Supporting Information for

Controlled Van der Waals Heteroepitaxy of InAs Nanowires on Carbon Honeycomb Lattices

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Supporting Figures and Description

S1. GaAs nanostructures grown on thin graphitic layers.

In order to clarify the role of lattice coherency between III–V arsenide and graphite for the vertical nanowire formation, the van der Waals heteroepitaxy of GaAs was investigated. We performed the VDW growth under the well-optimized GaAs nanowire MOVPE growth condition. As shown in Figure S1a, graphitic surface yielded only GaAs island morphologies mostly along the naturally formed step-edges of graphitic layers. No nanowires were formed on the graphitic surface, in contrast to the result of vertical InAs nanowires formed on graphitic layers (Figure 1).

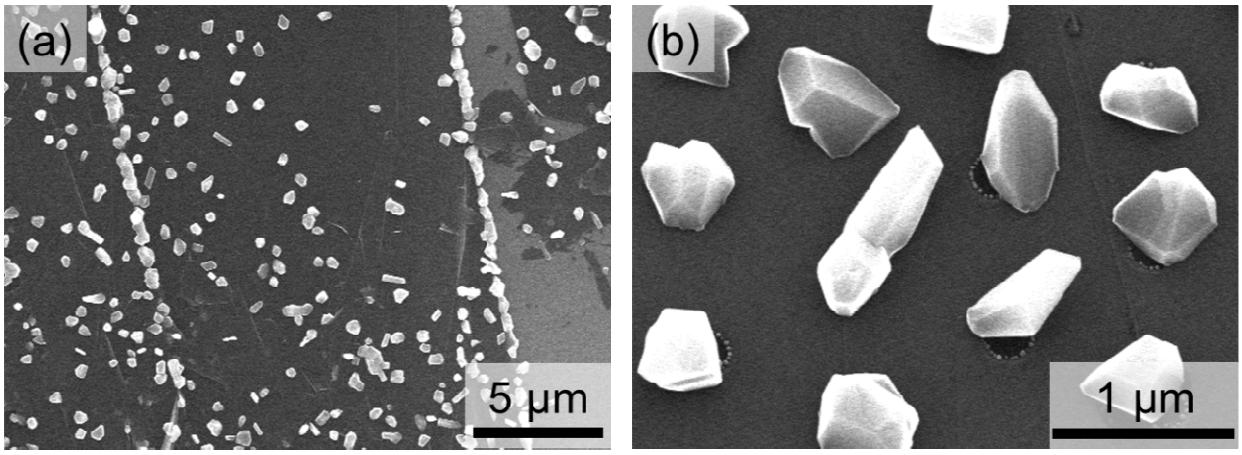


Figure S1. GaAs nanostructures grown on thin graphitic layers. (a) Top-view SEM images of GaAs nanoislands grown specifically along the step-edges of graphitic layers. (b) Tilt-view SEM image of GaAs nanoislands grown on patterned graphitic layers. The growth was performed under the well-optimized nanowire growth condition for Si or GaAs (111)B substrates.

The selective area growth was further performed using graphitic layers coated with hole patterned SiO_x growth mask. No nanowires were formed on the patterned graphitic layer, but island morphologies were grown on each hole pattern (Figure S1b). Since the employed growth condition of GaAs in this study has reproducibly yielded vertical nanowires on GaAs[1] and Si[2] substrates, this observation

supports that the large in-plane lattice mismatch of –6.22 % between GaAs and graphite obstructed the nanowire formations in the VDW epitaxy.

S2. Effect of roughness of graphitic substrates on vertical alignment of InAs nanowires.

The rms roughness of graphitic layer considerably influences the vertical alignment of InAs nanowires. Very smooth graphitic layers (etched by O_2 RIE for 3 s) yielded vertically well-aligned InAs nanowires (left panel in Figure S2), while the rough graphitic layer (etched for 10 s) resulted in the formation of inclined nanowires (right panel in Figure S2).

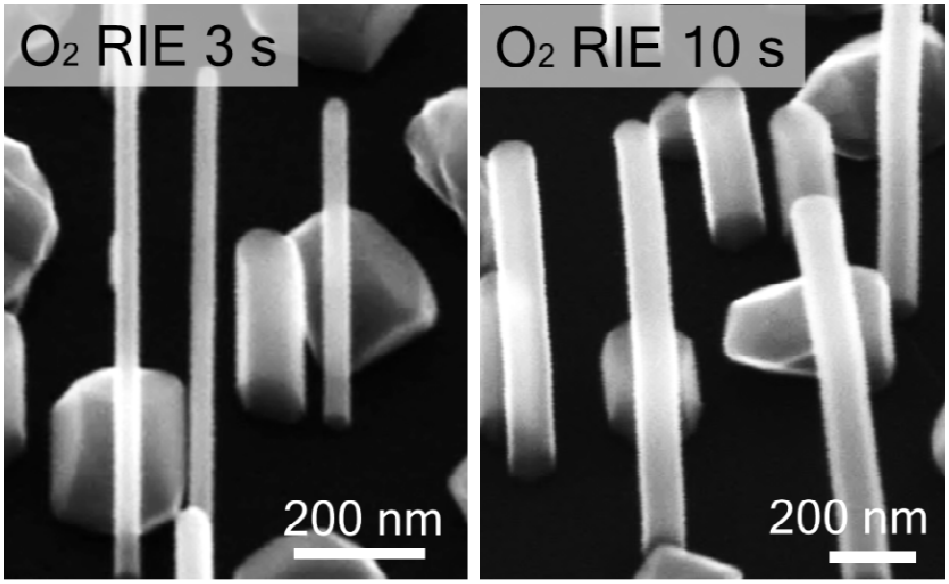
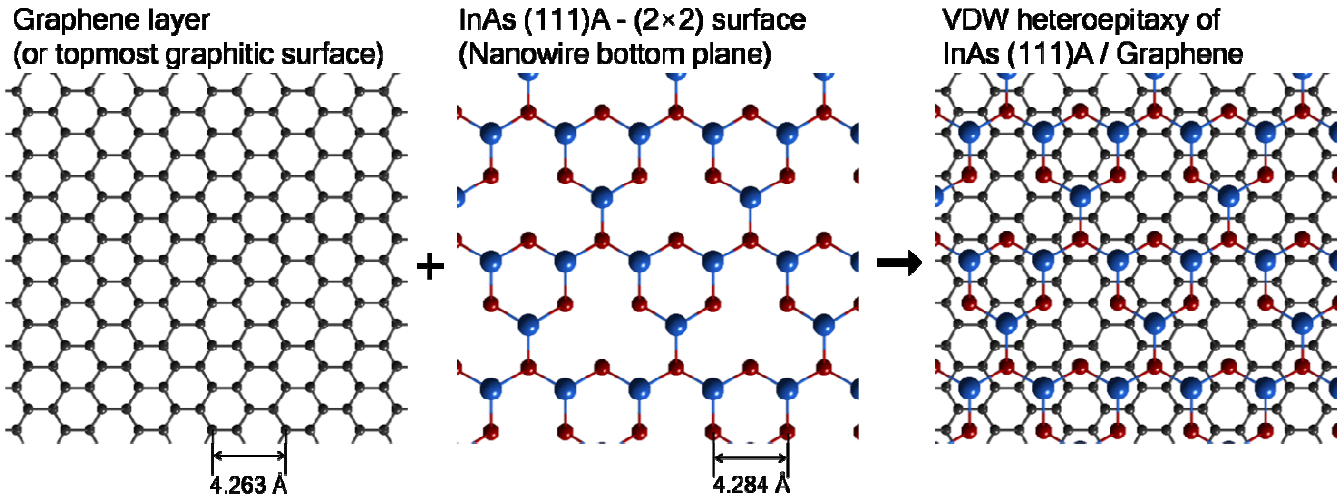


Figure S2. SEM images of InAs nanowires grown on graphitic layers etched by O_2 RIE for 3 s (left panel), and 10 s (right panel), showing that highly rough graphitic surface deteriorates the vertical alignment of nanowire arrays.



$$\text{Lattice mismatch of InAs on graphite} = \frac{\frac{a(\text{InAs})}{\sqrt{2}} - \frac{3\times a(\text{Graphite})}{\sqrt{3}}}{\frac{3\times a(\text{Graphite})}{\sqrt{3}}} \times 100\ \% = \frac{4.284-4.263}{4.263} \times 100\ \% = 0.49\ \%$$

, where a(InAs) = 6.058 Å and a(graphite) = 2.461 Å are the lattice constant of InAs and graphite, respectively.

Figure S3. Plan-view schematics of atomic configurations for heteroepitaxy of InAs on graphite (or graphene). Upper panel shows how InAs(111)A layer is structurally compatible with the graphitic surface. The calculation of in-plane lattice mismatch between InAs and graphite for the VDW heteroepitaxy is given at the bottom panel.

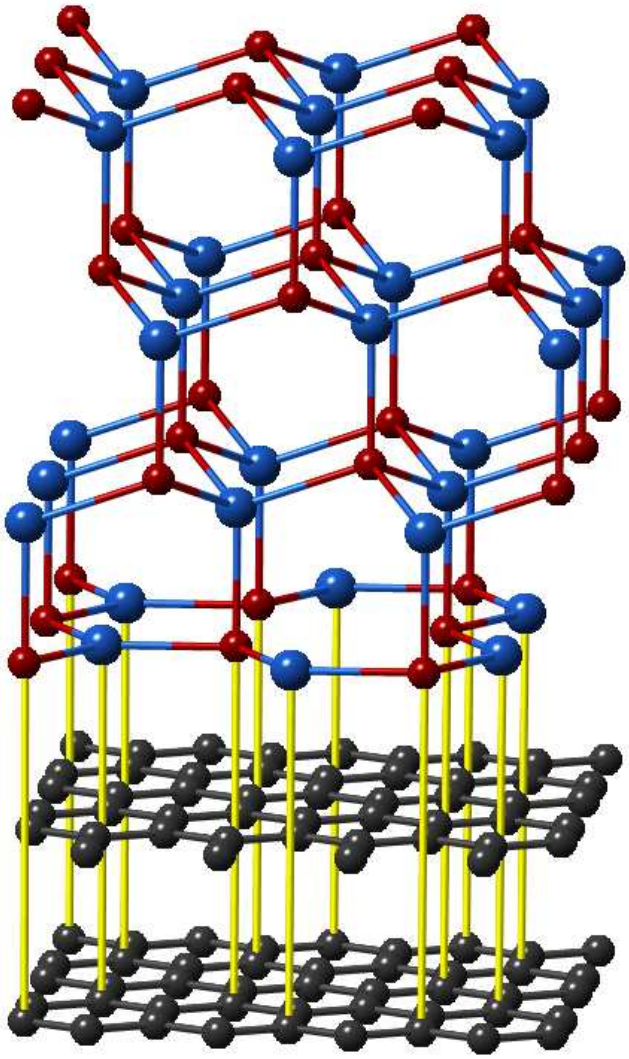


Figure S4. Bird's eye-view schematics of atomic configurations for the van der Waals heteroepitaxy of InAs nanowires on carbon honeycomb lattices. Grey, red and blue balls represent carbon, arsenic, and indium atoms, respectively. Yellow sticks represent the VDW bonding for the heteroepitaxy.

Supporting References

[S1] Noborisaka, J.; Motohisa, J.; Fukui, T. Catalyst-Free Growth of GaAs Nanowires by Selective-Area Metalorganic Vapor-Phase Epitaxy. *Appl. Phys. Lett.* **2005**, *86*, 213102.

[S2] Tomioka, K.; Kobayashi, Y.; Motohisa, J.; Hara, S.; Fukui, T. Selective-Area Growth of Vertically Aligned GaAs and GaAs/AlGaAs Core-Shell Nanowires on Si(111) Substrate. *Nanotechnology* **2009**, *20*, 145302.