Defects, Dislocations and Disorder in Graphene at the Atomic Level

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The atomic structure of graphitic nanomaterials can be directly image using high resolution transmission electron microscopy (HRTEM) with spherical aberration correctors (1,2). Using accelerating voltages of 80 kV limits damage to graphene and nanotubes and enables studies of how the atoms are arranged. However, in order to fully resolve the atomic structure of graphene, chromatic aberration effects need to be addressed. I shall present results on defects, dislocations and disorder in graphene obtained with Oxford’s JEOL 2200MCO HRTEM, equipped with probe and image spherical aberration correctors, plus a new double-Wien filter monochromator. The accelerating voltage is reduced to 80 kV, and we can achieve 80 picometer spatial resolution.

Using this sub-Angstrom resolution we have resolved several key structures associated with plastic deformation, such as edge dislocations. We have fully resolved 5 and 7 member rings, shown in figure 1, and reveal that C-C bond elongation and compression occurs in specific locations on edge glide dislocations. I will show how we can intentionally create defects and disorder in pristine graphene with an accuracy of 10 nm. Some of these highly strained regions of disorder relax back to pristine graphene, whilst others remain stable.

We have also shown that trilayer graphene grown by chemical vapour deposition can adopt ABC stacking. I will present a full analysis of the unique atomic structure of Rhombohedral stacked trilayer graphene.

These results demonstrate that improved resolution in HRTEM can enable new insights into the atomic structure of defects, dislocations, disorder, and also the layer stacking in graphene and few layer graphene sheets.

References

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[2] J. H. Warner, N. P. Young, A. I. Kirkland, G. A. D. Briggs, *Resolving Strain in Carbon Nanotubes at the Atomic Level*, ***Nature Materials,*** 10, 958-962, (2011)

Figures

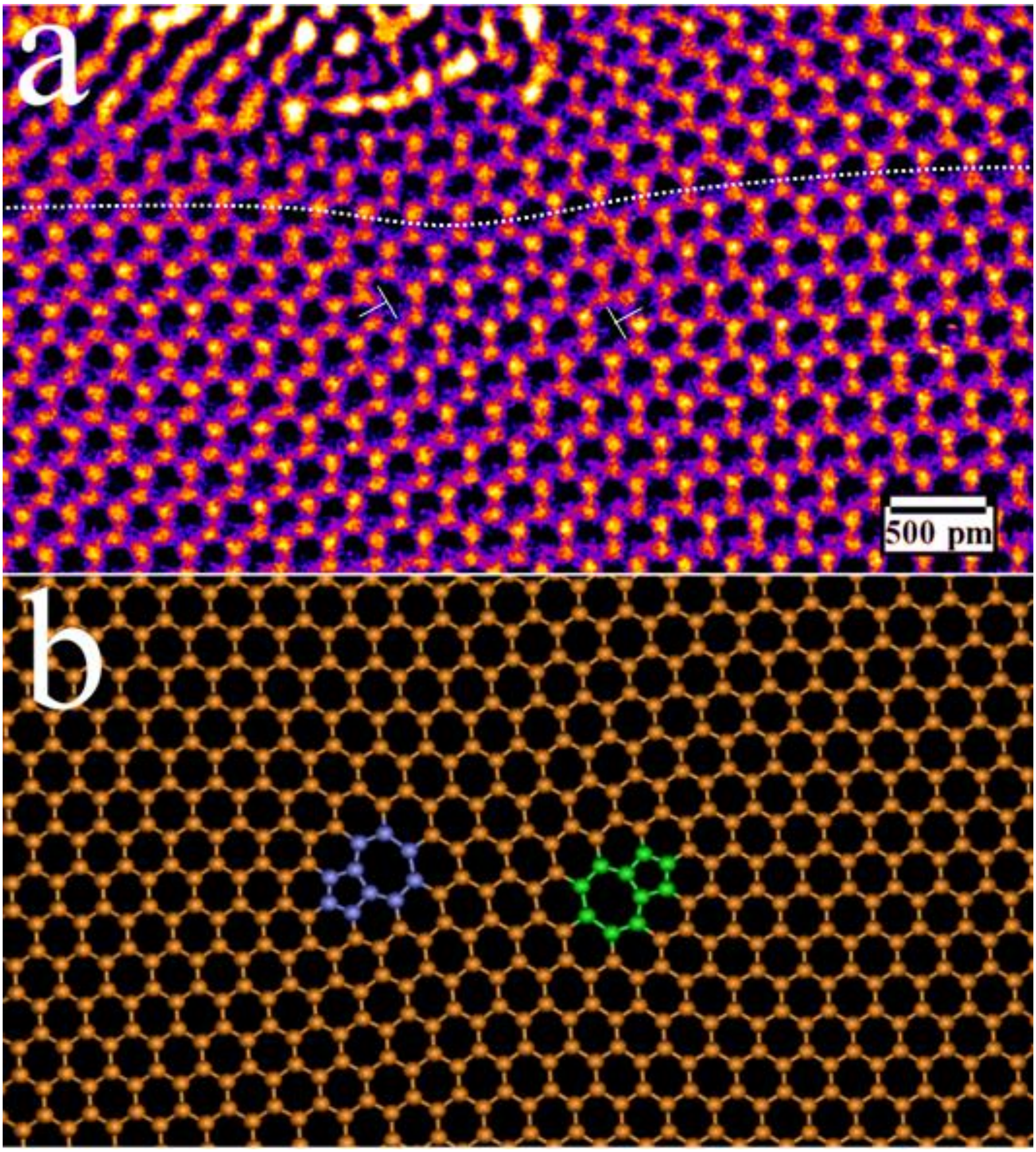

Figure 1. (a) Aberration-corrected HRTEM image (with monochromation of electron beam) of monolayer graphene showing two edge glide dislocations, plus the elastic strain induced in the lattice. (b) Atomic model representation of (a).