Supplementary Information for

Real-time Observation of Morphological Transformation in II-VI Semiconducting Nanobelts via Environmental Transmission Electron Microscopy

*Rahul Agarwal[1], Dmitri N. Zakharov[2], Nadia M. Krook[1], Wenjing Liu[1], Jacob Berger[1], Eric A. Stach[2], Ritesh Agarwal[1]**

[1] Department of Materials Science and Engineering, University of Pennsylvania, Philadelphia, PA 19104, USA

[2] Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, NY 11973, USA

* To whom correspondence should be addressed. E-mail: riteshag@seas.upenn.edu

This file includes:

SEM, TEM and ETEM Experimental Details, Growth Details of CdTe Nanobelts

Figures S1-S4

Captions for Movies S1 to S7

Other Supplementary Information for this manuscript includes the following:

Movies S1 to S7

SEM, TEM and ETEM Experimental Details: SEM experiments were performed on FEI DB Strata 235 FIB at an acceleration voltage of 20 kV. Regular TEM experiments were performed on JEOL 2100 at an accelerating voltage of 200 kV. Energy dispersive spectroscopy (EDS) was performed on JEOL 2010F TEM equipped with an EDS detector. Environmental TEM experiments were performed on a FEI Titan ETEM equipped with an objective-lens aberration corrector at 300 kV in bright field mode. ETEM chamber was pumped down to UHV (~ 10^{-7} Torr) before the introduction of reaction gas at 0.16 Torr. TEM samples for both regular and ETEM experiments were prepared by dry transferring as-grown nanobelts on a carbon support Cu grid and subsequently heated via Gatan in-situ heating holder.

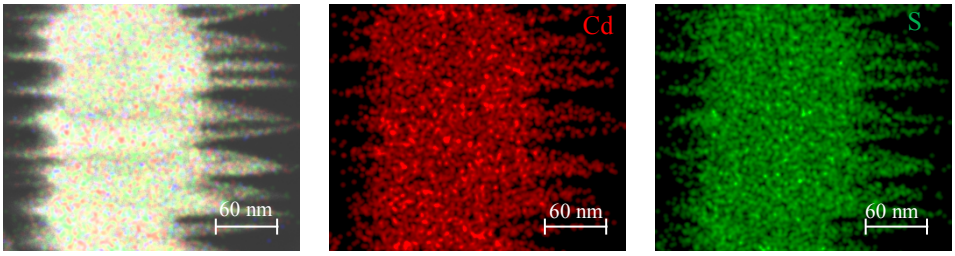

Figure S1: Energy dispersive X-ray spectroscopy map of a branched wurtzite CdS nanobelt obtained after heating in a tube furnace at moderate vacuum of 25 mTorr. The branched nanobelt remains chemically uniform after the morphological transformation.

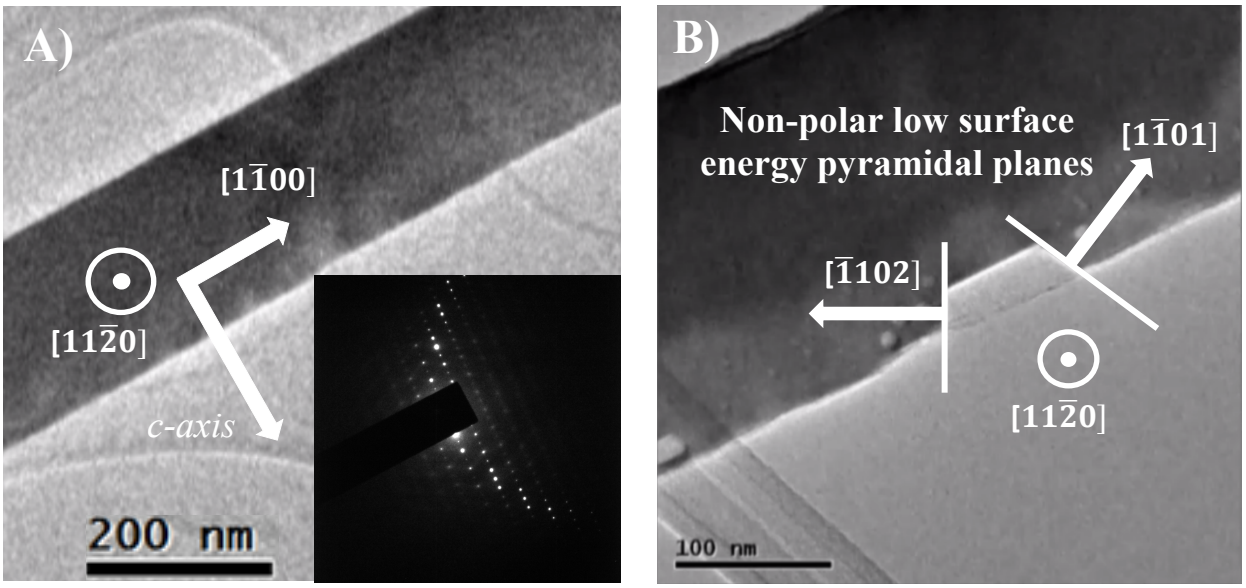

Figure S2: In-situ TEM heating of CdS nanobelts in ultra-high vacuum at 600 ºC. A) Transmission Electron Microscope image of an as-grown Wurtzite CdS nanobelt growing perpendicular to the c-axis. Inset: SAED pattern of the belt. B) TEM micrograph of the CdS nanobelt shown in A) after sublimation has started taken place along the pyramidal planes on heating the belt inside a TEM at 600 ^{0}C under UHV (~ 10^{-7} Torr).

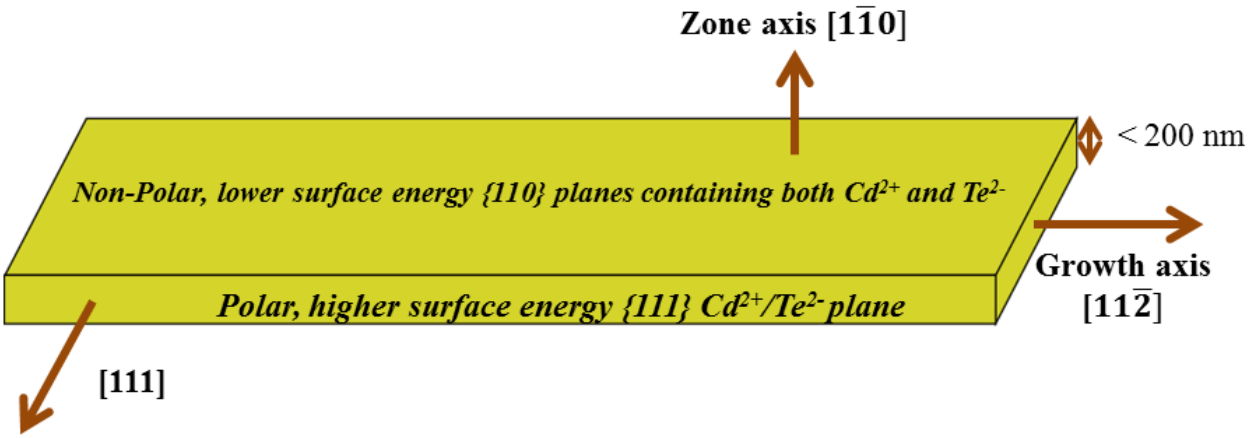

Figure S3: Schematic of a typical as-grown CdTe nanobelt highlighting all the crystal facets.

CdTe Nanobelt Synthesis: CdTe nanowires were synthesized in a quartz tube furnace using evaporation of 99.995% pure CdTe powder (Sigma-Aldrich). 5 mg of CdTe powder was placed in a quartz boat in the middle of the tube, and Si substrates covered by a 8 nm thick Au layer using e-beam evaporation were placed 15 cm downstream (referenced to the middle of the tube). The tube was evacuated to 20 mTorr and argon carrier gas was introduced at a flow of 15 SCCM to reach a stable pressure of 5 Torr. The tube was rapidly heated to 750 °C and maintained there for 120 minutes after which the furnace was cooled by a forced airflow.

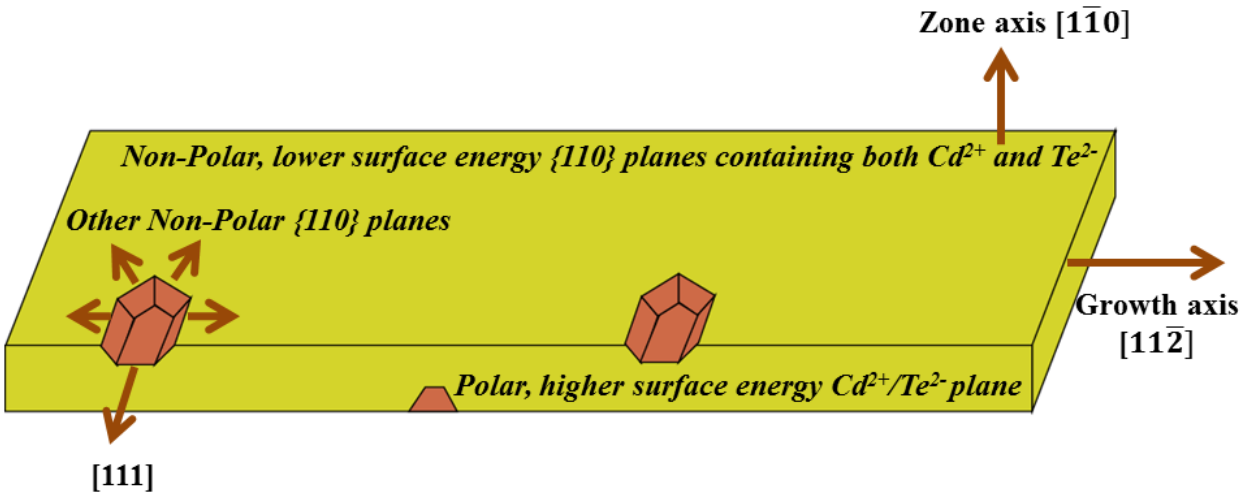

Figure S4: Schematic of a CdTe nanobelt undergoing etching along the {110} surfaces (orange planes) in other directions in addition to the [111] direction thus leading to a more isotropic sublimation.

Movie S1: Video showing real-time sublimation but no branching in Wurtzite CdS nanobelt in presence of inert helium (0.16 Torr) inside an environmental TEM up to 600 ^{0}C. The video is played at 16 X the original speed.

Movie S2: Video showing real-time branch formation in Wurtzite CdS nanobelt in presence of oxygen (0.16 Torr) inside an environmental TEM at 500 ^{0}C. The video is played at 16 X the original speed.

Movie S3: Video showing real-time branch formation in Wurtzite CdS nanobelt in presence of hydrogen (0.16 Torr) inside an environmental TEM at 500 ^{0}C. The video is played at 4 X the original speed.

Movie S4: Video showing real-time branch formation in Wurtzite CdTe nanobelt in presence of oxygen (0.16 Torr) inside an environmental TEM at 500 ^{0}C. The video is played at 16 X the original speed.

Movie S5: Video showing real-time sublimation but no branching in Wurtzite CdTe nanobelt in presence of oxygen (0.16 Torr) inside an environmental TEM up to 600 ^{0}C. The video is played at 16 X the original speed.

Movie S6: Video showing real-time branch formation and sublimation in CdTe nanobelt in presence of oxygen (0.16 Torr) inside an environmental TEM at 600 ^{0}C. The nanobelt is partially Zincblende and partially Wurtzite where branching is only observed in the latter and sublimation in the former. The video is played at 8 X the original speed.

Movie S7: Video showing real-time branch formation in pre-notched Wurtzite CdS nanobelt inside conventional TEM under UHV at 500 ^{0}C. The video is played at 16 X the original speed.