RamanFest 2022

Raphaël Strenaer[1]

Yannick Guhel[1], Guillaume Brocero[1], Christophe Gaquière[2] and Bertrand Boudart[1]

[1] Normandie Université, GREYC, UNICAEN, ENSICAEN, CNRS 6072, Caen, France

[2] IEMN, CNRS 8520, Villeneuve d'Ascq, France

raphael.strenaer@unicaen.fr

Micro-Raman spectroscopic estimation of the volume and surface temperature of GaN-based electronic devices

GaN-based electronic devices are promising components for radar and telecommunication applications [1]. Unfortunately, the reduction in size and increase in power dissipation of these devices lead to increasingly higher operating temperatures. As a result, their electrical properties and reliability can be degraded by self-heating effects. Therefore, it is crucial to accurately estimate the channel temperature in biased GaN-based components to improve their performance and their reliability by optimizing their thermal management. An example of the studied GaN-based device is shown in Figure 1-a. To estimate the self-heating temperature (ΔT) of these devices, micro-Raman spectroscopy is a good technique allowing a spatial resolution of about 1 µm. It is generally used to estimate the volume average temperature of the GaN layer. When the device is biased, its temperature increases due to the Joule effect resulting in a shift of Raman modes attributed to the GaN semiconductor that are sensitive to this temperature change. For example, Figure 1-b shows a decrease in the position of the E_2(high) mode of the GaN layer for unbiased and biased device. We can see that the temperature induces a shift in the Raman mode position. Thus, the self-heating temperature can be deduced using a temperature calibration curve, as presented in Figure 1-c for E_2(high) mode of GaN. In these conditions, the estimated ΔT is 196 °C. However, the temperature of the metal contacts cannot be directly estimated by Raman spectroscopy. To circumvent this problem, the only solution is the use of the Raman micro-thermometers, such as CeO_2 particles. By measuring the Raman band shift related to these microparticles, the ΔT of the metal contact surface can be evaluated. Since the micro-Raman thermometers are deposited on the entire device, ΔT of the GaN semiconductor surface can also be measured. In conclusion, the use of micro-Raman spectroscopy combined with CeO_2 micro-Raman thermometers is the only optical technique to simultaneously estimate the ΔT of a semiconductor surface, a metal surface and a volume average through the GaN layer of a biased GaN-based electronic device.

References

[1] G. Brocero, Y. Guhel, P. Eudeline, J. P. Sipma, C. Gaquière, B. Boudart, IEEE Trans. Electron Devices 66, n° 10 (2019) pp. 4156-4163.

Figures

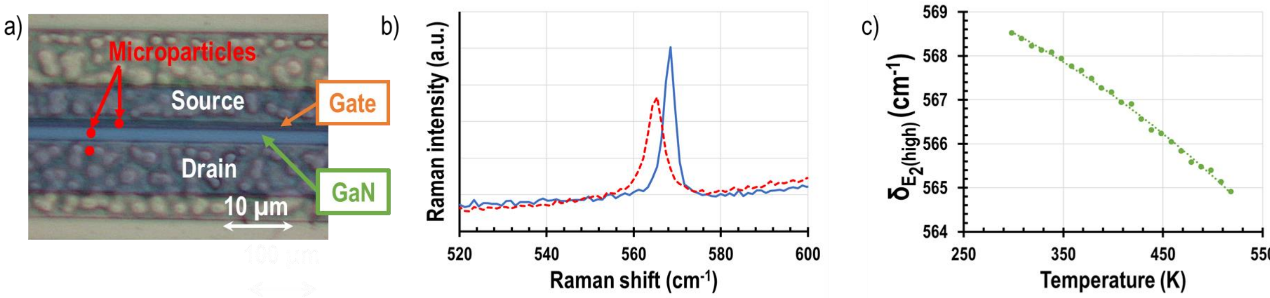

Figure 1: (a) Photograph of the studied component (b) Raman spectra of E_2(high) mode of GaN obtained for unbiased (solid line) and biased device (dashed line) and (c) temperature calibration curve of E_2(high) mode of GaN