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► **To cite this version:**

Bertrand Vergne, Sigo Scharnholz, Dominique Planson, Dominique Tournier, Pierre Brosselard. Precise Automated Semiconductor Characterization under Ambient Control for testing wide band gap semiconductors. International Symposium on High Voltage Engineering (ISH) 2015, Aug 2015, Pilsen, Czech Republic. hal-02428642

HAL Id: hal-02428642

<https://hal.science/hal-02428642>

Submitted on 6 Jan 2020

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Precise Automated Semiconductor Characterization under Ambient Control for testing wide band gap semiconductors

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Keywords: wide band gap semiconductor, silicon carbide, diamond, automatic testing, vacuum system, high-voltage techniques

Nowadays, power electronics are growing towards better efficiencies and most of all higher voltages for higher power distribution or use. At the same time, wide band gap semiconductors are becoming more and more within our reach. Diamond and silicon carbide technologies are the ones that will replace our traditional silicon devices in renewable energy production, HVDC networks, smart grids, high energy physic experiments and some niches applications. These new incoming devices like diodes, thyristors, transistors or IGBTs made of high voltage material will unlock new features as a wider usable temperature range, a faster switching speed, a reduce number of components and lower electrical losses. These high voltage devices can cover the range from 3 300 V up to 20 kV and more [1]. However, designing and processing such components implies that they need to be characterized. It is not possible to wait a packaged component to start analyzing its performances in regards to their cost and new processes or new designs involved. As a consequence, these new technologies need a constant evaluation during their manufacturing process. One of these evaluations consist in recording their reverse blocking or forward blocking characteristics up to their maximum designed blocking voltage. In order to complete such operations during the fabrication process, we need a system that should avoid as much as possible contaminating the wafer. By that way, no further cleaning step is needed and the manufacturing process can resume without any complications. Another difficulty is that silicon carbide or diamond materials are far from being perfect: defect densities are still high and the material is expensive. This leads most of the time to small sizes and probing a large number of components per wafers in order to extract behavior statistics.

Nowadays, no commercial probing station is able to conduct such measurements in an automated way on a large variety of wafer arrangements. We propose to introduce our automated system which is able to recover $I(V)$ curves at the wafer level. Thanks to vacuum insulation, it allows us to test any kind of diode or thyristor and soon any kind of transistor up to 20 kV. All the apparatus is controlled by software and it can take measurements without the help of anyone after the initialization phase. It can handle a wafer of 4 inches diameter and it can be used with any kind of device geometries and with any wafer alignment. Leakage current measurements can be taken by using voltage steps with 10 pA accuracy or a constant voltage ramp for faster experiments. Our system had been successfully tested with Schottky, JBS, PiN diodes and thyristors made of SiC or diamond up to 11 kV and 540 K from collaborators or ourselves [2].

[1] S. Ryu, "Ultra high voltage IGBTs in 4H-SiC", IEEE WiPDA, 2013

[2] P.N. Volpe, "Extreme dielectric strength in boron doped homoepitaxial diamond", IEEE APL, 2010