SiC Schottky Barrier Diode (SBD)

Absolute Maximum Ratings and Electrical Characteristics

Description

This document mainly describes the absolute maximum ratings and electrical characteristics listed in the datasheets of SiC SBD used for switching power supplies, etc. The following items are the repetition peak reverse voltage, forward DC current, forward pulse current non-repetition peak forward current, junction temperature as maximum ratings, and forward voltage, reverse current, junction capacitance, total charge as electrical characteristics.
Table of Contents

Description ........................................................................................................................................................................... 1
Table of Contents .................................................................................................................................................................. 2
List of Figures ...................................................................................................................................................................... 3
1. Absolute Maximum Ratings .............................................................................................................................................. 4
   1.1. Parameters Specified as Absolute Maximum Ratings .......................................................................................... 4
      1.1.1. Repetitive Peak Reverse Voltage $V_{RRM}$ .............................................................................................. 4
      1.1.2. Forward DC Current $I_{F(DC)}$ .................................................................................................................. 4
      1.1.3. Forward Pulse Current $I_{FP}$ .................................................................................................................... 4
      1.1.4. Non-Repetitive Peak Forward Surge Current $I_{FSM}$ .................................................................................. 4
      1.1.5. Junction Temperature $T_j$ ........................................................................................................................ 4
2. Electrical Characteristics .................................................................................................................................................. 5
   2.1. Parameters Specified as Electrical Characteristics .............................................................................................. 5
      2.1.1. Forward Voltage $V_F$ ................................................................................................................................ 5
      2.1.2. Reverse Current $I_R$ ..................................................................................................................................... 5
      2.1.3. Junction Capacitance $C_j$ .......................................................................................................................... 6
      2.1.4. Total Junction Capacitive Charge $Q_{cj}$ ...................................................................................................... 6

RESTRICTIONS ON PRODUCT USE .................................................................................................................................. 7
List of Figures

Figure 2.1 Example of SiC SBD I_F-V_F curve ................................................................. 5
Figure 2-2 Example of I_R – V_R curve ............................................................................. 5
Figure 2-3 Example of C_J – V_R curve ........................................................................... 6
1. Absolute Maximum Ratings

Absolute maximum ratings are specified for each item that must not be exceeded during operation even instantaneously. The maximum allowable values of the current that can be applied to SiC SBD and the voltage that can be applied are specified as the maximum rated values. Recognizing the maximum rating in designing circuits is very important not only for the effective operation of SiC SBD but also for reliable operation that is sufficiently high for the target operating hours.

Characteristics may not be recovered if used beyond the rating. When designing a circuit, pay attention to fluctuations in the supply voltage, variations in the characteristics of electrical components, the stress higher than the maximum ratings at the time of circuit adjustment, changes in ambient temperature, fluctuations in the input signal, etc., and avoid even one of the ratings.

However, even if the product is used under the operating conditions (operating temperature, current, voltage, etc.) within the absolute maximum rating, if the product is used continuously under high loads (high temperature and large current, high voltage application, large temperature change, etc.), the reliability of the product may be significantly reduced. Therefore, in order to ensure reliability, we recommend an appropriate reliability design considering de-rating.

1.1. Parameters Specified as Absolute Maximum Ratings

1.1.1. Repetitive Peak Reverse Voltage $V_{RRM}$

The maximum value of the reverse voltage that can be repeatedly applied.

1.1.2. Forward DC Current $I_{F(DC)}$

Maximum value of the allowable DC current.

1.1.3. Forward Pulse Current $I_{FP}$

Maximum value of the allowable pulse current under the specified condition.

1.1.4. Non-Repetitive Peak Forward Surge Current $I_{FSM}$

Non-repetitive maximum allowable forward peak current as one cycle of 50Hz sine waveform (conduction angle 180°) at the specified junction temperature.

1.1.5. Junction Temperature $T_j$

The maximum allowable chip temperature at which a SBD operates.
2. Electrical Characteristics

Electrical characteristics specified in SiC SBD datasheet are explained by item. \( T_a = 25 \, ^\circ C \) unless otherwise specified.

2.1. Parameters Specified as Electrical Characteristics

2.1.1. Forward Voltage \( V_F \)

Voltage drop across terminals caused by forward current under specified current and temperature conditions. This item is usually specified with pulse current because of its high temperature dependence.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward voltage</td>
<td>( V_F ) (1)</td>
<td>( I_F = 5 , A ) (pulse measurement)</td>
<td>-</td>
<td>1.2</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Forward voltage</td>
<td>( V_F ) (2)</td>
<td>( I_F = 10 , A ) (pulse measurement)</td>
<td>-</td>
<td>1.45</td>
<td>1.6</td>
<td>V</td>
</tr>
</tbody>
</table>

The temperature coefficient of forward voltage is positive in the high current range.

![Figure 2.1 Example of SiC SBD \( I_F-V_F \) curve](image)

2.1.2. Reverse Current \( I_R \)

Reverse leakage current at the specified reverse voltage. This item is usually specified by the pulse voltage because of its high temperature dependence.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse current</td>
<td>( I_R )</td>
<td>( V_R = 650 , V ) (pulse measurement)</td>
<td>-</td>
<td>0.5</td>
<td>50</td>
<td>( \mu A )</td>
</tr>
</tbody>
</table>

![Figure 2.2 Example of \( I_R-V_R \) curve](image)
2.1.3. Junction Capacitance $C_j$

The junction capacitance of SiC SBD is the capacitance between the anode-side metal or the P-type semiconductor and the cathode-side N-type semiconductor. The junction capacitance depends on the reverse voltage ($V_R$), and it is specified on the datasheet by the equivalent capacitance between the terminals to measure with specified $V_R$ when a signal for measurement is applied at a certain frequency.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction capacitance</td>
<td>$C_j$</td>
<td>$V_R = 650 V$, $f = 1 \text{ MHz}$</td>
<td>-</td>
<td>36</td>
<td>-</td>
<td>pF</td>
</tr>
</tbody>
</table>

![Figure 2.3  Example of $C_j$ – $V_R$ curve](image)

2.1.4. Total Junction Capacitive Charge $Q_{cj}$

The total junction capacitive charge is the amount of charge to charge or discharge the parasitic capacitance. Therefore, it is calculated by the following equation (1). The values in the data sheet are calculated by integrating the Junction capacitance – Reverse voltage curve.

$$Q_{cj} = \int C_j(V)dv \quad \cdots \cdots (1)$$

The integration range is from 0 to $V_R$ specified in the datasheet.
RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as "TOSHIBA".
Hardware, software and systems described in this document are collectively referred to as "Product".

- TOSHIBA reserves the right to make changes to the information in this document and related Product without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.
- PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE"). Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT. For details, please contact your TOSHIBA sales representative or contact us via our website.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.

SiC Schottky Barrier Diode (SBD)
Application Note

Toshiba Electronic Devices & Storage Corporation

https://toshiba.semicon-storage.com/

© 2020 Toshiba Electronic Devices & Storage Corporation

7 2020-08-04