In-Operando X-ray Studies on Graphene Spintronic Devices

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Graphene's high carrier mobility, long spin diffusion lengths [1], and atomically thin structure make it a promising material for next-generation spintronic and quantum devices. Graphene is commonly combined with other two-dimensional materials to overcome its limitations and to introduce new functionalities. Its sensitivity to interfacial interactions also enables tuneable electronic properties when integrated with oxides [2]. To fully understand and optimize the charge and spin transport characteristics of graphene-based devices, it is essential to probe their electronic structure under operating conditions. In this context, X-ray-based techniques, such as X-ray Photoelectron Spectroscopy (XPS) and Angle-Resolved Photoemission Spectroscopy (ARPES), have emerged as powerful tools [3,4]. These techniques enable direct measurement of band alignment, chemical shifts, and local potential variations in biased devices, directly showing how electrical bias or material interfaces affect electronic behaviour. These measurements are particularly relevant in heterostructures and devices with varying transport properties. In-operando combined X-ray measurements offer a direct way to probe the electronic behaviour of graphene-based and other 2D material systems under bias, allowing for a better understanding of charge and spin transport in device-relevant conditions. In our study, we apply in-operando X-ray techniques to investigate electronic structure and potential variations in 2D material-based devices under bias.

References

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