The 62Pak IGBT module range employing the 3rd Generation 1700V SPT++ chip set for 175°C operation

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Abstract
In this paper, we present a newly developed 1700V IGBT and diode chip set with optimized performances for high temperature operations. The latest generation of ABB's planar 1700V IGBT (SPT++) has been improved by introducing a new termination concept and silicon design. Diode leakage current at 175°C has been significantly reduced by introducing the field shielded anode concept and still keeping the same electrical characteristics of the previous ultra-soft SPT+ diode platform. All mentioned features enable the development of a 1700V module rated 300A 62Pak operating on -40°C to 175°C junction temperature range with low losses and high Safe Operating Area (SOA).

Synopsis
In the last few years the trend toward higher output powers in combination with the requirement of higher power handling margins is pushing the development of power devices able to be operated up to 175°C junction temperature.

The new 1700V IGBT uses the (soft punch through) SPT++ technology, which offers 250mV lower on-state voltage drop for the same current density when compared to the previous SPT+ generation (Fig.1) [1]. The optimization of the termination results in a significantly reduced leakage current and enables now 175°C operation of the IGBTs. The enhancement layer at the cell has been optimized and tailored to the n-base material doping. These factors generate an excellent ruggedness while keeping the static blocking margins.

The field shielded anode concept [2] has been introduced to the 1700V diode (Fig. 1). The plasma has been shaped for low forward-voltage drop and soft reverse-recovery by using both local and uniform lifetime control. The deep buffer anode at the front side is supporting the electrical field during blocking and separates it from the defect of the local lifetime control. Hence the leakage contribution originating from the deep levels is eliminated and the diode can be operated at 175°C.

This high temperature chip set has been specifically optimized to suit the standard industrial 62mm package offering full Tvj=175°C operation. The IGBT is characterized by soft and well-controllable turn-on and turn-off switching Fig. 2. The IGBT exhibits controlled switching characteristics as well as short current tails. In Fig.4 the module-level RBSOA test is shown where a current of more than 1800A is turned off at a DC-link voltage of 1300V proving the ruggedness of the SPT++ IGBT-design when used in the 62Pak module. Figures 3 and 5 show the diode reverse recovery SOA measured respectively at either nominal condition or under severe SOA conditions with a very high commutation speed exceeding the typical dI/dt by a factor of 2.

Special care has been taken to develop a reliable 62mm module which is demonstrated with the intermittend operating life test operated at high frequency to stress the bond-wire

connection at the front side of the chips. The direct comparison to a reference device shows the benmarking capability of this module.

Conclusion

In this paper the new ABB 1700V SPT++ IGBT and diode chip-set for high temperature operation will be presented. This chip-set has been used in a new high temperature 1700V 300A 62Pak which shows excellent electrical static and switching performances with low losses and soft current transients. The optimizations of the IGBT passivation process and a new diode anode concept are demonstrated.

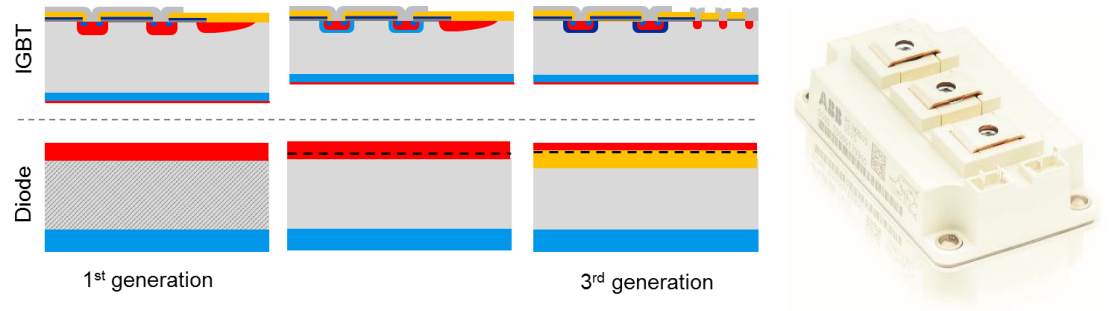

Figure 1. Schematic drawing for the various IGBT and diode generations & test vehicle for electrical and reliability characterization.

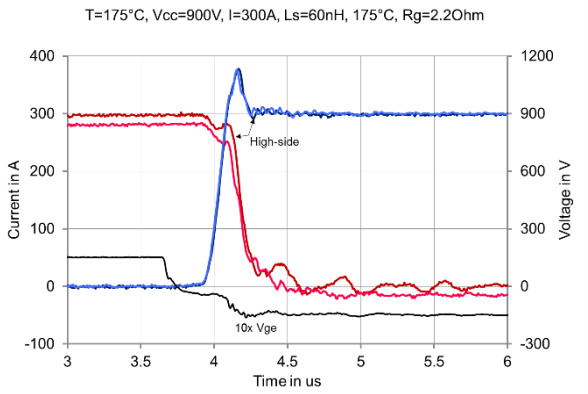

Figure 2. IGBT turn-off under nominal conditions.

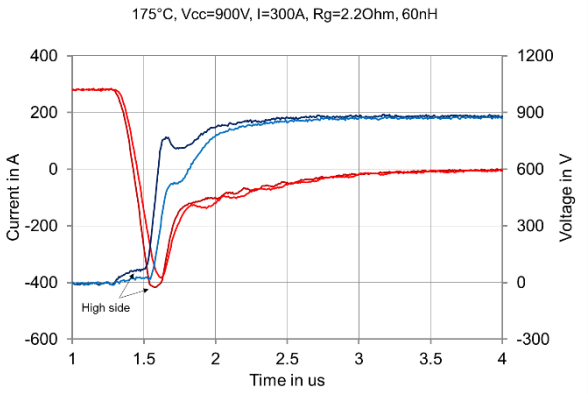

Figure 3. Diode turn-off under nominal condition and elevated temperature of 1

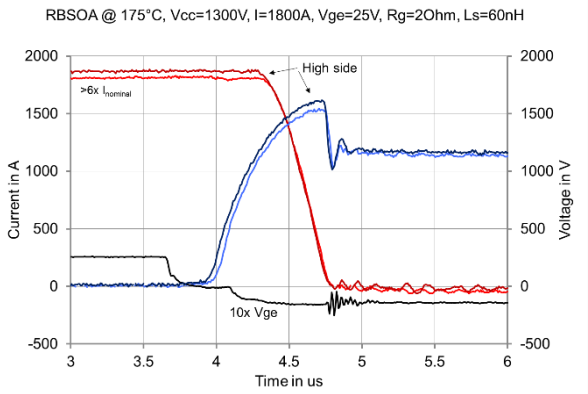

Figure 4. Schematic drawing for the various IGBT and diode generations & test vehicle for electrical and reliability characterization.

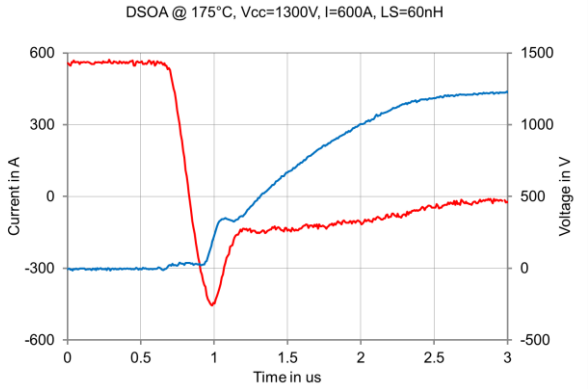

Figure 5. Diode turn-off under harsh conditions. The commutation speed dI/dt is beyond 5kA/µs which is twice as high as under nominal operation conditions at 175°C and the recommended gate resistor of 2.2Ohm.

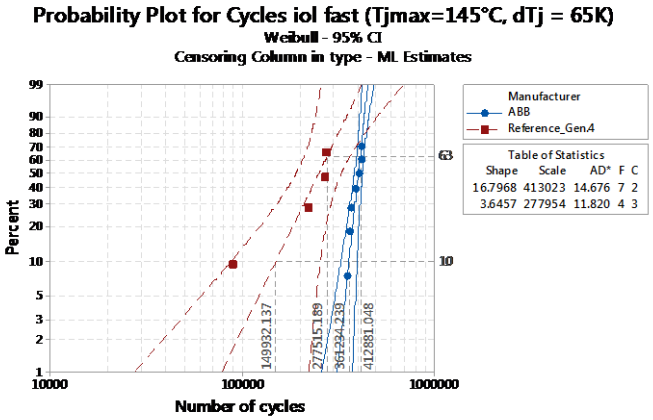

Figure 6. IGBT turn-off under nominal condition

References

[1] M. Rahimo, A. Kopta, S. Linder, “Novel Enhanced-Planar IGBT Technology Rated up to 6.5kV with Lower Losses and Higher SOA Capability”, Proc. ISPSD’06, Napoli, Italy, June 2006.

[2] S. Matthias, J. Vobecky, C. Corvasce, A. Kopta, and M. Cammarata, “Field Shielded Anode (FSA) concept enabling higher temperature operation of fast recovery diodes,” in Proc. IEEE ISPSD, San Diego, CA, 2011, pp. 88–91