Contact Strategies for SiC Power Devices

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The necessity to reduce the environmental footprint of human activity, expressed in the Paris agreements in 2015 (COP21), is prompting governments to turn their attention to more respectful and responsible energy consumption. To achieve the reduction objectives of greenhouse gas emissions, key resolutions focus on improving the energy efficiency of electrical systems and the electrification of transportation. In this context, largely driven by Electrical Vehicle (EV) market, development of new semiconductors for power applications, that improve power efficiency compared to silicon, is a key issue. Today, Silicon Carbide (SiC) is the wide bandgap semiconductor, working under a high temperature and high power, that leads the market, with Gallium Nitride (GaN) as emerging competitor. Junction Bipolar Schottky (JBS) diodes and MOSFET transistors, that are the widespread elementary devices in any SiC-based power systems, are realized in the well-established 4H-SiC polytype and most of the famous brands embed in their EV these SiC-based power devices. To improve quality, reliability and efficiency of the power systems, contacts on SiC devices is one of the major milestones.

In this work, using a JBS diode as an ideal test vehicle, we will review both the Schottky and ohmic contacts used in 4H-SiC devices and the associated progresses. Recently, the new generations of 4H-SiC devices are fabricated on thinned wafers to significantly reduce substrate contribution to the R_{ON} in vertical topologies and improve their power efficiency. But the use of thinned wafers has a large impact on the device fabrication flow. Therefore, for vertical devices, the ohmic contact, that is classically fabricated using rapid thermal annealing (RTA), is no more a solution. In the last years, the device improvement, requiring fabrication modifications, has been carried out using laser thermal annealing (LTA). Indeed, LTA is mandatory to fabricate ohmic contact due to the low substrate temperature elevation that must be achieved in the process flow.

In the presentation, we will mainly focus on LTA advances for SiC vertical devices, going from the better understanding of ohmic contact by the means of TCAD simulations up to their physical characterization and electrical performance consecutive to laser irradiation [1–3].

References

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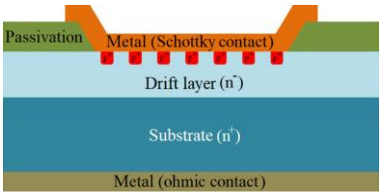
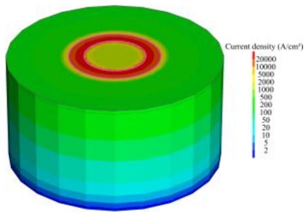


(a)



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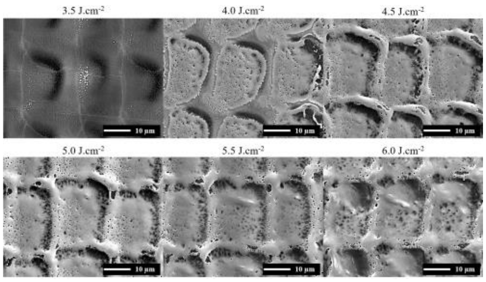

(c)

Fig. 1: (a) Example of 4H-SiC JBS structure, (b) 3D simulation of a c-TLM structure, (c) SEM images of Ni LTA annealed at fluences between 3.5 and 6.0 J cm^{-2}.

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