Advances in pressure and chemical sensing with 2D materials

Paolo Samorì
ISIS, Université de Strasbourg & CNRS, 8 alleé Gaspard Monge, 67000 Strasbourg, France
samori@unistra.fr

Abstract

Physical and chemical sensor bear a direct societal impact on well-being, which includes, along others, the monitoring of human's health, the quality and composition of the air we breathe, the water we drink, and the food we eat.

Physical sensors are essential components for the fabrication of devices for medical diagnosis and health monitoring, upon use of active materials with sensitivities in the low-pressure or medium-pressure range, respectively. In this framework, flexible piezoresistive pressure sensors are compatible with wearable technologies for digital healthcare, human-machine interfaces and robotics. Among active materials for pressure sensing, graphene-based materials are extremely promising because of their outstanding physical characteristics. Currently, a key challenge in pressure sensing is the sensitivity enhancement through the fine tuning of the active material's electro-mechanical properties. We have achieved this by combining chemically reduced graphene oxide (rGO) with (macro)molecular materials with controlled mechanical properties. Among these, the use of a polybenzoxazine thermoresist matrix in combination with rGO made it possible to tailor electrically conductive nanocomposites where the thermally triggered resist's polymerisation modulates the active material rigidity and consequently the piezoresistive response to pressure. [1]

In chemical sensing higher sensitivity, faster response time and fast recovery time can be achieved by using 2D materials as active components. Instead, selectivity can be achieved either through the optimization of the energy levels of the analyte with respect of those of the active material, as demonstrated via the fabrication of sensors of heavy metals[2] or polyaromatic molecules[3], or through the functionalization of the latter with supramolecular receptors ensuring a high discrimination of ions and small molecules in the sensing event.[4]

Strategies for simple integration of working devices with electrical read-outs will be presented.

References

[1]   S. Vitale et al, "Tuning the piezoresistive behaviour of graphene-polybenzoxazine nanocomposites: Towards high-performance materials for pressure sensing applications" submitted (2023)

[2]   F.J. Urbanos, S. Gullace, P. Samorì, "MoS2 Defect Healing for High-Performance Chemical Sensing of Polycyclic Aromatic Hydrocarbons", ACS Nano 2022, 16, 11234.

[3]   F.J. Urbanos, S. Gullace, P. Samorì "Field-Effect Transistors Based Ion Sensors: Ultrasensitive Mercury (II) Detection via Healing of MoS2 Defects", Nanoscale, 2021, 13, 19682

[4]   A. Zhuravlova, A.G. Ricciardulli, D. Pakulski, A. Gorczyński, A. Kelly, J.N. Coleman A. Ciesielski, P. Samorì, "High selectivity and sensitivity in chemiresistive sensing of Co(II) ions with liquid-phase exfoliated functionalized MoS2: a supramolecular approach", Small 2023, in press.