Intrinsic potential barriers of heterojunctions formed by multi-terraced indium selenide nanosheets

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The electrical isolation of atomically thin graphene in 2004 generated much excitement in the physics, nanotechnology, and engineering communities as it presented the opportunity to study, for the first time, an atomically thin two-dimensional semi-metal [1] with electronic Dirac states. This interest led to the discovery of rich physics such as the half-integer quantum hall effect [2,3] and the realization of unconventional superconductors by twisting two graphene layers [4], for instance. Many others layered materials have managed to be exfoliated until the single-layer unit, these exhibiting a distinctive semiconducting behaviour [5-9], which can constitute the building blocks of new heterostructures based on 2D materials [10] with potential applications in optoelectronic [11], spintronic [12,13] and valleytronics [14,15].

The fabrication of 2D heterostructures with clean and sharp interfaces is essential for preserving optoelectronic properties driven by the interlayer or intralayer coupling [16]. Van der Waals heterostructures could be created by stacking diferent 2D materials using mechanical transfer techniques [17]. However, the control of the interface quality remains challenging. Only under controlled interface conditions, abrupt interfaces have been realized and allowed, for instance, the realization of interlayer excitonic states in van der Waals bound heterobilayers [18]. In this work, we propose that abrupt interfaces intrinsically appear in multi-terraced nanosheets of 2D materials. In particular, we have analysed the electronic properties of interfaces formed in multi-terraced InSe nanosheets, by nano-photoemission and photocurrent response measurements.

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