Application Note Of CRRC Press-Pack IGBT

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1. Introduction to press-pack IGBTs

Press-pack IGBTs are an alternative to isolated-base plastic modules. Instead of the wire bonds and solder joints used in traditional isolated-base modules, Press-pack rely on the application of force by an external clamping system, to make contact to the chips.

Compared with the traditional IGBT module, the Press-pack IGBTs have the following characteristics:

(1) They also benefit from higher reliability, since pressure contacts are typically more robust than wire bonds and solder joints. The spring and press clamping technology is used to do the connection job. They solves the problems of thermal fatigue of wire bonds and solder joints, increases the long-term reliability of the connection, greatly improves the service life of the device, and also greatly reduces the stray inductance inside the IGBT device.

(2) The electric field direction of the Press-pack IGBT is consistent with the clamping axis, so it is easy to clamp the Press-pack IGBT in series, and make the electrical connection from top to bottom. While the traditional IGBT is installed on a heat-sink horizontally, the electrical connection also needs to be bent, and additional stray inductance is introduced.

(3) There is no substrates and baseplate in the structure of Press-pack IGBT, and the better thermal conductivity materials have been applied, so Press-pack IGBT has smaller thermal resistance than traditional IGBT module.

(4) The chips of Press-pack IGBT are sealed in the case housing. The humid air cannot diffuse into the inside of Press-pack IGBT. The anti-moisture property of Press-pack IGBT is better than traditional IGBT module.

CRRC has developed two types of Press-pack IGBT, TG2000SW45ZC-P200 and TG3000SW45ZC-P200.

Table1.1 CRRC Press-pack IGBT products

Type	Rated current	Rated voltage
TG2000SW45ZC-P200	2000A	4500V
TG3000SW45ZC-P200	3000A	4500V

The TG2000SW45ZC-P200 is taken as an example to introduce the CRRC Press-pack IGBT in this note.

2. Design of Press-pack IGBTs

2.1 Circuit configuration

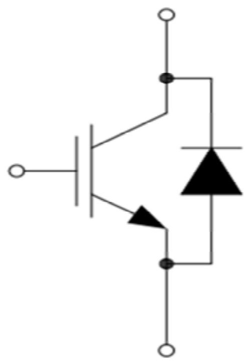

Fig.2.1 - The circuit configuration of CRRC Press-pack IGBT

The CRRC Press-pack IGBT is designed to be a single IGBT device. There are IGBT part and FRD part inside the device. The rated current of IGBT part and FRD part are the same.

2.2 Inner structure

When the device is clamped, the spring assemblies of device inner structure compress to transmit the force to the sub units. If the clamping force exceeded the threshold force specified in the product datasheet, the excess force could applied to the pressure limitation framework of device inner structure. The height of device will be compressed. The height of TG2000SW45ZC-P200 and TG3000SW45ZC-P200 are both 35mm. After be compressed, the height of both ones are 33.4mm. It is shown as Fig.2.1.

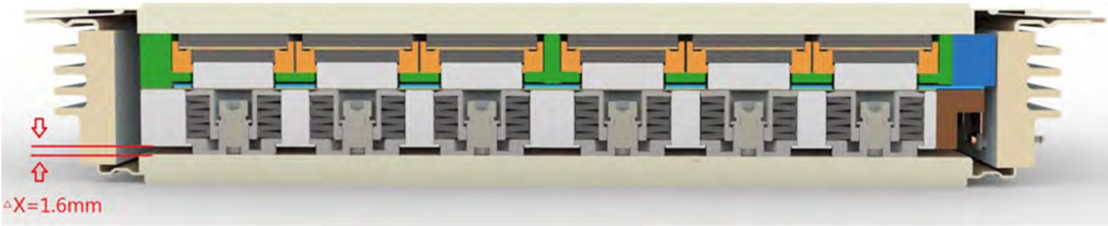

Fig.2.2 - The circuit configuration of CRRC Press-pack IGBT

2.3 Sub unit

CRRC uses 21mm×21mm large scale chips to produce sub units of Press-pack IGBT. Sub units employ silver sinter bonding technology to bond the adjacent molybdenum platelets to the chips.

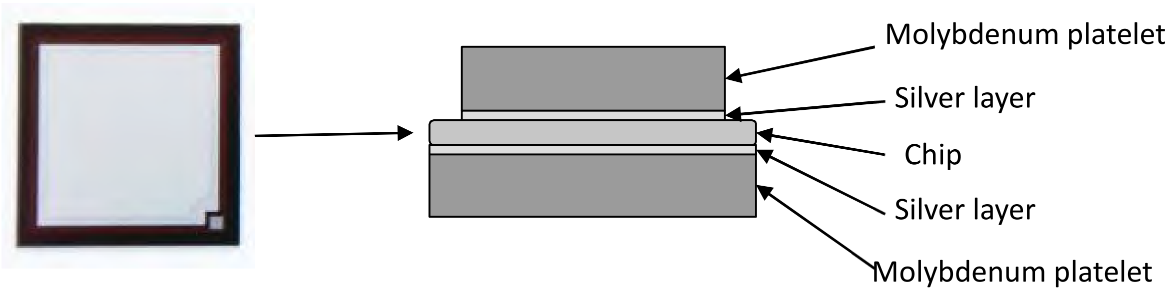

Fig.2.3 - The chip and sub unit of CRRC Press-pack IGBT

The combined chip and molybdenum platelets are framed by a high temperature and antiflaming plastic framework. The gates of IGBT chips are connected to a connecting PCB by spring pins.

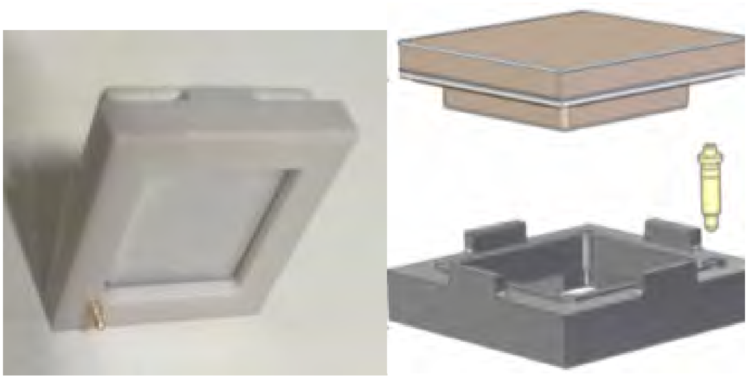

Fig.2.4 - The chip and sub unit of CRRC Press-pack IGBT

Specialized designs of gate connection PCB make sure the paths of each sub unit's gate are the same.

2.4 Clamping

The Fig.2.5 shows the clamping footprint of inner sub units and framework under 85kN. The effect of clamping is good for the device. And the corresponding outside clamping footprint is shown as Fig.2.6

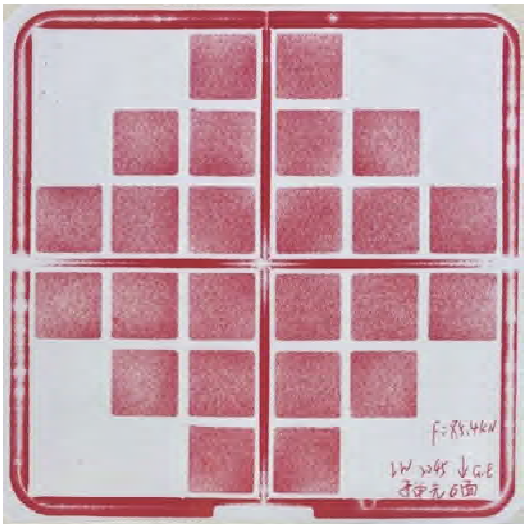

Fig.2.5 - The clamping footprint of inner sub units and framework under 85kN

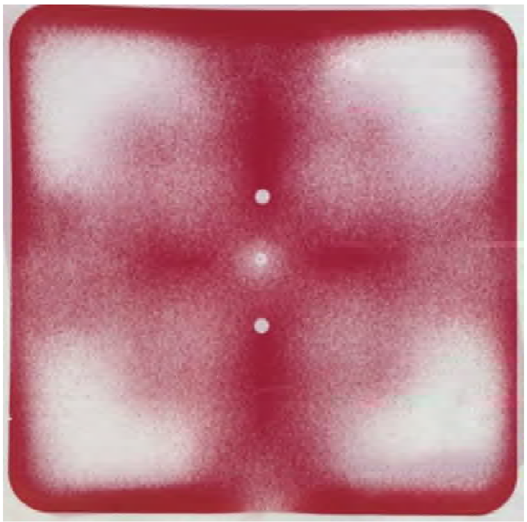

Fig.2.6 - The outside clamping footprint under 85kN

2.5 Thermal designs

CRRC did the thermal simulation and thermal resistance test for Press-pack IGBT, and get the thermal dissipation ratio of two sides of device.

$$R_{th(C)}: R_{th(E)} = 1:10.5$$

3. Rating

3.1 Press-pack IGBT datasheets

The definitions for most parameters given on a CRRC press-pack IGBT datasheet are the same as those given on a datasheet for CRRC's isolated-base IGBT modules. The significant difference, from a user's perspective, is in the mounting of the device.

3.2 Dynamic test

Dynamic test is an important way to help us to understand press-pack IGBT's dynamic behaviors. We usually use the double pulse test method, Fig.3.1 shows the test circuit topology of double pulse test and Fig.3.2 shows a dynamic test waveform.

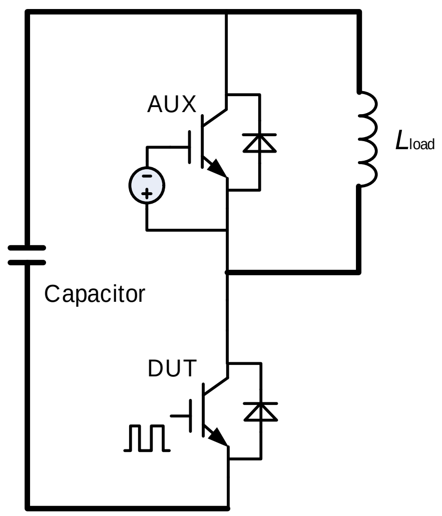

Fig.3.1 - Double pulse test circuit

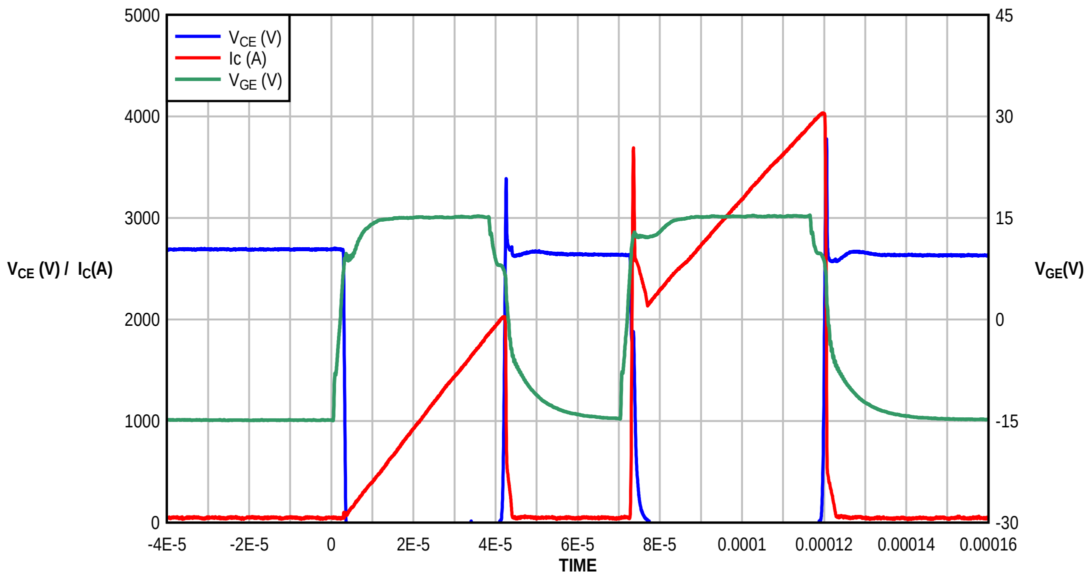

Fig.3.2 - Dynamic test waveform

3.3 Safe operating area

Safe-operating area ratings for CRRC's 4.5kV press-pack IGBT range permit operation with line voltages up to 3.4kV and guarantee the capability of the IGBT to turn off over-currents of up to twice the product's rated current at this line voltage.

CRRC press-pack IGBTs typically have ultimate capabilities far exceeding their datasheet ratings. To illustrate the robustness of CRRC's press-pack IGBT, the following examples are given.

3.3.1 IGBT reverse bias safe operating area (IGBT RBSOA)

Fig.3.3 shows a CRRC 2kA, 4.5kV press-pack IGBT (TG2000SW45ZC-P200) turning off 6kA – 3 times its rated current - at a line voltage of 3.4kV and a junction temperature of 125°C.

Fig.3.4 shows a CRRC 2kA, 4.5kV press-pack IGBT (TG2000SW45ZC-P200) turning off 4kA – 2 times its rated current - at a line voltage of 4.2kV, meanwhile, the module's over-voltage up to 4.5kV,and the junction temperature of 125°C

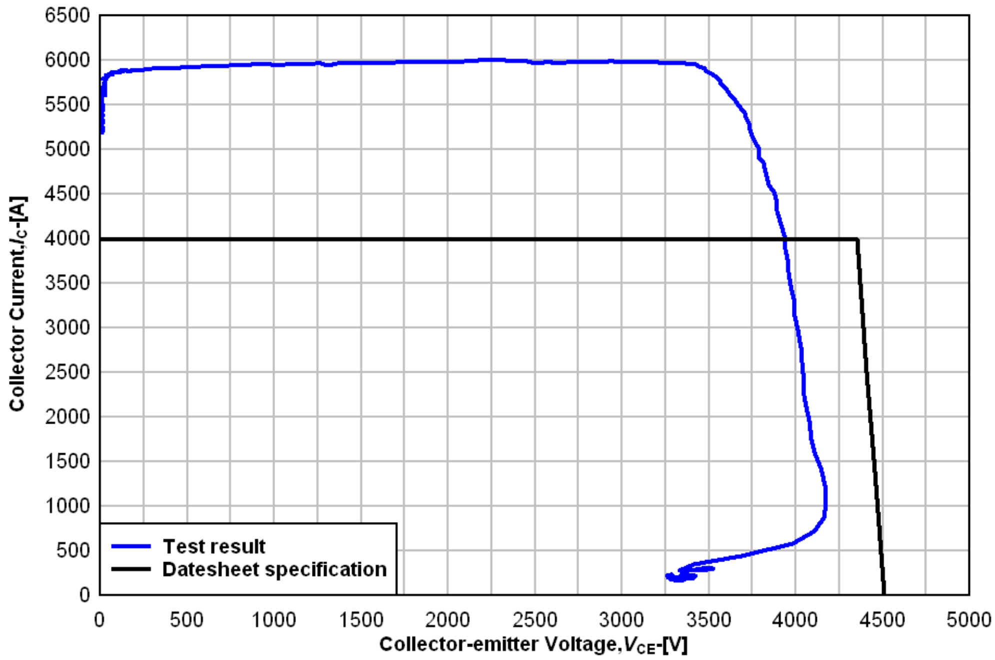

Fig.3.3 - IGBT RBSOA robustness – successfully turn-off of 6kA by a device rated at 2kA, 4.5kV (TG2000SW45ZC-P200)

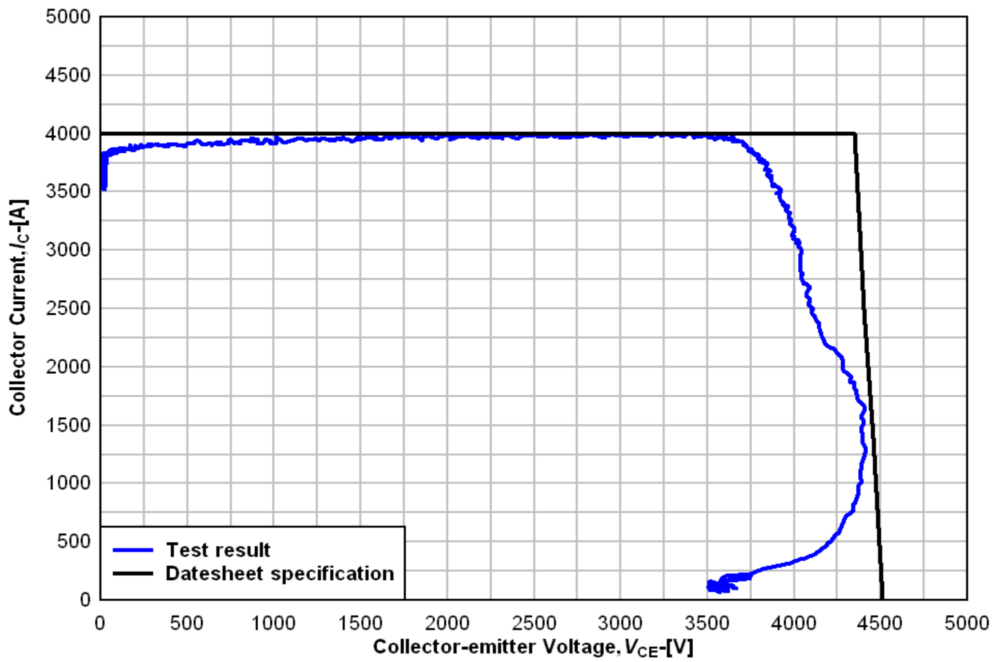

Fig.3.4 - IGBT RBSOA robustness – successfully turn-off of 4kA at 4.2kV test voltage by a device rated at 2kA, 4.5kV (TG2000SW45ZC-P200)

3.3.2 FRD reverse recovery bias safe operating area (FRD RBSOA)

Fig.3.5 shows a CRRC 2kA, 4.5kV press-pack FRD (TG2000SW45ZC-P200) doing reverse recovery at 5kA – 2.5 times its rated current - at the line voltage of 3.4kV and the junction temperature of 125°C (IGBT driver's turn-on resistor is 3Ω).

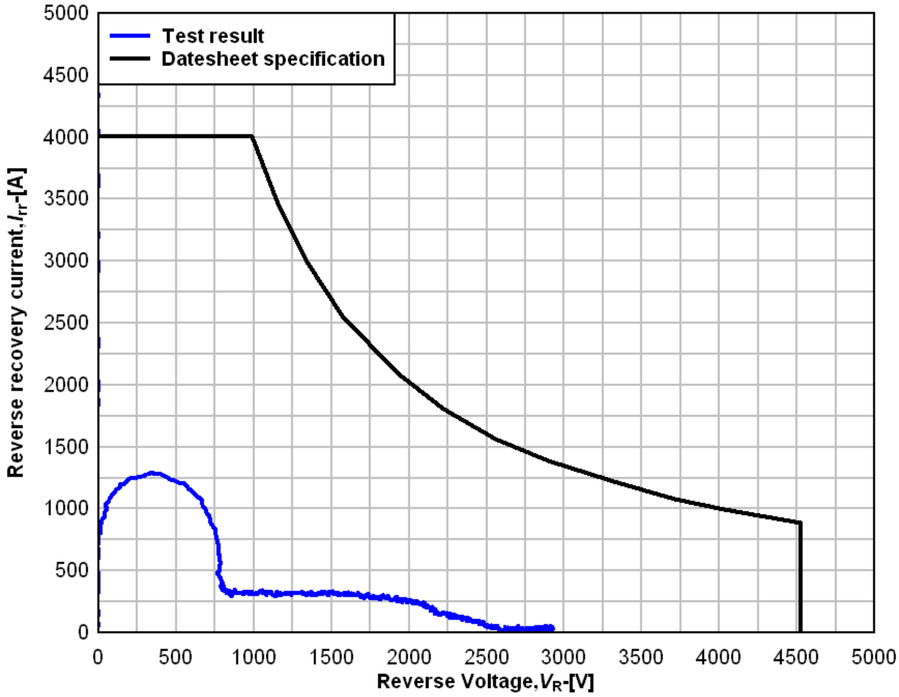

Fig.3.5 - FRD RBSOA robustness – successful reverse recovery at 5kA and 3.4kV Voltage level by a device rated at 2kA, 4.5kV (TG2000SW45ZC-P200)

3.3.3 Short-circuit safe operating area (SCSOA)

Fig3.6 shows a CRRC 2kA, 4.5kV press-pack IGBT (TG2000SW45ZC-P200) withstanding a type-1 short-circuit test performed at a line voltage of 3.4kV and a junction temperature of 125°C for a duration of 20μs – 2 times industry standard.

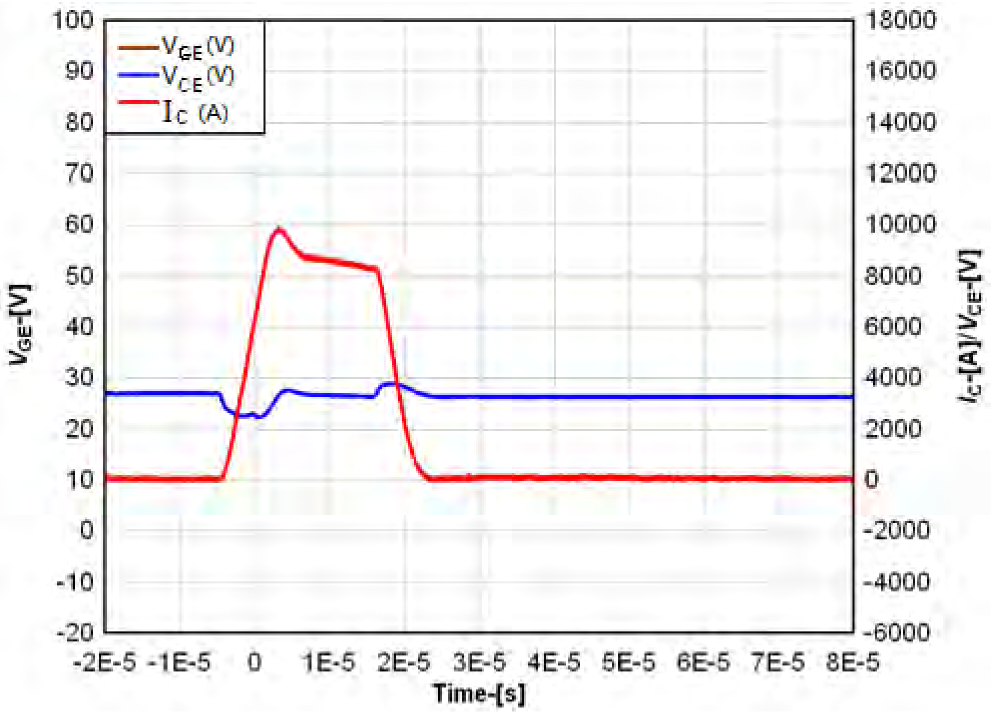

Fig.3.6 - IGBT SCSOA robustness – a 4.5kV, 2kA (TG2000SW45ZC-P200) device surviving a 3.4kV, 20μs short-circuit test.

4. Ability to Bear Current in Case of Failure

CRRC has performed tests to confirm that press-pack IGBTs were able to withstand current for a period of time after short circuit failure occurred. We packed two failed sub units into the test sample intentionally to simulate the situation of failure and subjected the sample to endurance test at I_C =1500A DC. Fig.4.1 shows the test circuit, Fig.4.2 shows the sample's V_{CE} variation with respect to test time.

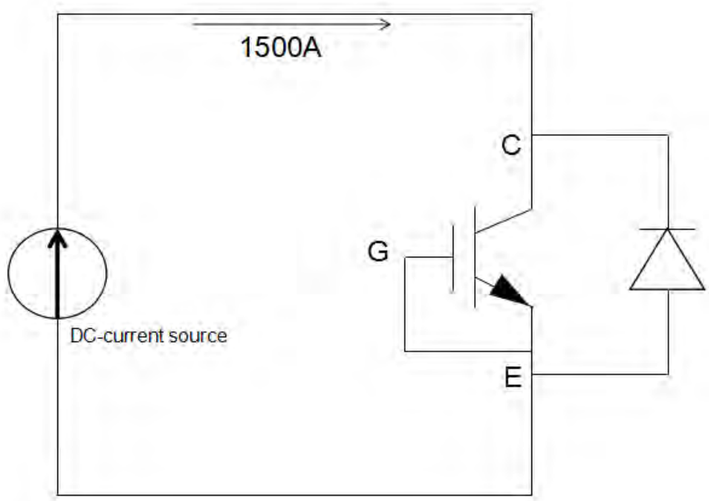

Fig4.1- The test circuit

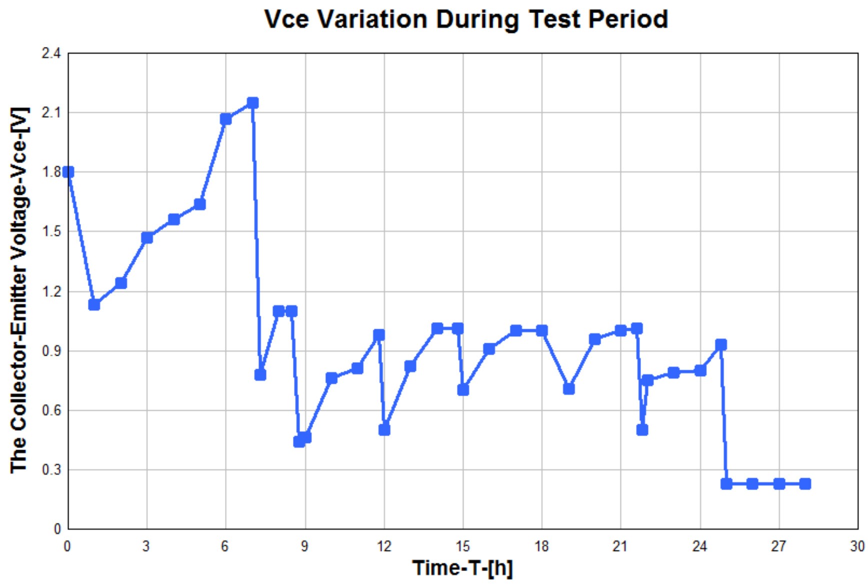

Fig4.2 - Vce variation during test period

5. Mounting instructions

5.1 Heat-sink mounting area properties

To achieve the specified performance of the device, the mounting surfaces should meet the following mechanical specifications:

- Flatness 20 micrometer (μm) over the sub-module area
- Flatness 100 μm over whole heat-sink
- Roughness Ra 1.6 μm

The heat-sink contact surfaces should be machined without ridges, steps or grooves.

5.2 Assembly

The semiconductor and heat-sink surfaces may first be lightly polished. Before assembly, the contact surfaces must be thoroughly cleaned. The assembly should be carried out in a clean environment free of dust and humidity as the surfaces must be kept clean during the whole assembly process. Heat-sink and semiconductor surfaces should not be touched with bare hands. We recommend the use of lint-free gloves for the handling of semiconductor devices and heat-sinks. The heat-sinks and IGBT should be handled with care to avoid scratches and other damage to the surfaces.

5.3 Electrostatic discharge (ESD) protection

IGBTs are sensitive to electrostatic discharge (ESD). All modules are ESD protected during transportation and storage. While handling the press-packs, the gate and auxiliary terminals should be short-circuited with the wire provided or with a metal strip to prevent damage by static charges. A conductive-grounded wristlet and a conductive-grounded working place are highly recommended during assembly.

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