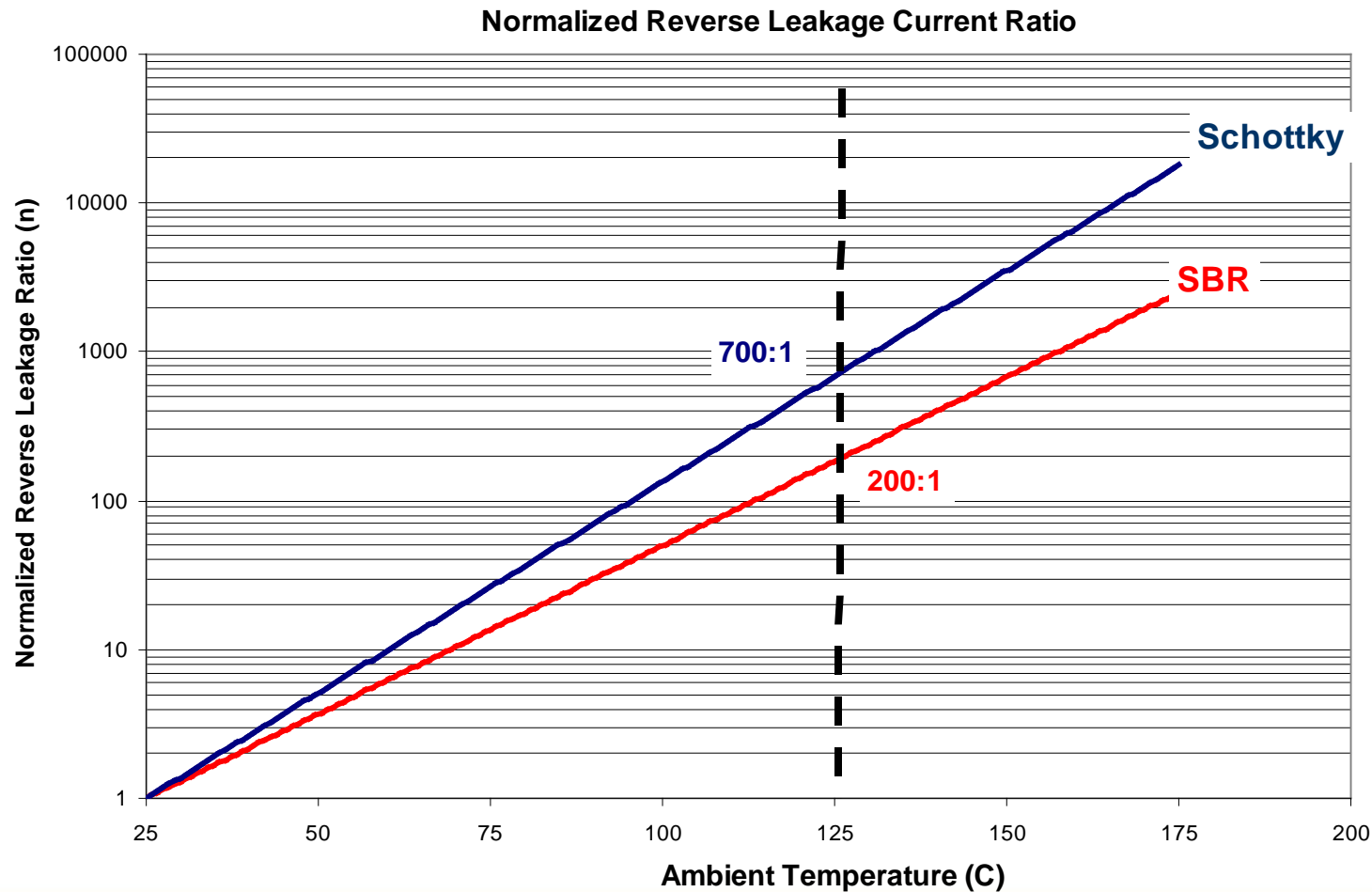
The Ultra-Low V_F SBR[®] has lower forward voltage (V_F) than competitive Schottky devices in the market

Current Density Comparison between Schottky and SBR



SBR[®] Normalized Reverse Leakage Ratio

SBR[®] technology has significantly lower normalized reverse leakage ratio at higher temperature than conventional Schottky devices

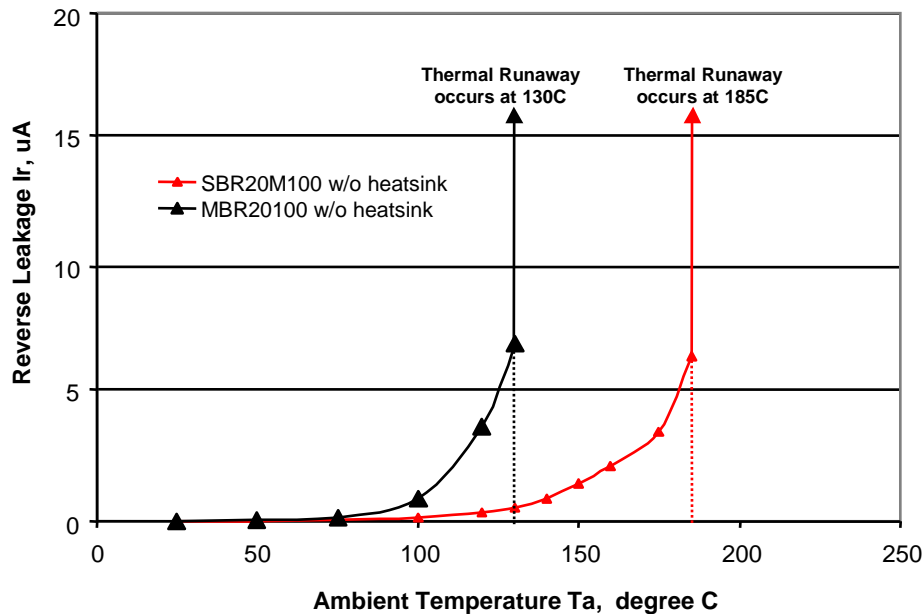


Thermal Breakdown

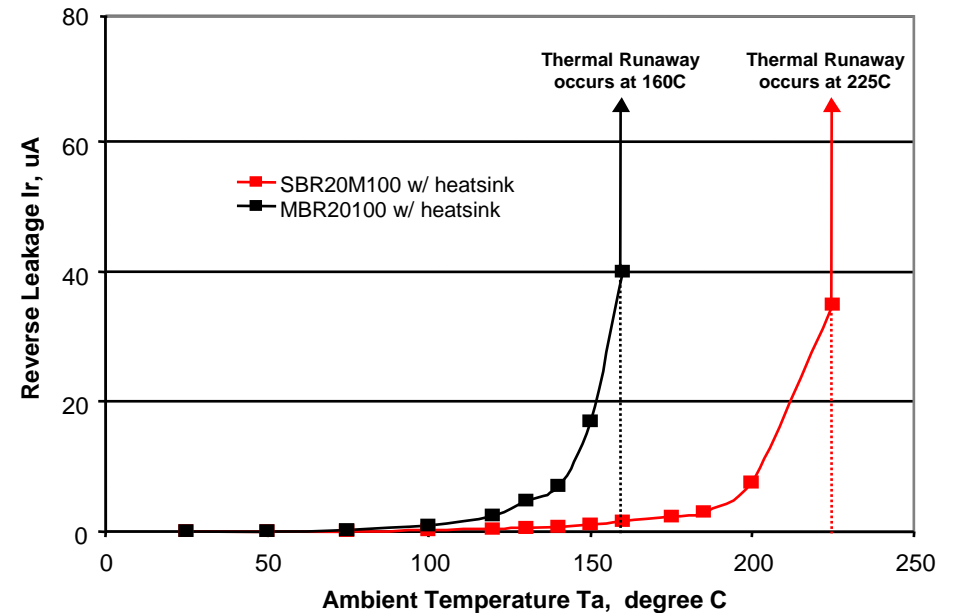
The high temperature stability of the SBR[®] leads to significantly higher thermal runaway capability than a Schottky, resulting in...

- Higher operation reliability
- Higher temperature application usage
- Potential of eliminating the use of a heat sink

HTRB: Diodes SBR20M100 vs. IR MBR20100 without Heatsink



HTRB: Diodes SBR20M100 vs. IR MBR20100 with Heatsink



Note: Please visit Diodes website for technical paper on this subject





Current SBR[®] Product Line



Current Product Portfolio & Offerings

SBR[®] product portfolio include both small and large package outline

Small outline package

- Leading edge performance for mobile phone & portable electronics applications

Large outline package

- Most cost effective solution for power supply rectifier applications

SBR Current Product Offering and Development

	0.2A	0.2A - 0.7A	1A	1A	2A - 3A	3A	1A - 3A	10A	6A-10A	10A-60A	10-40A	10-60A	40-60A
Reverse Voltage (V)	SOD-523	DFN1006-2	DFN1411-3	SOD-323	PowerDI-123	DFN3030-8	SMA	PowerDI-5	PAK	D2PAK	ITO-220AB	TO-220AB	TO-247
20	●	●					●						
30	●	●		●	●	■	●					●	
40-45		●	●	●	●		●	●*	●*	●*	●	●	■
60								●	●	●	●	●	■
100		●				●		■	●	●	●	●	■
150						●	●		■	■	●	●	■
200								●	●	●	●	●	■
300										●	●	●	●

● Current Product Offering

■ In Development

* Solar SBR Product Offering



SBR10U45SP5 and SBR1045SP5 – SBRs for Solar Panels

THE DIODES ADVANTAGE



Product benefits

- PowerDI®5 is a low profile proprietary package that delivers a thermal performance 50% lower than competing solutions, such as TO-252, from a footprint that is 55% smaller.
- Industry first PowerDI®5 bypass diodes designed in accordance to Solar Industry Safety Standards (IEC61730-2, IEC61215-2).
- Ultra-Low V_F for reduced forward power loss to improve efficiency and higher cell power generation.
- Very low high temperature reverse leakage characteristics unlike traditional Schottky rectifiers.
- Large safe operating area (SOA) with maximum selectively rated 200°C junction temperature for higher reliability.
- High forward surge current rating (I_{FSM}) to prevent against current surges and lightning strikes.
- Low profile height of 1.1 mm for possible integration into the solar panels.



Product Application – Solar Panel Market

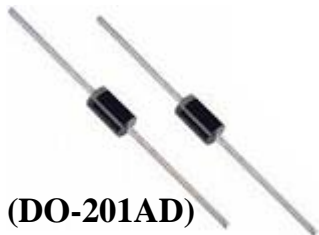
-Use of Bypass Diodes for Series-Connected PV Modules-

Bypass Diodes in Solar Panels

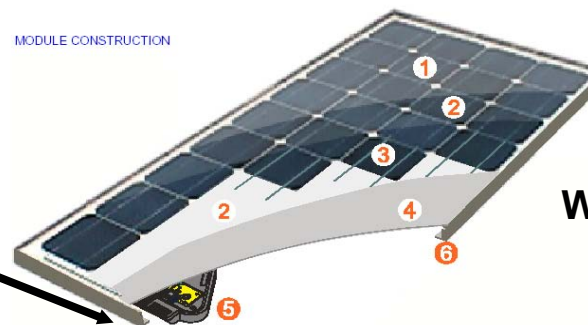
The new SBR10U45SP5 and SBR1045SP5 are the industry's first low profile bypass diodes specifically designed in accordance with the high temperature requirements of the IEC 61730-2 solar panel safety standard.

Current SBRs Offering for Solar Panel Market						
Part No.	Description	Package	Max T _j	V _F @ rated current 125°C, Typ	I _R @ rated voltage, 125°C, Typ	Samples Availability
SBR8A45SP5	8 Amperes / 45 Volts, Low VF SBR	PowerDI-5	200C*	0.52V	10mA	Avaliable Now!
SBR10U45SP5	10 Amperes / 45 Volts, Ultra-Low VF SBR	PowerDI-5	200C*	0.38V	9mA	Avaliable Now!
SBR1045SP5	10 Amperes / 45 Volts, Standard Version SBR	PowerDI-5	200C*	0.47V	7mA	Avaliable Now!
SBR10U45SD1	10 Amperes / 45 Volts, Ultra-Low VF SBR	DO-201	200C*	0.38V	9mA	Avaliable Now!
SBR12A45SD1	12 Amperes / 45 Volts, Low VF SBR	DO-201	200C*	0.40V	9mA	Avaliable Now!
SBR15U30SP5	15 Amperes / 30 Volts, Ultra-Low VF SBR	PowerDI-5	200C*	0.36V	1.5mA	Avaliable Now!
SBR3045SCTB	30 Amperes / 45 Volts, Low VF SBR	TO-263	200C*	0.54V	9mA	Avaliable Now!
New SBRs Solar Product Developments						
SBR1045SD1	10 Amperes / 45 Volts, Low VF SBR	DO-201	200C*	0.47V	7mA	Avaliable Now!
SBR1545SD1	15 Amperes / 45 Volts, Low VF SBR	DO-201	200C*	0.45V	9mA	Apr-11
SBR12U45SLH	12 Amperes / 45 Volts, Ultra-Low VF SBR	PowerDi-5SP	200C*	0.54V	9mA	Apr-11

*Selectively Rated



PowerDI™5



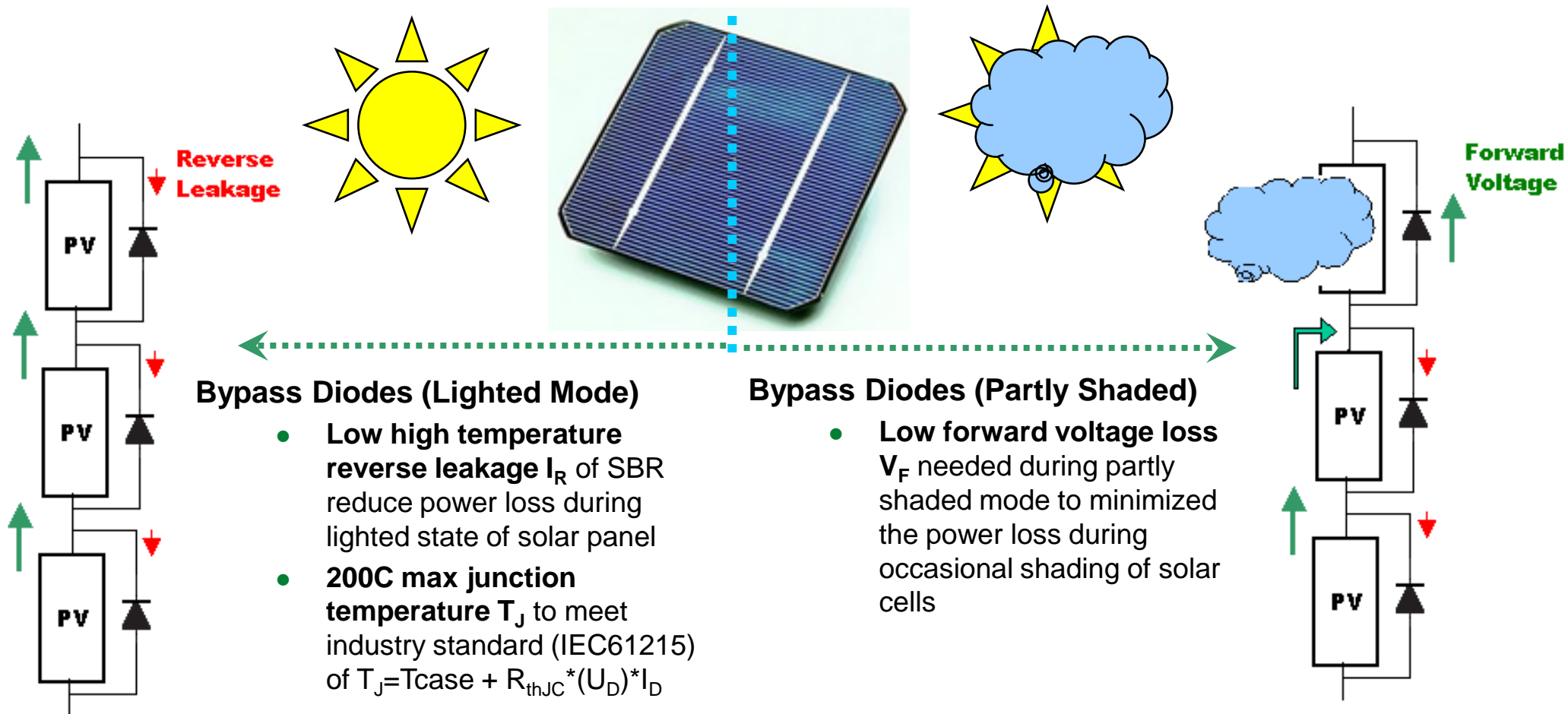
With low profile height, new SBR bypass diodes can be possibly integrated into the solar panel

Many module manufacturers will provide modules with the bypass diodes integrated into the module junction box.



Key Product Application – Solar Panel Market

-Bypass Diodes in High Temperature Solar Panels Applications-



Bypass Diodes (Lighted Mode)

- **Low high temperature reverse leakage I_R** of SBR reduce power loss during lighted state of solar panel
- **200C max junction temperature T_J** to meet industry standard (IEC61215) of $T_J = T_{case} + R_{thJC} * (U_D) * I_D$

Bypass Diodes (Partly Shaded)

- **Low forward voltage loss V_F** needed during partly shaded mode to minimized the power loss during occasional shading of solar cells



New Targeted SBR Market – Solar Bypass Diodes

	Max T_j	V_F	High Temp I_R	Package Requirements
Key Solar Requirements	✓ Requires highest possible T_j to pass IEC-61512 reliability standards	✓ Requires lowest possible V_F to increase efficiency from solar panels during bypass mode	✓ Require lowest possible I_R for increased reliability over lifetime of solar panels	✓ Next generation panels requires low profile and smaller package to decrease size of junction box
SBR	● T_j up to 200C	● Low V_F	● Low I_R	● Available 1.1mm low-profile PowerDI-5 package
Schottky	● T_j up to 175C	● Low V_F	● High I_R	● Available only in standard TO or DO packages
PN Junction	● T_j up to 175C	● High V_F	● Low I_R	● Available only in standard TO or DO packages



Solar Panels

IEC 61215-2/61730-2 on Bypass Diodes

IEC 61215 requires all solar modules to meet over time the following condition (after a certain preconditioning):

$$T_j = T_{\text{case}} + R_{\text{THjc}} \times U_D \times I_D$$

- a) T_j = diode junction temperature (max.)
- b) T_{case} measured diode case temperature
- c) R_{THjc} = Thermal resistance Junction to case ($R_{\theta\text{JA}}$)
- d) U_D = diode voltage (V_F)
- e) I_D = diode current (max short circuit current)

a), c), d)

are related to the bypass diodes specification

b) is related to the thermal characteristics of the diode AND the way the diode is mounted in the solar module

e) is related to the design of the solar module; e.g. less solar cells in parallel and more blocks in series would decrease the max. short circuit current

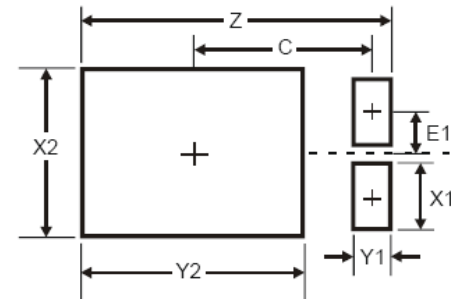


Solar Panels

IEC 61215-2/61730-2 on Bypass Diodes

IEC 61215/61730 requires all solar modules to meet over time the following conditions (after a certain preconditioning):

$$T_j = T_{\text{case}} + R_{\text{THjc}} \times U_D \times I_D$$



Standard MRP:

Dimensions	Value (in mm)
Z	6.6
X1	1.4
X2	3.6
Y1	0.8
Y2	4.7
C	3.87
E1	0.9

Based on 16*MRP Pad Layout:

Part No.	PCB material	IF(A)	VF(V)	Ta(°C)	Rthja(°C/W)	Pd(W)	Tj (°C)	Tjmax (°C)
SBR10U45SP5	Polymide	10.0	0.357	75.1	20.3	3.6	147.8	200.0
SBR1045SP5	Polymide	10.0	0.444	74.4	21.4	4.4	169.5	200.0

Sufficiently Passing the Requirements of $T_j > T_{j\text{max}}$

Operating Temperature Range	$V_R \leq 80\% V_{\text{RRM}}$	T_j	-65 to +150	°C
	$V_R \leq 50\% V_{\text{RRM}}$		≤180	
	DC Forward Mode		≤200	





Thank You

DIODES
I N C O R P O R A T E D