Zinc-blende structured Au catalysed epitaxial III-V semiconductor nanowires prefer to grow along the [111]_B direction featuring approximately hexagonal cross sections with side-wall facets dominated by six {112} planes or six {110} planes. In contrast, only a hand-full of studies in non-Au catalysed 1-D nanostructure growth have been reported up to date. In this study, by using Ag as catalysts, we demonstrate to grow 1-D InAs nanobelts grown along <112>_B directions. Through detailed electron microscopy characterizations, the growth mechanism of these InAs nanobelts is explored.

Commercially available 40nm Ag nanoparticles were used to grow epitaxial 1D InAs nanostructures on GaAs (111)_B substrate in a MOCVD reactor. The growth was carried out using trimethylindium and arsine as the group III and group V precursors, respectively. A growth temperature of 500°C and a V-III ratio of 2.9 were selected as the key growth parameters.

Fig. 1a is an overview SEM image and shows the general morphology of as-grown Ag-catalyzed 1-D nanostructures. From the enlarged SEM image (Fig. 1b), inclined nanostructures show belt-like morphology. Fig. 1c is a side-view SEM image of a typical nanobelt, from which the inclined angle of the nanobelt is measured as ~70° (when the electron beam is parallel to a <110> direction and perpendicular to the inclined nanobelts), so that its axial direction can be crystallographically determined to be along <112>_B directions. It is of interest to note that "steps" can be found on the top facets of the nanobelt, whereas the bottom surface is relatively smooth. Fig. 1d and e are SEM images of a typical nanobelt viewed from top-view and edge-on view, respectively. As can be seen from the top view (Fig. 1d), the nanobelt is tapered. When the nanobelt is viewed along its axial direction (Fig. 1e, ~20° tilt), the sidewall facets of the nanobelt shows a rectangular shape with two short {110} facets and two long facets developed from {111} planes. The top facet contains many surface "steps" consistent with other SEM observations.

By using a number of TEM techniques, the structure, sidewall facets, chemical composition, planner defects and nanobelt/catalyst interface of the as-grown nanobelts are investigated in detail, from which a growth schematic of Ag-catalyzed InAs nanobelt is proposed and shown in Fig. 2. During Ag catalyzed 1-D nanostructure growth, the catalyst promotes two processes: (1) collects group III growth material and (2) transports the growth material to the growth front of the nanostructure and nucleates the growth. It is believed that the formation of the "steps" and the planer defects is closely related to the In concentration in the catalyst during the nanobelt growth.

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Fig. 1: (a) SEM overview of the Ag-catalysed InAs nanostructures. (b) SEM image of a typical nanobelt. (c) Side-view of a typical nanobelt. (d) and (e) a typical nanowire viewed when the beam is perpendicular to the substrate and parallel to the nanobelt axial direction.

Fig. 2: Schematic illustration of the “step” and defect formation. Perturbations in In concentration introduces new facets during the nanobelt growth.