

Predominant incorporation of Bi atoms on {111}B rather than on {111}A with a stack-fault interface in $\text{InP}_{1-x}\text{Bi}_x$ nanowires

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Diluted Bismuth-contained III-V compound semiconductors are attracting much more interests due to its potential applications in spintronic¹⁻³ and optoelectronic devices.⁴⁻⁵ The formation of their heterostructures with abrupt interfaces still remains challenging. Furthermore, it is essential to enhance the understanding about Bi-atom incorporation behavior in heterostructure formation. Here we report growth and characterization of $\langle 112 \rangle$ -oriented $\text{InP}_{1-x}\text{Bi}_x$ nanowires grown by self-catalyzed vapor-liquid-solid (VLS) mode. We have clarified predominant incorporation of Bi atoms on {111}B rather than on {111}A with a stacking-fault interface. Such polarity-dependent incorporation behavior of Bi atoms leads to heterostructure formation with stacking-fault hetero-interfaces in $\text{InP}_{1-x}\text{Bi}_x$ nanowires.

We grew $\text{InP}_{1-x}\text{Bi}_x$ nanowires in an MOVPE system using pre-deposited InBi nanoparticles via self-catalyzed VLS mode.^{6,7} Usually, $\langle 111 \rangle$ -oriented InP nanowires are vertically aligned on substrates by epitaxial growth. When a SiO_2 amorphous substrate is used, the $\langle 112 \rangle$ -oriented InP nanowires are resulted (Fig. 1).⁸ In such $\langle 112 \rangle$ -oriented nanowires, stacking faults are parallel to the $\langle 112 \rangle$ growth direction. Regions on two sides of a stacking fault exhibit different polarities along the $\langle 112 \rangle$ direction, namely, {111}A and {111}B.⁸

We have analysed structure and composition by using Cs-STEM. The compositional mapping of Bi indicates clear difference on two adjacent regions of stacking faults (Fig. 2). We further clarify the polarity property of the nanowire and correlated the polarity with Bi compositional profile (Fig. 2). The domains with {111}B polarity exhibits higher Bi composition than those with {111}A polarity in spite of from a same catalyst nanoparticle (Fig. 2). The result indicates polarity-dependent incorporation efficiency behavior of Bi atoms in InPBi nanowires. Such growth phenomenon directly causes the heterostructure formation with atomically-abrupt stacking-fault interfaces.

In summary, we demonstrate that growth of $\langle 112 \rangle$ -oriented InPBi nanowires via the self-catalyzed VLS mode. We reveal that predominant incorporation of Bi atoms on {111}B rather than on {111}A. This work offers a new approach to form InPBi heterostructures and opens up opportunities for new novel nanostructures.

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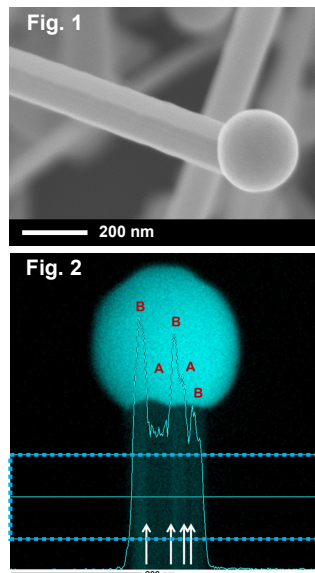


Fig. 1. SEM image of $\langle 112 \rangle$ -oriented InPBi nanowires with an InBi particle tip.

Figure 2. Compositional mapping of Bi in the particle-nanowire region. The light blue curve shows the Bi compositional profile along the radial direction, which is integrated from the data collected in the dotted rectangular region. The red-colored letters of A and B represent {111}A and {111}B growth front surfaces identified by Cs-STEM measurement. The scale bar denotes 200 nm.