US & Japan TG 4 activities of QA Forum

QA Task Force 4 : Diode, Hot Spot, Shading & Reverse Bias

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2014 Photovoltaic Module Reliability Workshop

(PVMRW) Golden, Colorado, February 25–26.

Overview

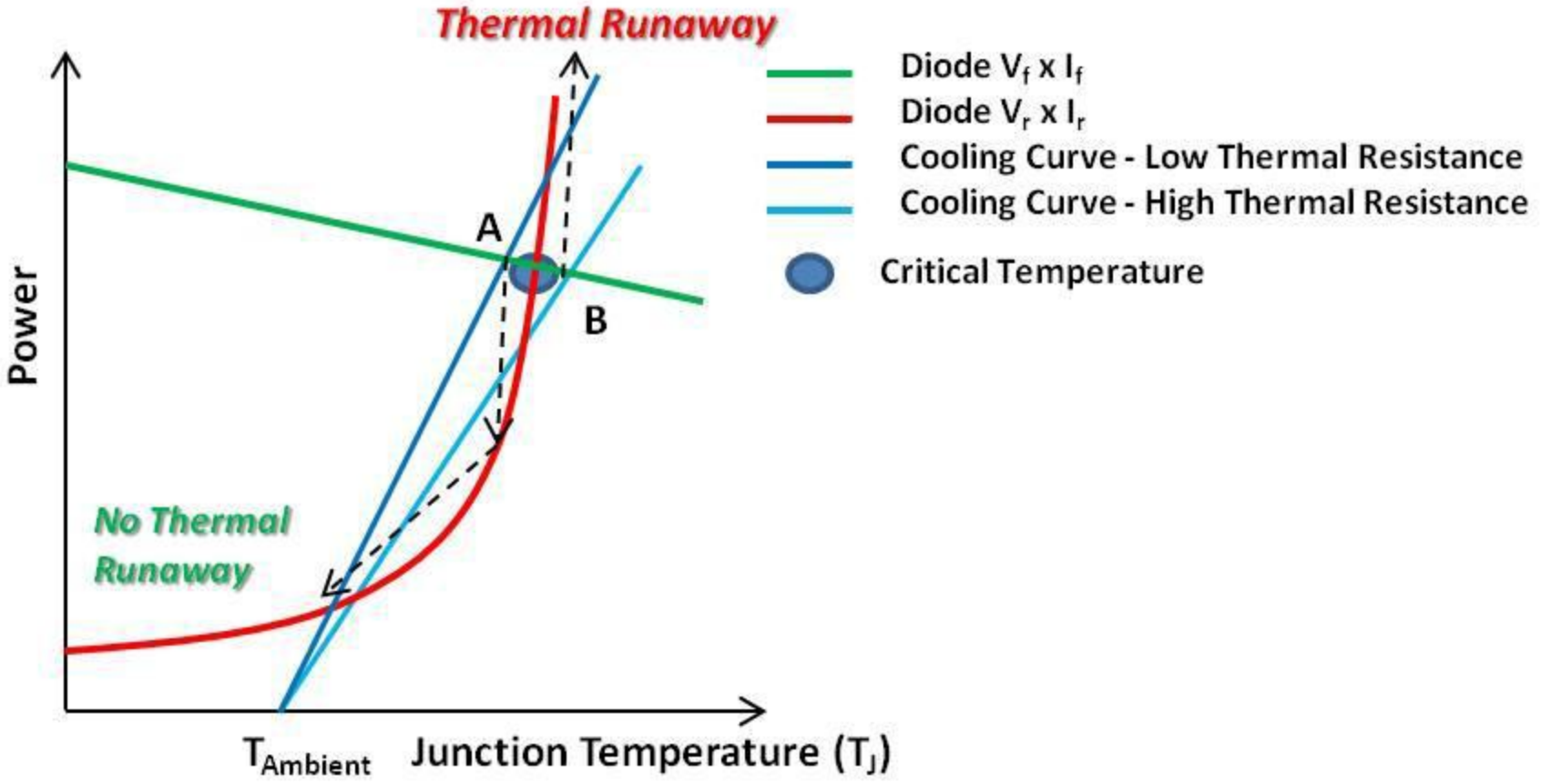
- History and Results
- Poster - Testing by the Japan Team (ESD, Diode, J-box & Module)
  - Y. Uchida (JET) & Y. Konishi (Onamba)
- Posters and papers - Testing at FSEC and Jabil (Thermal runaway model and experiments)
  - Narendra Shiradkar, Eric Schneller, Neelkanth Dhere
- Next steps

History

- 2011: Task Group 4 reviewed testing standards and identified potential gaps:
  - Accuracy of diode technical data sheet.
  - Qualification tests that ensure reliability.
  - *Electrostatic Discharge (ESD) susceptibility.*

- 2012: Task Group performed series of experiments
  - ESD testing HBM, MBD, IEC Model
  - Extended bypass diode tests
  - *HTRB and thermal cycling testing*
  - *Statistical and Weibull*

- 2013: Experiments and NWIP's
  - Thermal runaway tests and runaway models
  - IEC 62916 TS(Guideline) Bypass diode electrostatic discharge
  - NWIP for Thermal runaway from team in Japan is out for vote.


Thermal Runaway
Diode V_f x I_f
Diode V_r x I_r
Cooling Curve - Low Thermal Resistance
Cooling Curve - High Thermal Resistance
Critical Temperature
A
B
Power
No Thermal Runaway
$T_{Ambient}$
Junction Temperature (T_J)

International PV Module Quality Assurance Forum
Task-4 J-TG4

The proposal of thermal runaway test for bypass diode
Tj measurement method for bypass diode

(J-TG 4 activities of QA Forum / QA Task Force 4 ; Diode, Shading & Reverse Bias)

This presentation contains no confidential information.

This work was performed in cooperation with SHARP, Onamba, Nihon Inter Electronics and Sanken Electric.

Feb. 25-26, 2014 *@ Denver, USA*

Y. Uchida / JET (Japan Electrical & Environment Technology Laboratories)

1. The proposal of thermal runaway test for bypass diode

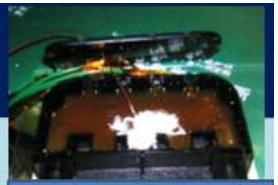
Current situation ;

NWIP draft for "Thermal runaway test for bypass diode" was submitted to TC82/WG2 on Jan. 18, 2014 and is expected to be discussed in the next WG2 meeting in June.

Scope and Purpose

This international standard provides a method for evaluating whether a bypass diode as mounted in the module is susceptible to thermal runaway or if there is sufficient cooling for it to survive the transition from forward bias operation to reverse bias operation without overheating.

Comparison results
between "Tcase method" and "Vf-Tj method"


Test sample

■ Tcase method

Tj = Tcase + Vf × If× Rth

Tcase : 95.6℃ (Temp. of diode's case)

Vf : 0.3391V

(Saturated voltage after 1h operating)

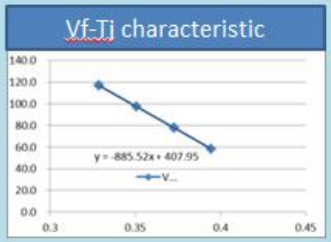
If : 9A (Forward current)

Rth : 1.5℃/W presented by manufacturer

Tj = 95.6(℃) + 0.3391(V) × 9(A)× 1.5(℃/W)

= 100.2℃

■ Vf-Tj method



Tj = -885.52 Vf + 407.95

= -885.52 × 0.3391 + 407.95

= 107.7 ℃

The Rth changes depending on where the diode is placed in the J-box.

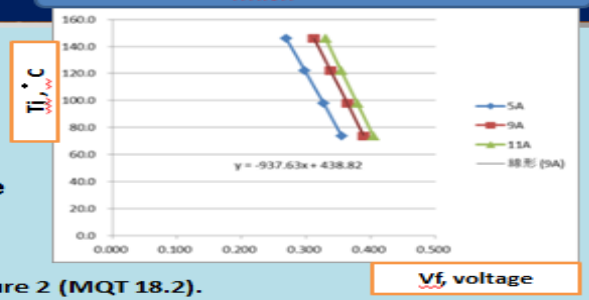
Conclusion of Tcase/lead method

Due to the Rth change and the Tcase/lead measurement error, the calculated value of the Tj has some error compared to the real Tj.

Therefore, the judgment by using Tj value which is calculated by Tcase/lead method is misleading !!!!!

Vf – Tj method

- Once Vf-Tj relation is obtained, Tj is easily and accurately decided from the value of Vf. Vf-Tj relation can be acquired by measuring the temperature of the lead and the voltage across the diode in thermal equilibrium condition.
- It is specified in IEC61215-2 Ed.1 draft / 4.18.2 Procedure 2 (MQT 18.2).
- To achieve this, the preparation of some special measuring equipment is required.



MODEL FOR PREDICTING THERMAL RUNAWAY IN BYPASS DIODES

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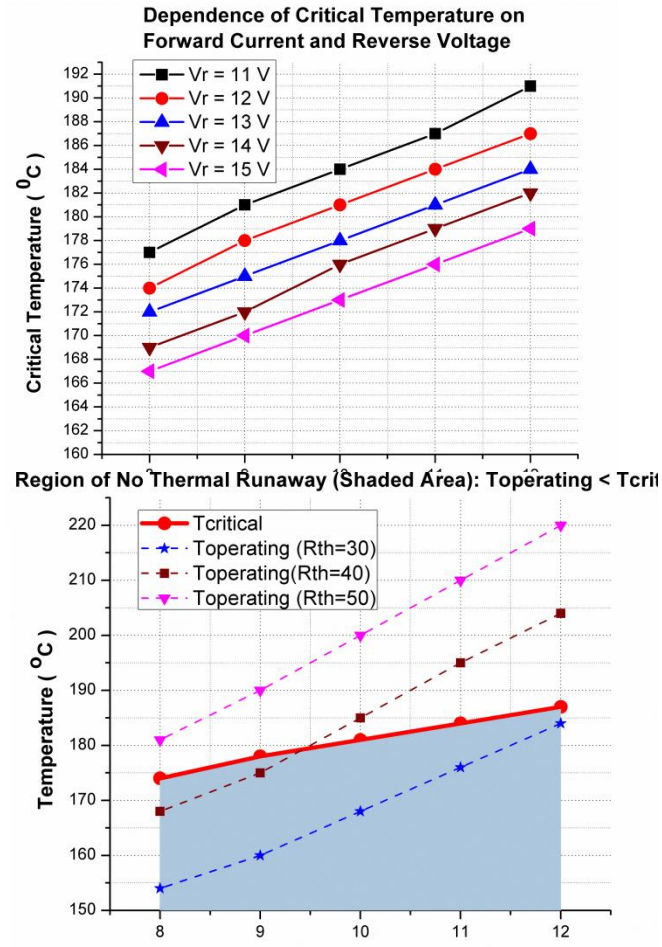

RECOMMENDATIONS

- The operating temperature of the diode at 1.25 x Isc during the bypass diode test in IEC 61215 can be used as an estimate for worst-case operating temperature.
- This information, along with the critical temperature data obtained by either of the described methods can be used to understand the vulnerability of bypass diode towards thermal runaway.
- Whenever necessary, the "thermal runaway test" can be carried out as an additional test.
- In order to avoid potential for thermal runaway, the diode should be operated several degrees below critical temperature as the region near critical temperature is experimentally found to be unstable.

Next activities

1. Preparation of special measuring equipment for establishing Vf-Tj relation to calculate Tj.
2. More tests to validate theoretical models related to critical temperature using different diode manufacturers. This can potentially result in a NWIP for guidance in diode selection.
3. Extended temperature soak tests. As performance and reliability is known to degrade with exposure to high temperatures for longer periods.
4. Evidence of diode failures in field has been observed by several group and the intent would be to investigate field diode failures to suggest relevant tests that can generate a NWIP within the next 6 months.
5. Make suggestions for qualification test protocols related to diode tests.

Thank you for your attention.