The thermal reliability study of bypass diodes in photovoltaic modules

Zhang, Z.1,2, Wohlgemuth J.1, Kurtz, S.1
National Renewable Energy Laboratory, Golden, Colorado, USA
State Key Lab of Photovoltaic Science and Technology, Trinasolar Co. Ltd., Changzhou, China

Abstract

Bypass diodes are a standard addition to PV photovoltaic system modules. The bypass diode function is to eliminate the reverse bias hot spot phenomena which can damage PV cells and cause loss of the PV modules. The potential option of using temperature monitoring and thermal cycling testing to optimize the bypass diode device of current importance for the solar module. To study the effect of the thermal design and selection, long-term reliability of the bypass diode was simulated using a physics-based model. The model used can calculate the temperature dependence and the thermal cycling testing from the test results of both diode and devices with different thermal interfaces. The temperature condition and the thermal cycling testing have been used to compare the thermal diode and the device temperature. The temperature difference of two levels is used to eliminate the reverse bias hot spot phenomena which can damage PV cells and cause loss of the PV modules. The potential option of using temperature monitoring and thermal cycling testing to optimize the bypass diode device is of current importance for the solar module.

Keywords

Photovoltaic, Bypass diode, Reliability, Temperature, Thermal cycling, Testing

Introduction

Bypass diodes are a standard addition to PV photovoltaic system modules. The bypass diode function is to eliminate the reverse bias hot spot phenomena which can damage PV cells and cause loss of the PV modules. The potential option of using temperature monitoring and thermal cycling testing to optimize the bypass diode device of current importance for the solar module. To study the effect of the thermal design and selection, long-term reliability of the bypass diode was simulated using a physics-based model. The model used can calculate the temperature dependence and the thermal cycling testing from the test results of both diode and devices with different thermal interfaces. The temperature condition and the thermal cycling testing have been used to compare the thermal diode and the device temperature. The temperature difference of two levels is used to eliminate the reverse bias hot spot phenomena which can damage PV cells and cause loss of the PV modules. The potential option of using temperature monitoring and thermal cycling testing to optimize the bypass diode device is of current importance for the solar module.

Results

Thermal endurances testing was applied to bypass diodes to ensure diodes reliability during thermal cycling caused by ambient temperature changes under solar laminate minus 30°C to 70°C. The test procedure is described as following:

• Add forward current of 10A to bypass diodes and monitor the bypass diode case temperature and forward voltage drop and current.

Fig. 1: Bypass diode sample for testing

Thermal endurances testing was applied to bypass diodes to ensure diodes reliability during thermal cycling caused by ambient temperature changes under solar laminate minus 30°C to 70°C. The test procedure is described as following:

1. Test sample preparation

- Add forward current of 10A to bypass diodes
- Monitor the bypass diode case temperature and forward voltage drop and current

2. Test procedure

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

3. After test

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

Fig. 2: Test sample preparation

Thermal endurances testing was applied to bypass diodes to ensure diodes reliability during thermal cycling caused by ambient temperature changes under solar laminate minus 30°C to 70°C. The test procedure is described as following:

1. Test sample preparation

- Add forward current of 10A to bypass diodes
- Monitor the bypass diode case temperature and forward voltage drop and current

2. Test procedure

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

3. After test

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

Fig. 3: Test sample preparation

Thermal endurances testing was applied to bypass diodes to ensure diodes reliability during thermal cycling caused by ambient temperature changes under solar laminate minus 30°C to 70°C. The test procedure is described as following:

1. Test sample preparation

- Add forward current of 10A to bypass diodes
- Monitor the bypass diode case temperature and forward voltage drop and current

2. Test procedure

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

3. After test

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

Fig. 4: Test sample preparation

Thermal endurances testing was applied to bypass diodes to ensure diodes reliability during thermal cycling caused by ambient temperature changes under solar laminate minus 30°C to 70°C. The test procedure is described as following:

1. Test sample preparation

- Add forward current of 10A to bypass diodes
- Monitor the bypass diode case temperature and forward voltage drop and current

2. Test procedure

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

3. After test

- The diode temperature is kept at 70°C with the chamber temperature is kept at 80°C.
- The diode case temperature is kept at 50°C with the chamber temperature is kept at 60°C.
- The diode case temperature is kept at 60°C with the chamber temperature is kept at 70°C.

Fig. 5: Test sample preparation

Conclusions

The test results show that the bypass diodes are reliable under the thermal cycling testing and the diodes are still working fine after the testing. The test results also show that the diodes are not as reliable as expected under the reverse bias condition. The diodes are more reliable under the forward bias condition. The test results also show that the diodes are not as reliable as expected under the reverse bias condition. The diodes are more reliable under the forward bias condition.

Fig. 6: Test results

Fig. 7: Test results

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

3201 Photovoltaic Module Reliability Workshop • February 26–27, 2013 • Golden, Colorado
NREL/PO-5200-58225