北京大学量子材料科学中心

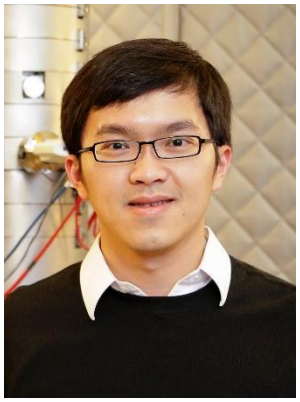
International Center for Quantum Materials, PKU

Weekly Seminar

Low voltage aberration corrected STEM for two-dimensional heterostructures

Wu Zhou(周武）

School of Physical Sciences and CAS Center for Excellence in Topological Quantum Computation, University of Chinese Academy of Sciences, Beijing, China.



Time: 4:00Pm, Oct. 17, 2018 (Wednesday)

时间：2018年10月17日 （周三）下午4:00

Venue: Room W563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

Aberration-corrected scanning transmission electron microscopy (STEM) operated at low accelerating voltage can now provide real space imaging and spectroscopy analysis at the atomic scale with single atom sensitivity. We have demonstrated that via quantitative STEM imaging analysis, chemical nature of each atom can be directly identified in two dimensional (2D) materials, and chemical bonding of single dopants can be measured experimentally via analysis of the fine structure in electron energy-loss spectra[1]. This opens new opportunities for quantitative study of the structure and chemistry at the interface of 2D heterostructures. Such studies, especially when combined with first-principles calculations, serve as an important step to correlate the interface structure with their local properties, unveil the atomic growth mechanism for new quantum-structures, and help to create new functionalities in these 2D materials via controlled growth.

Using low-voltage aberration corrected STEM imaging, we presented a systematic study of lateral 2D semiconductor heterostructures with and without lattice mismatch, where quantitative STEM imaging can be applied to perform atom-by-atom chemical mapping and strain analysis at the interfaces. We show that for 2D lateral heterostructures where the two monolayer components have similar crystal structure and negligible lattice mismatch, such as WS_2/MoS_2 or $WSe_2/MoSe_2$, lateral epitaxial growth can lead to atomically abrupt interface [2]. In contrast, strain relaxation at lateral interfaces with lattice mismatch often lead to misfit dislocation arrays. We demonstrate that such misfit dislocations can induce the formation and growth of sub-2-nm quantum-well arrays in semiconductor monolayers, driven by dislocation climb [3]. Such misfit-dislocation-driven growth can be applied to different combinations of 2D monolayers with lattice mismatch, paving the way to a wide range of 2D quantum-well superlattices with controllable band alignment and nanoscale width.

References

[1] W. Zhou et al., Physical Review Letters 109, 206803 (2012).

[2] Y. Gong et al., Nature Materials 13, 1135-1142 (2014).

[3] W. Zhou et al., Science Advances 4, eaap9096 (2018).

[4] W.Z. acknowledges close collaborators Profs. P.M. Ajayan, K.P. Loh, Z. Liu, Y. Gong, S.T. Pantelides, Y.-Y. Zhang, M.F. Chisholm for their contribution to the results discussed here. Financial support was provided by the Natural Science Foundation of China (51622211), the CAS Pioneer Hundred Talents Program, the CAS Key Research Program of Frontier Sciences, and the U.S. Department of Energy.

About the speaker

周武，2006年清华大学本科毕业，2010年获美国Lehigh大学材料科学博士学位，曾任美国橡树岭国家实验室研究员。现为中国科学院大学物理科学学院研究员、长聘教授。先后获得美国橡树岭国家实验室Eugene P. Wigner Fellowship，中科院百人计划，自然科学基金委优秀青年基金支持。长期从事低电压球差校正扫描透射电子显微学及功能纳米材料研究。主要研究的材料体系包括二维材料，异相催化剂，以及电池材料等。在Nature，Nature子刊，PRL等学术期刊上发表论文100余篇，SCI引用9000余次.