Graphene CMOS integration for sensors and imagers

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Abstract

The complementary metal-oxide semiconductor (CMOS) readout integration of the graphene devices enables several key application areas including biosensor and gas sensor arrays[1] as well as imaging arrays[2]. For biosensing the reliability of analysis is becoming increasingly important as point-of-care diagnostics are transitioning from single analyte detection towards multiplexed multianalyte detection. Multianalyte detection benefits greatly from CMOS integrated sensing solutions, offering unique opportunities with multiplexed sensing arrays, integrated readout electronics and sensor array miniaturization. The development of CMOS integration compatible graphene field-effect transistor (GFET) based biosensing has been rapid during the last few years, both in terms of the fabrication scale-up and functionalization towards biorecognition from real sample matrices. The next steps in industrialization relate to improving reliability and require increased statistics. Regarding functionalization and referencing towards truly quantitative sensors and on-chip bioassays, improved statistics require sensor arrays with reduced variability in functionalization. Such multiplexed bioassays, whether based on graphene or on other sensitive nanomaterials, are among the most promising technologies for label-free electrical biosensing. As an important step towards that, we report wafer-scale fabrication of CMOS integrated graphene FET arrays (Figure 1a) with high yield and uniformity, designed especially for biosensing applications. We demonstrate the operation of the sensing platform array with 512 GFETs in simultaneous detection for sodium chloride concentration series (Figure 1b). This platform offers a truly statistical approach on graphene FET based biosensing and further to quantitative and multi-analyte sensing. The technique can also be applied to other fields relying on functionalized GFETs, such as gas or chemical sensing or infrared imaging. For these we also demonstrate the wafer-scale fabrication of the GFET devices on CMOS readout wafers and the multi-project wafer run possibilities in the 2D-EPL.

References

[1] Zanjani, S. M., Holt, M., Sadeghi, M. M., Rahimi, S. & Akinwande, D. 3D integrated monolayer graphene–Si CMOS RF gas sensor platform. NPJ 2D Mater Appl 1, 36 (2017).

[2] Goossens, S. et al. Broadband image sensor array based on graphene-CMOS integration. Nat Photonics 11, 366-371 (2017).

Figures

a) b)

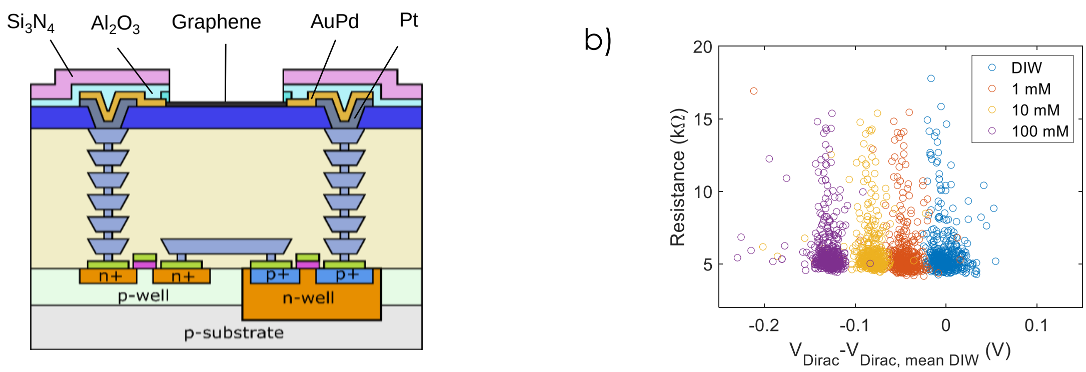

Figure 1: a) A schematic illustration of the post-processed GFET on CMOS readout b) The resistance values as a function of V_{Dirac}-$V_{Dirac, mean DIW}$ for the 512 GFETs.