Supplementary Online Material

Synthesis and Optoelectronic Properties of Ultrathin Ga_2O_3 Nanowires

Eli Sutter,[1*] Juan Carlos Idrobo,[2] and Peter Sutter[3]
[1]Department of Mechanical & Materials Engineering, University of Nebraska-Lincoln, Lincoln NE 68588, United States
[2]Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, Oak Ridge, TN 37831, United States
[3]Department of Electrical & Computer Engineering, University of Nebraska-Lincoln, Lincoln NE 68588, United States

1. Supplementary Figures

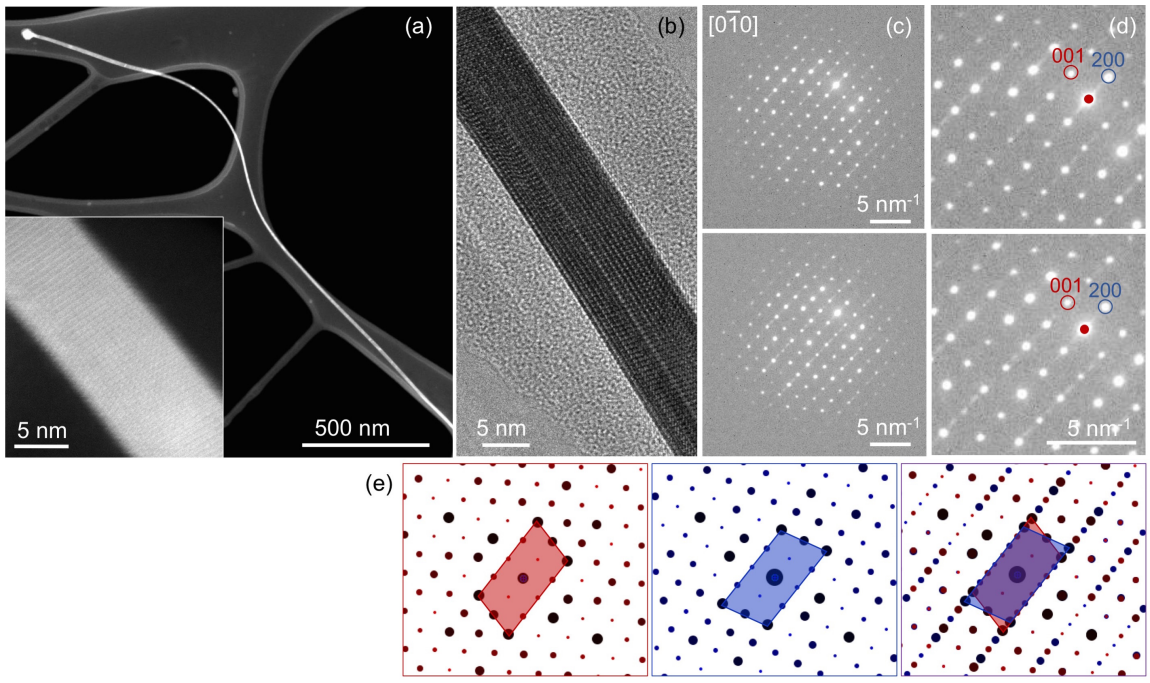

Figure S1. Morphology of single crystalline β-Ga_2O_3 nanowires grown on SiO_2/Si (100) substrate covered with nominally 2 nm Au film. **(a)** Overview STEM image of a Ga_2O_3 nanowire on amorphous carbon film (growth temperature: 550°C). Inset: High-resolution HAADF-STEM image of a small section of the nanowire. **(b)** High-resolution TEM image of a section of the Ga_2O_3 nanowire showing twinning along the [200] direction. **(c)** Electron diffraction patterns obtained at two positions along the Ga_2O_3 nanowire. **(d)** Higher magnification images of the diffraction patterns in (c) showing the single crystal stricture (top) and extra spots due to twinning (bottom). (e) Simulated diffraction patterns along the [0-10] zone axis (left), [010] one axis (middle) and superimposed (right) demonstrating that the mirror imaging of the planes leads to the additional spots in the diffraction patterns.

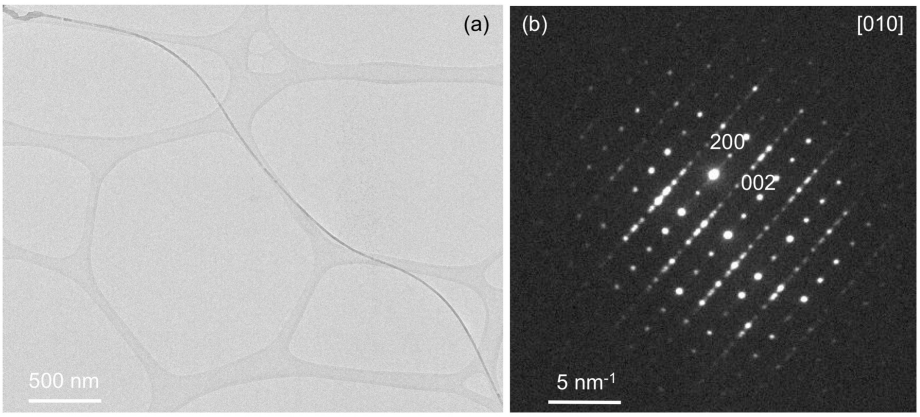

Figure S2. Morphology of single crystalline Ga_2O_3 nanowires grown on SiO_2/Si (100) substrate covered with nominally 2 nm Ag film. (a) Overview TEM image of a typical Ga_2O_3 nanowire on amorphous carbon film (growth temperature: 550°C). **(b)** Electron diffraction pattern of the Ga_2O_3 nanowire along the [010] zone axis.

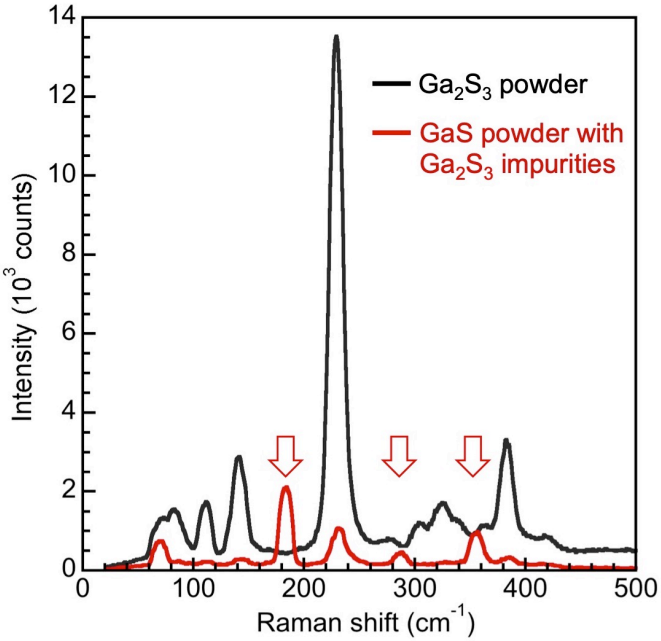

Figure S3. Raman spectrum of the Ga_2S_3 precursor powder. The observed modes (black curve) are consistent with pure Ga_2S_3, see ref. 1. Comparison with the spectrum of a GaS powder containing a small amount of Ga_2S_3 impurities (red curve) shows no detectable GaS in our Ga_2S_3 precursor (absence of GaS peaks marked by red arrows).

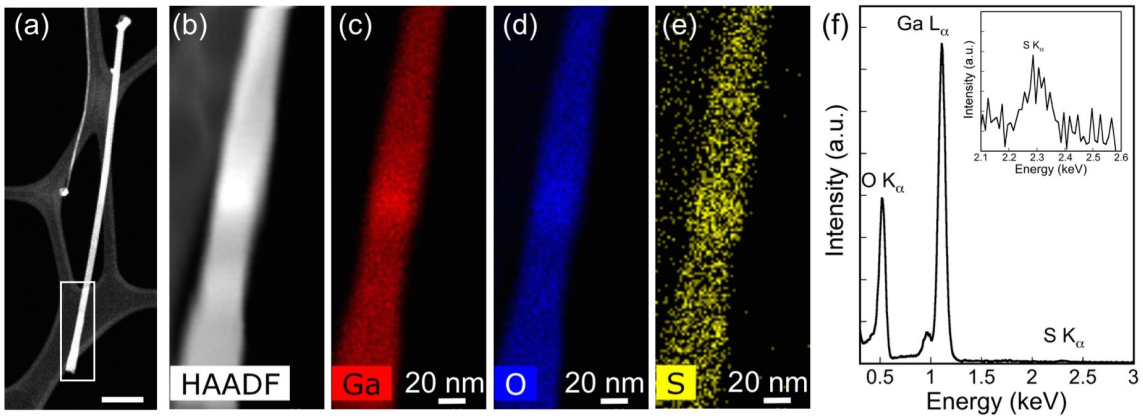

Figure S4. EDS elemental maps of single crystalline Ga_2O_3 nanowires. (a) HAADF-STEM image of representative Ga_2O_3 nanowires (scale bar: 200 nm). **(c) - (e)** EDS elemental maps of one of the Ga_2O_3 nanowires showing the distribution of Ga (red), oxygen (blue) and sulfur (yellow). **(f)** EDS spectrum from the nanowire. The inset shows the magnified sulfur K_α region of the spectrum.

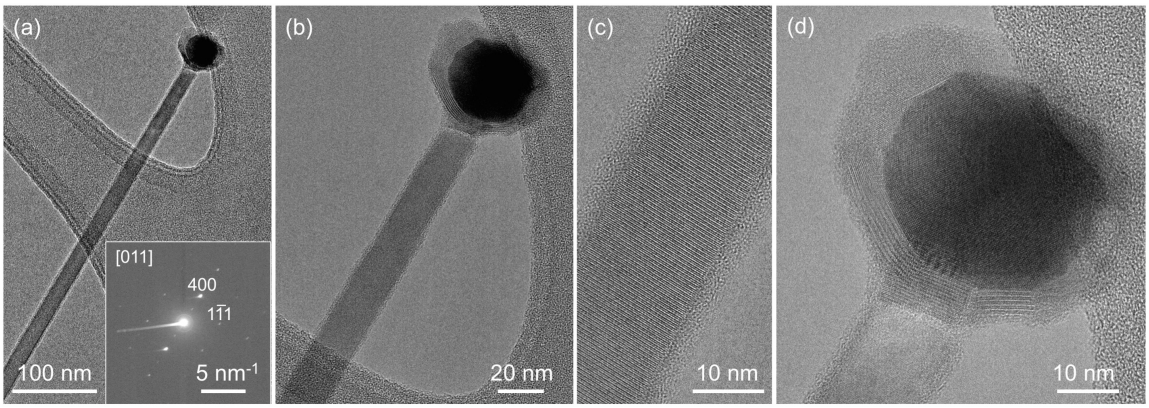

Figure S5. Single crystalline Ga_2O_3 nanowires. (a) Overview TEM image of a representative Ga_2O_3 nanowire (growth temperature: 500°C). Inset: Electron diffraction pattern of the nanowire. **(b)** TEM image of the nanowire close to the Au-rich tip. **(c)** High-resolution TEM image of the nanowire. **(d)** High-resolution TEM image of the core-shell structure of the tip consisting of layered GaS tightly wrapping the Au-rich nanoparticle. Note the sharp interface between the shell and the nanowire.

References

1. Julien, C.; Barnier, S.; Massot, M.; Pardo, M. P., Vibrational studies of solid solutions formed in the gallium-cadmium-sulphur system. *Materials Research Bulletin* **1994,** *29* (7), 785-794.