Graphene Epitaxy: from Misorientation-Free to Misorientation-Engineered Graphene Films

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Abstract (Century Gothic 11)
Graphene has garnered widespread interest and confer remarkable potential for next-generation technological applications, which relies on the controllable preparation of high-quality graphene films. Chemical vapor deposition (CVD) is considered the most promising method, and great progress has been achieved over the last decade. Currently, this field is being pushed to new heights that pursuit structure control (e.g. orientation, layer, stacking order, contamination, doping, etc.) and low-cost production (e.g. increasing the production capacity and growth rate)[1,2]. In this talk, I will introduce our recent works on controlled growth of high-quality graphene films via CVD approach, especially on controlling the crystallographic orientation of graphene. By designing and preparing single-crystal Cu(111) foils, we have opportunities in realizing the epitaxial growth of large-area single-crystal misorientation-free graphene film[3]. We designed and constructed a pilot-scale CVD system suitable for producing A3-size graphene films, which works well and output high-quality graphene films with high capacity. In another hand, we explore the possibility on controlling the layer number and stacking order, which is motivated by the emerging twistronics. Here I will present our state-of-the-art hetero-site nucleation method for growing twisted bilayer graphene (tBLG)[4]. Gas-flow perturbation and switching of the graphene edge termination play crucial roles in triggering the formation of interlayer twist. The growth mechanism is carefully investigated by using an isotope-labelling technique, and the as-obtained tBLGs show high crystalline quality (high carrier mobility of 68,000 $cm^2\ V^{-1}\ s^{-1}$ at room temperature). We also established a slip-line-guided growth principle to explain and predict the crystal orientation distribution of graphene on a variety of metal facets, further enabling the controllable synthesis of single-crystal graphene and grain boundary engineering of bi-crystal graphene on designed metal facets[5], which opens a new avenue for manipulating the crystal orientations, grain boundary structures, and even twisted angles of bilayer 2D materials in a bottom-up manner

References

[1] **L. Sun,** G. Yuan, L. Gao*, J. Yang, M. Chhowalla*, M. H. Gharahcheshmeh, K. K. Gleason*, Y. S. Choi, B. H. Hong*, Z. Liu*, ***Nat. Rev. Methods Primers***, 1(2021) 5.
[2] **L. Sun,** L. Lin, Z. Wang, D. Rui, Z. Yu, J. Zhang, Y. Li, X. Liu, K. Jia, K. Wang, L. Zheng, B. Deng, T. Ma, N. Kang, H. Xu, K. S. Novoselov, H. Peng*, Z. Liu*, ***Adv. Mater.*** 31 (2019) 1902978.
[3] **L. Sun**, B. Chen, W. Wang, Y. Li, X. Zeng, H. Liu, Y. Liang, Z. Zhao, A. Cai, R. Zhang, Y. Zhu, Y. Wang, Y. Song, Q. Ding, X. Gao, H. Peng, Z. Li*, L. Lin*, Z. Liu*, ***ACS Nano*** 16 (2022) 285.
[4] **L. Sun**, Z. Wang, Y. Wang, L. Zhao, Y. Li, B. Chen, S. Huang, S. Zhang, W. Wang, D. Pei, H. Fang, S. Zhong, H. Liu, J. Zhang, L. Tong, Y. Chen, Z. Li, M. H. Rümmeli, K. S. Novoselov, H. Peng*, L. Lin*, Z. Liu*, ***Nat. Commun.*** 12 (2021) 2391.
[5] Y. Li, H. Liu, Z. Chang, H. Li, S. Wang, L. Lin, H. Peng, Y. Wei*, **L. Sun***, Z. Liu*, ***Adv. Mater.*** 34 (2022) 2201188.