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Physical and electrical characterization of wide band gap for power electronic application

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Résumé

The energy transition will require power electrical devices able to manage high voltages and high currents for typical applications such as electrical motor. Although today's electronic converter market is dominated by silicon-based technology, these electronic devices have elevated intrinsic losses due to silicon physical limited properties. Thanks to their excellent physical properties Wide-Band-Gap (WBG) semiconductors such as silicon carbide (SiC) or Gallium Nitride (GaN) or even Ultra Wide-Band Gap (UWBG) semiconductors such as diamond or Ga₂O₃ are particularly interesting for power electronic applications. These materials are not all at the same stage of maturity, and their fields of application are not yet fully identified. The aim of our work is to understand the links between WBG material quality and device performances. In particular, we want to clarify:

- How the initial wafer quality and defects impact the epitaxial layer
- What wafer and epi layer defects are critical for device performance and yield?

To this aim several physical and electrical characterization methods are adopted to qualify the quality of the WBG material such as:

- Micro-Raman spectroscopy (1) : doping level, dislocation, mechanical stress...
- Deep level transient spectroscopy (DLTS) (1) : active defects or charge carrier traps
- Optical beam induced current (OBIC) (2) : homogeneity/variation of the electric field and efficiency of the periphery protection

*Intervenant

In this talk we will present our recent results on characterization of WBG semiconductors such as SiC, GaN, Diamond and Ga₂O₃.

First several physical characterization techniques are used to assess the quality of the substrate and of the epilayers. In a second time, electrical characterizations are done on test devices such as Schottky diodes to understand the impact of WBG material quality on the device electrical performances. The third part is dedicated to the analysis and the combination of the results of the physical characterizations of the epilayers and of the electrical characterization of the test devices.

References :

(1) V. Raja et al, Microelectronics Journal, Vol. 128, 105575 (2022)

(2) C.Sonneville et al., Mat Sci Forum, 1004, p290 (2020)

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