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著者	Watanabe Akihiko, Tsukuda Masanori, Omura Ichiro
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Real Time Monitoring System for Internal Process to Failure of High Power IGBT

Akihiko Watanabe[1], Masanori Tsukuda[1,2] and Ichiro Omura[1]

[1] Kyushu Institute of Technology
1-1 Sensui, Tobata-ku, Kitakyushu, Fukuoka 804-8550, Japan
Phone: +81-93-884-3298 E-mail: nave@elcs.kyutech.ac.jp
[2] The International Centre for the Study of East Asian Development
1-8 Hibikino, Wakamatsu-ku, Kitakyushu, Fukuoka 808-0138, Japan

Abstract

A real time failure analysis system for widely used high power IGBT modules is proposed, which enables to inspect internal process to failure of the devices under power stress test as a movie. This system was realized by combining a scanning acoustic tomography (SAT/SAM), power stress controlling, device cooling, water jet system and chip temperature monitoring. This system successfully obtained internal images of a DUT under the load current of 200A.

1. Introduction

Downsizing of power semiconductors increases their productivity and enable huge volume manufacturing. On the other hand, it increases power density of the devices and maximizes reliability risk of them. In this situation, failure mechanism base reliability assessment would be important to minimize reliability risk of power semiconductors. As one of the failure analysis techniques, a "real time" monitoring of internal process to failure of a device under test (DUT) give us useful information for the reliability assessment.

In this paper, a real time failure analysis system for high power IGBT modules is proposed, which enables to inspect internal process to failure of the devices under power stress test as a movie.

2. Components of the system

The main components for the proposed system were a) inside imaging of DUT, 2) high power stress control, 3) device cooling and 4) chip temperature monitoring as shown Fig. 1. Scanning acoustic tomography was employed as an imaging tool for internal process of DUT. The SAT is widely used for the failure inspection of the power devices by means of non-destructive imaging [1-8]. The DUT was attached to the view window at the bottom of an original water tank because couplant water for ultrasonic wave propagation is necessary for SAT imaging (Fig. 2).

Power stress was applied to the DUT by a 16 kW DC power supply which controlled by a PC. A switching box was inserted between the output of the power supply and DUT to separate them completely when the power stress was turn off. The temperature of DUT surface was controlled by the couplant water. Water cooled by a chiller was lead to a radiator attached to the bottom of the water tank and the radiator cooled down the couplant water in the tank. The cooled water in the tank was flowed to the DUT surfaces with water jet generated by a pump and a jet nozzle and kept the DUT surface temperature. The water jet also suppressed a local convection at the surface by self-heating of DUT which degrade the SAT image.

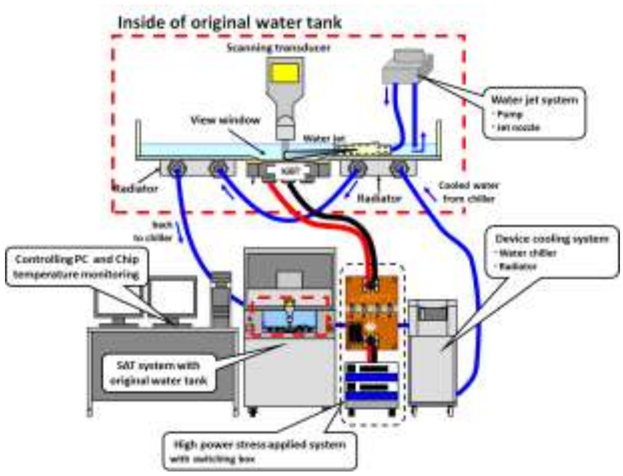

Fig. 1 The components of the system

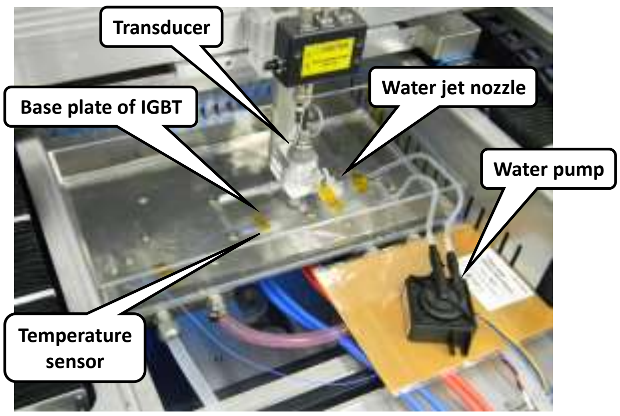

Fig. 2 DUT Setup

3. Real time monitoring of high power IGBT

The demonstration was performed with an IGBT mod-

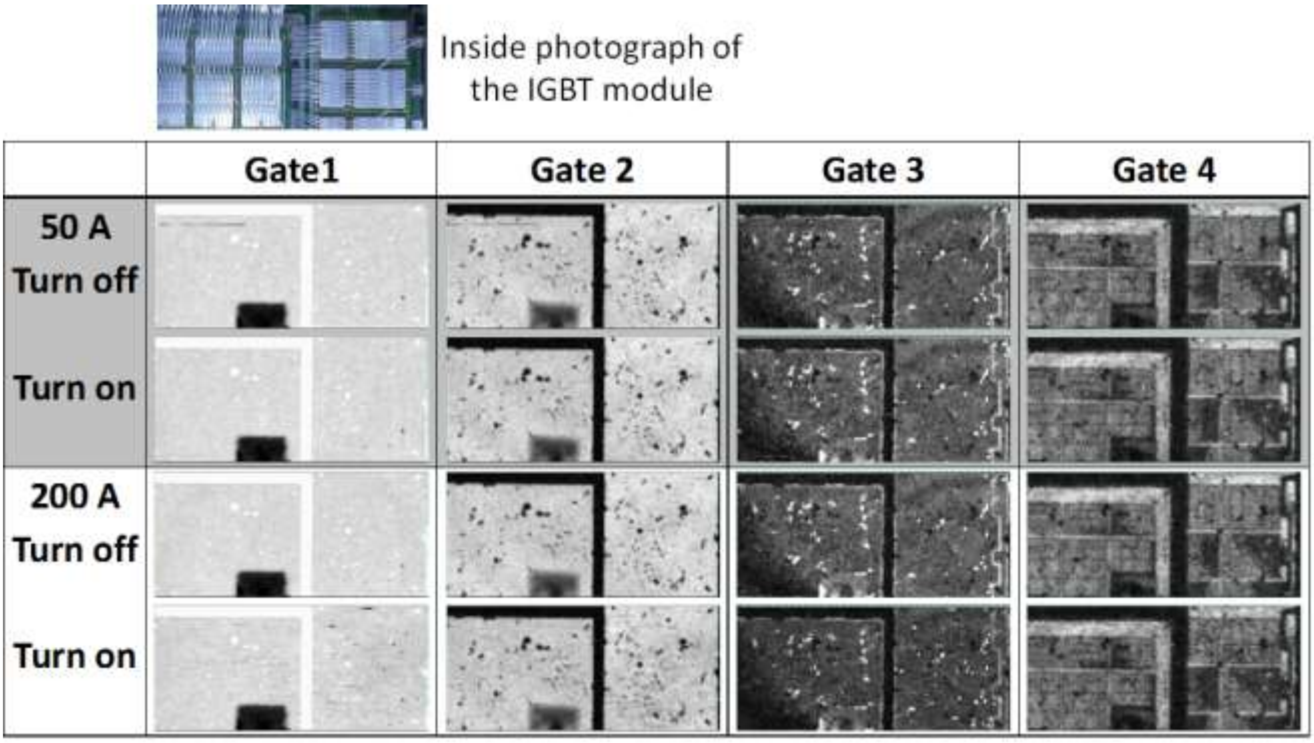

Fig. 3 SAT images of the DUT obtained under the different load current. The biased high-side chip is observed in the right side region of each image. The inside photograph is upset the top and bottom to adjust to the SAT image observed from the base plate substrate. A rectangular shadow in the bottom center in the SAT image is a shadow of an adhesive tape to settle the temperature sensor.

ule which maximum rating of collector current was 400 A. A constant gate-emitter voltage of 15 V was applied to only the high-side IGBT and the high-side emitter was connected to the earth. The load current to the collector was switched by the DC power supply with a programmed sequence.

Fig. 3 shows SAT images of the DUT obtained under the different load current. Four acquisition gates of echo wave reflected by different interfaces inside the IGBT were configured from the base plate substrate surface to the chip. It took 16 second to obtain one frame of the SAT image of 75 mm × 35 mm region with 0.5 mm pitch, therefore the load current sequence was configured 30 second turn-on and -off cycle. Comparing with the images under the load current was turn-on and -off, any remarkable image degradation was not recognized even under the 200 A load current flow. This result is also confirmed by the fact that the quality of image is not differ between at the biased high-side region and at the low-side region under the 200 A load current flow.

4. Conclusions

A real time monitoring system for high power IGBT modules is proposed. The system enables to inspect internal process to failure inside DUT as a movie even under high power stress. The demonstration with IGBT module successively obtained the inside image of DUT of 75 mm × 35 mm region with 0.5 mm pitch with 4 frames / minute. No-degradation of images was observed even under the load current of 200A flow.

Acknowledgements

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