Fabrication and Real-time Structural Characterizations of Low-dimensional Metal Oxides

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Metal oxides have been the subject of rapidly growing research motivated by their diverse technological applications due to the extraordinary physical and chemical properties. Here, employing the simple heating and chemical vapor deposition (CVD) methods, we show the successful synthesis of several typical metal oxides (such as CuO, ZnO, Al_2O_3, etc) nanostructures[1-4]. Further structural investigations indicate that the microstructures can be effectively tuned by controlling the growth conditions. For instance, based on the basic understanding of the growth mechanisms in CuO NWs, we are able to fabricate the two-dimensional CuO nanosheets at high temperature (>800 ^oC). Interestingly, the nannosheets show novel twinning (bi-crystal) structures with zigzag twin boundaries (TBs) that were never reported before[4]. With the joint efforts of Cs-corrected transmission electron microscopy (TEM)[5-7] and first principle calculations, the atomic-scale structural features especially the peroidic arrangement of point defects (Cu and O vacancies and interstitials) at the TBs are directly revealed and discussed in detail (Fig. 1).

In addition, in-situ TEM has been employed to study the real-time structural evolution of nanomaterials subjected to external stimuli, such as mechanical stress and electric field, which are frequently encountered during the applications[8-15]. For example, during compression, the CuO NWs exhibited high bending capabilities associated with high mechanical stress. Interestingly, anelasticity was consistently observed after stress release. Preliminary investigations reveal that the movement of point defects, such as the oxygen vacancies are proposed to account for this phenomenon. These results provide the intuitive understanding of the structure-property relationship in low-dimensional metal-oxides and will bring both novel opportunities and fresh challenges for the related applications.

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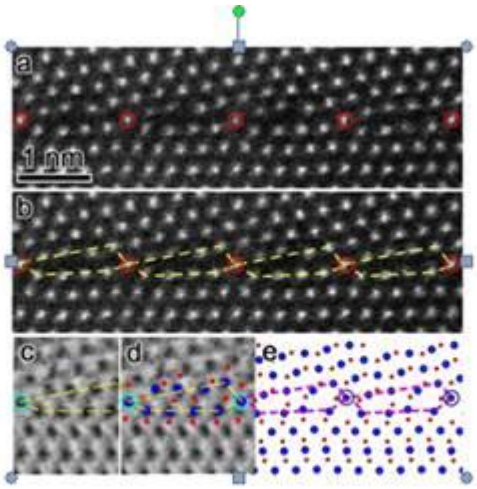

Fig. 1. Periodic arrangement of point defects at the TBs in CuO.