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# Applying of RC-IGBT using 300mm wafer to consumer use

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## Abstract

To improve productivity on semiconductor manufacturing processes enables to accelerate countermeasure for global warming. By changing wafer diameter from 200mm to 300mm, the productivity can be improved twice simply. Conventional RC-IGBT is applied 200mm wafer and is already installed to our SLIMDIP to achieve compact and inexpensive home appliance inverter system worldwide. RC-IGBT which is produced using 300mm wafer is installed in SLIMDIP as first trial. This paper introduces initial evaluation results that are equivalent to conventional electrical test results.

## 1 Introduction

The use of inverters to control motors in home appliances such as air conditioners, washing machines and refrigerators has increased significantly to improve their energy-saving efficiency and performance in recent years due to reduce of global warming. In particular, power semiconductors are highly expected as one of key technologies to contribute to the improvement of energy efficiency. Among power semiconductors, RC-IGBT (Reverse Conducting IGBT) has attracted attention as a power device that greatly contributes to making power modules smaller and lighter. [1] [2] By adopting RC-IGBT, our SLIMDIP achieves approx. 30% compact and light weight to compared with conventional Super Mini DIPIPM. SLIMDIP is becoming new de-facto-standard module in home appliance inverter system worldwide. [4] [5] [6] SLIMDIP is showed Fig.1.

**Fig.1** SLIMDIP

The conventional RC-IGBT has been produced using 200mm wafer, but it is planned to start mass production using 300mm wafer which have high productivity efficiency. [3] It is planned to first apply RC-IGBT using 300mm wafer to SLIMDIP because it is necessary to accelerate countermeasure for global warming by improving productivity. Therefore, this paper introduces initial evaluation results that are equivalent to conventional electrical test results.

## 2 RC-IGBT comparisons between 200mm and 300mm wafers

600V/15A RC-IGBT of 200mm and 300mm were produced and their electrical characteristics were compared. The different points are described in Table 1.

**Table 1**. Different points each wafers

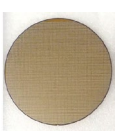
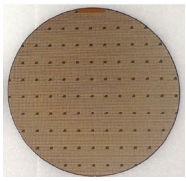
| Items | Conventional | New |
|---|---|---|
| Wafer size | 200mm | 300mm |
| Process | A | B |
| Machine | A | B |
| Picture |  |  |

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Fig.2 and 3 show the probability distributions of $V_{CE(sat)}$ and $V_F$ of a single wafer. Devices made by high performance equipment for 300mm wafer process show small in-plane wafer variation despite the larger wafer size. This was made possible by new high-performance equipment and new process technology at the new plant. [7]

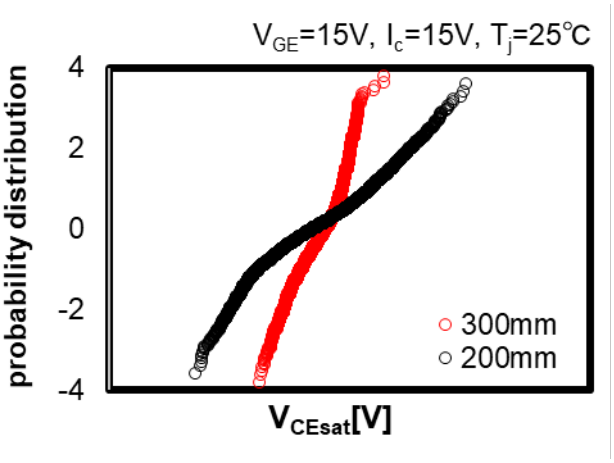


**Fig.2** $V_{CE(sat)}$ probability Distribution

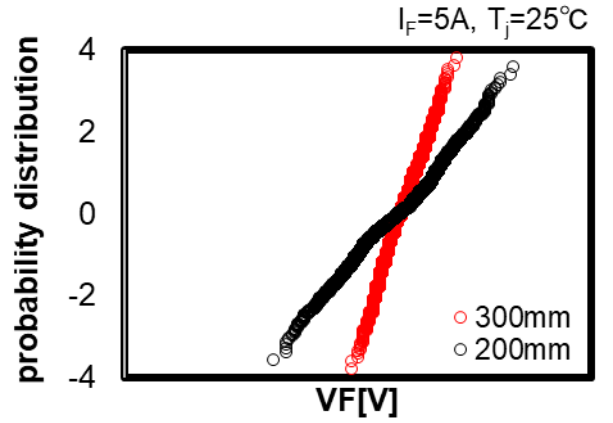


**Fig.3** $V_F$ probability Distribution

# 3 SLIMDIP comparisons between 200mm and 300mm wafers

## 3.1 Static characterstics

SLIMDIP was fabricated using the above RC-IGBT of 300mm wafer. Both SLIMDIP devices which install RC-IGBT using 300mm and 200mm wafers were tested and the static characteristics are shown in Fig.4 and Fig.5 respectively. Fig.4 shows $V_{CE(sat)}$ vs Ic and Fig.5 shows $V_{EC}$ vs -Ic at junction temperature Tj=125°C with conventional limitation values at 15 A. As the results, the static characteristics are within the limitation values, so it can be said that the changes are acceptable.

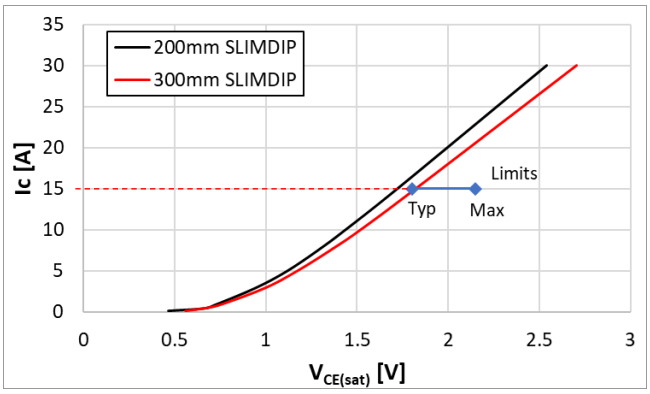


**Fig.4** $V_{CE(sat)}$ vs Ic at Tj=125°C

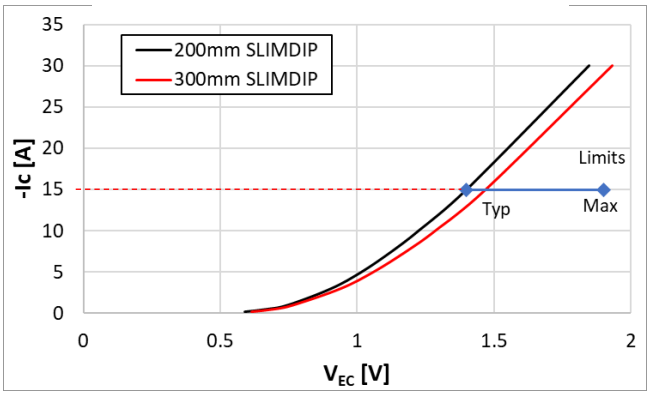


**Fig.5** $V_{EC}$ vs -Ic at Tj=125°C

## 3.2 Switching characterstics

Fig.6 shows the switching characteristics of Psw(on) and Psw(off) under the condition that DC link voltage is 300V, control supply is $V_D$=15V, junction temperature is Tj=125°C. Further, Fig.7 shows the switching waveform of turn-on and Fig.8 shows the switching waveform of turn-off under above condition at Ic=15A. The switching waveforms of both SLIMDIPs are overlaid. The switching waveform and switching characteristics could be confirmed similar.

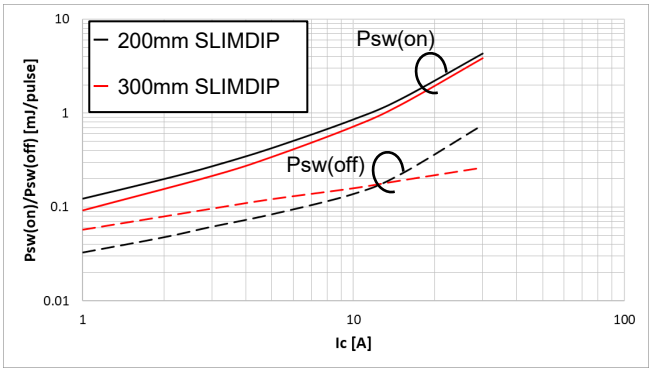


**Fig.6** Switching characteristics

Conditions: Vcc = 300V, $V_D$ = 15V, $V_{IN}$ = 0⇔5V, Inductive Load, Tj=125°C

 

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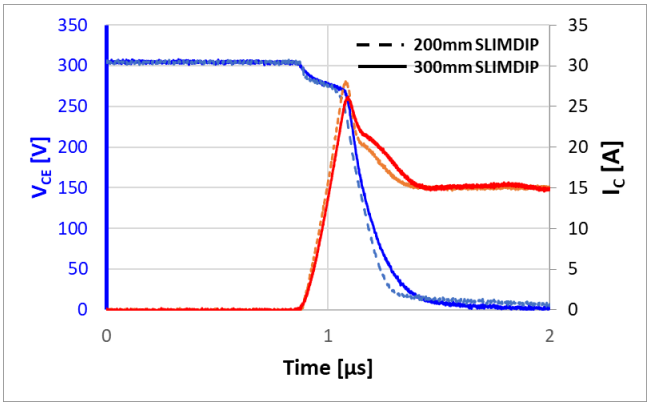


**Fig.7** Switching waveform of turn-on

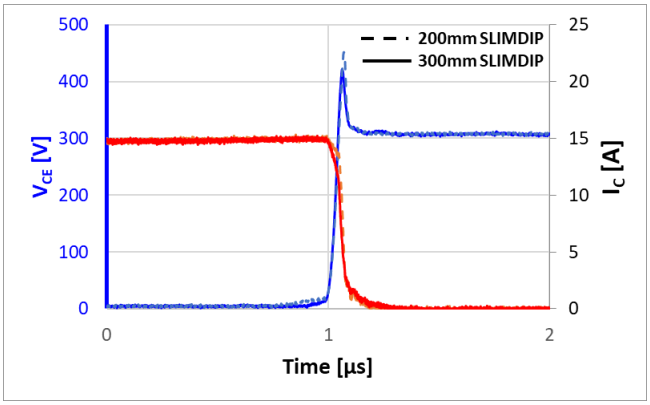


**Fig.8** Switching waveform of turn-off

## 3.3 Power loss simulation

Fig.9 shows the result of loss simulation results under one of air conditioner operating conditions. The graph shows that their total power loss are within 2% difference and SLIMDIP with 300mm wafer RC-IGBT has enough equivalency to conventional SLIMDIP.

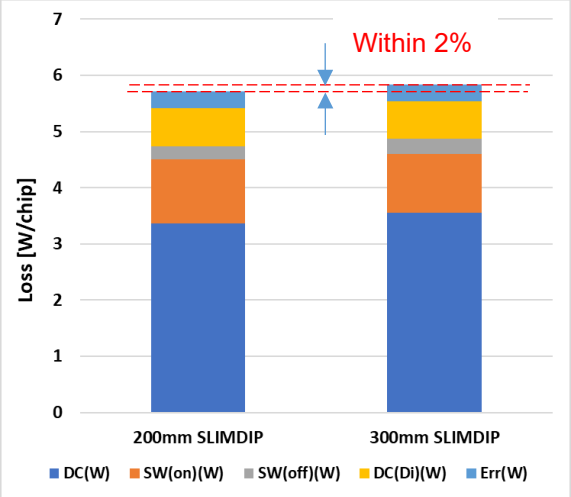


**Fig.9** Loss simulation results
Conditions: Sinusoidal modulation, Vcc=300V, Io=7.0Arms, $V_D$=15V, fc=5kHz, PF=0.8, M=1.0

## 3.4 Radiated noise

Radiated noise during motor operation with conventional SLIMDIP and SLIMDIP with 300mm wafer RC-IGBT were tested under the condition that motor current is 1.5Arms, DC link voltage is 300V to IPM and carrier frequency is 5kHz. Fig.9 shows the result of radiated noise comparison. The radiated noise profiles in Fig.10 show that SLIMDIP with 300mm wafer RC-IGBT has a more 5dB reduction from conventional SLIMDIP. Until now, noise tended to worsen as switching speed was increased to reduce loss. However, by adjusting the profile inside the chip, it was realized to reduce noise without worsening loss. [8] [9] By applying the above techniques, SLIMDIP with 300mm wafer RC-IGBT was able to achieve reduced radiated noise with the same level of loss.

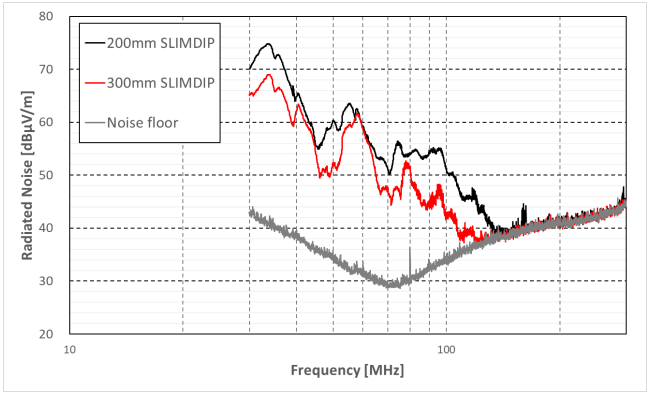


**Fig.10** Radiated noise profile during motor operation

# 4 Conclusion

This paper introduced the initial evaluation result of electrical characteristic comparison between SLIMDIP using 200mm wafer and 300mm wafer. Among them, it was shown that (1) the variations of electrical characteristics of $V_{CE(sat)}$ and $V_F$ were suppressed, and (2) the loss was almost same when installed in SLIMDIP. In near future, SLIMDIP equipped with RC-IGBTs using 300mm wafers will contribute to countermeasure of global warming.

* SLIMDIP is a trademarks of MITSUBISHI ELECTRIC CORPORATION.

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