Quantum Electronic Transport of Topological Surface States in β-Ag_2Se Nanowire

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Supporting Information

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Table S1. Parameters of β-Ag_2Se nanowires and nanoribbon samples.

No.	Resistivity at 2 K (mΩ·cm)	Width (nm)	Height (nm)	Channel length (μm)
D1	5.2	102	95	0.75
D2	1.3	139	75	0.79
D3	0.15	227	150	3.69
D4	0.18	2770	200	11.8
D5	0.40	140	150	0.55

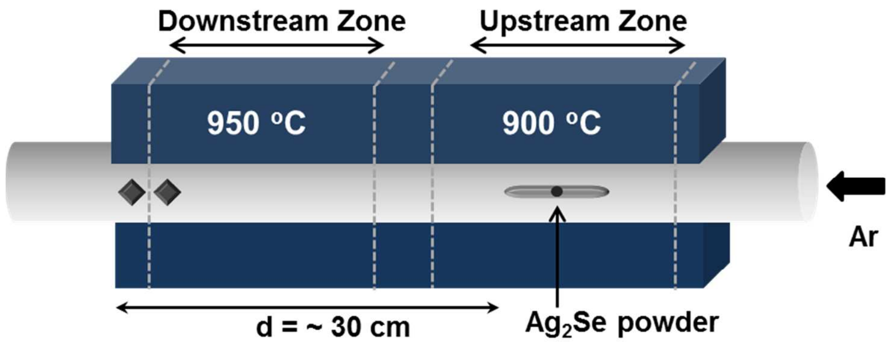

Figure S1. Experimental setup for the synthesis of β-Ag_2Se nanowires, nanoribbons and nanoplates.

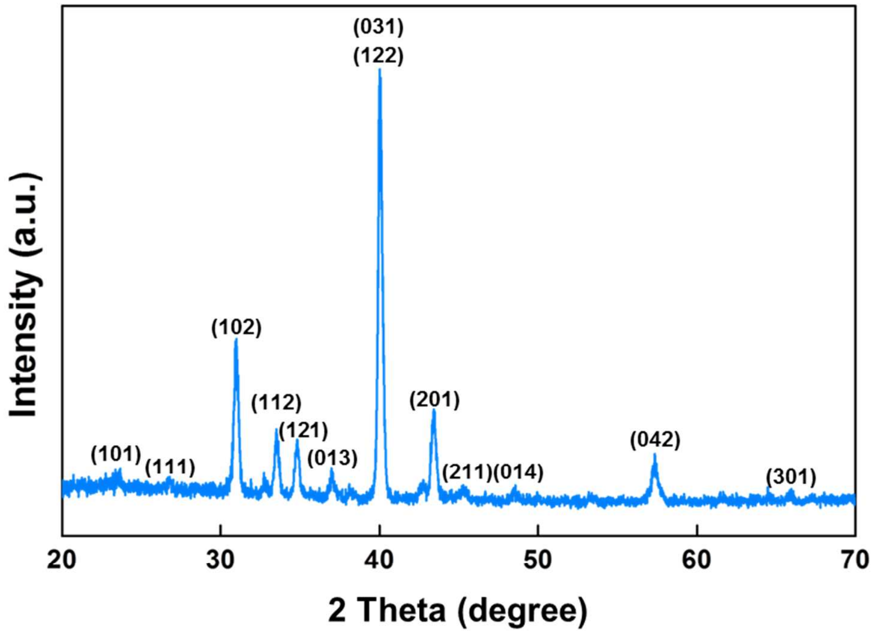

Figure S2. The X-ray diffraction (XRD) pattern obtained from as-grown nanowires, nanoribbons, and nanoplates on *c*-Al_2O_3 substrate. All the diffraction peaks are indexed to an orthorhombic β-Ag_2Se crystal structure (JCPDS card No. 01-071-2410).

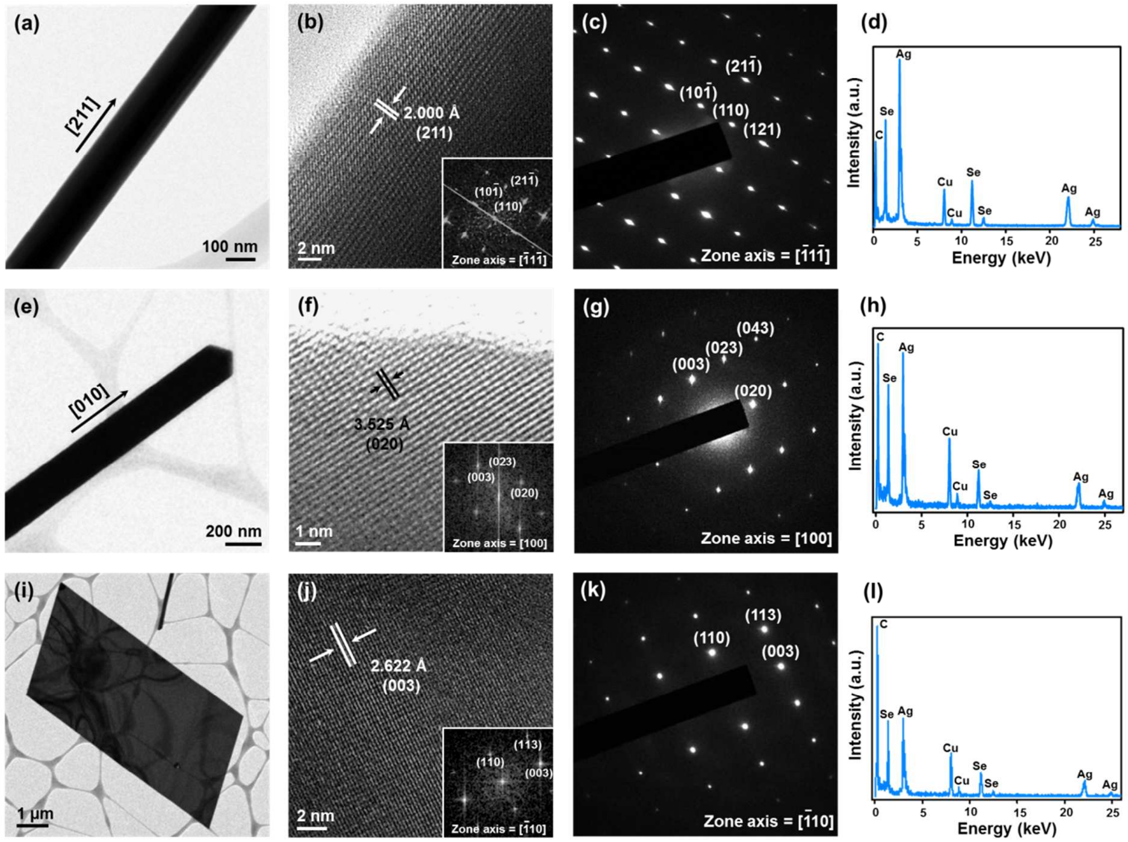

Figure S3. TEM images of β-Ag_2Se nanowires and nanoplate.

First column ((a), (e), (i)): Low-resolution TEM images of the β-Ag_2Se nanowires and nanoplate. Second column ((b), (f), (j)): High-resolution TEM images and FFT patterns (inset image) of β-Ag_2Se nanowires and nanoplate. Lattice spacings of 0.200 nm, 0.353 nm, and 0.262 nm agree well to those of (211), (020), and (003) planes of an orthorhombic β-Ag_2Se crystal structure, respectively. Third column ((c), (g), (k)): The SAED patterns along the various zone axes. The patterns show the single crystalline nature of β-Ag_2Se nanostructures. Fourth column ((d), (h), (l)): TEM-EDS spectra of β-Ag_2Se nanowires and nanoplate. The analyses of these results reveal that the atomic ratios of Ag and Se atoms are 2:0.86, 2:1.01, and 2:0.95, respectively, indicating the existence of selenium vacancies. For the accuracy of quantification, we used only the K-electron shells for both Ag and Se.

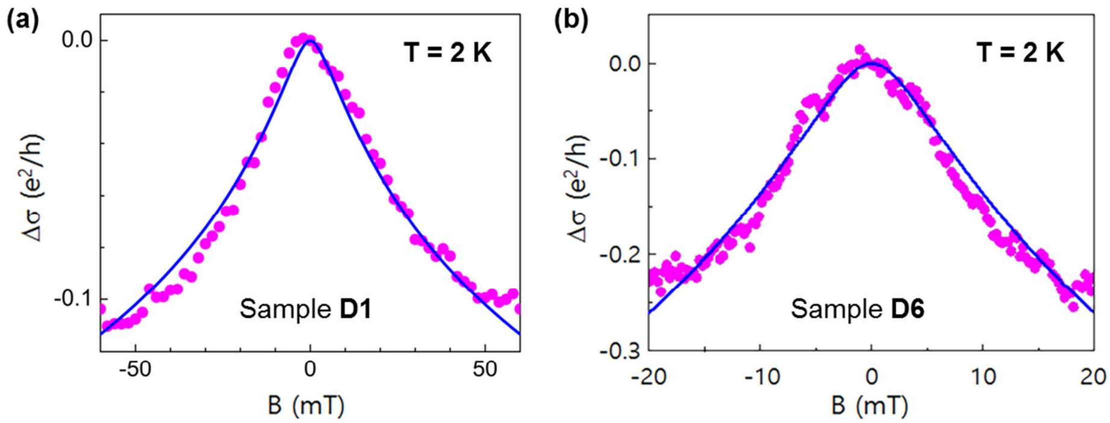

Figure S4. 2D differential magnetoconductance (MC) data (symbols) obtained from **(a)** sample **D1** and **(b) D6** at T = 2.0 K. Blue curves are a fit to the 2D weak antilocalization (WAL) model.[1] The model expects 2D MC $\Delta\sigma = -(\alpha e^2)/(2\pi^2\hbar)[\ln(B_0/B) - \psi(1/2 + B_0/B)]$, where α is a prefactor, $B_0 = \hbar/(4eL_\varphi^{\;2})$, L_φ is a phase coherence length, and ψ is a digamma function. A least square fit results in $\alpha = -0.25$ and $L_\varphi = 270$ nm for sample **D1** and $\alpha = -1.0$ and $L_\varphi = 300$ nm for sample **D6**. Geometric dimension of sample **D6** is given by w = 303 nm and L = 4.5 μm. In case of sample **D6**, the prefactor $\alpha = -1$ presents that the negative MC is due to the destructive interference with the Berry's phase of π in the top and bottom surfaces of the nanoribbon.

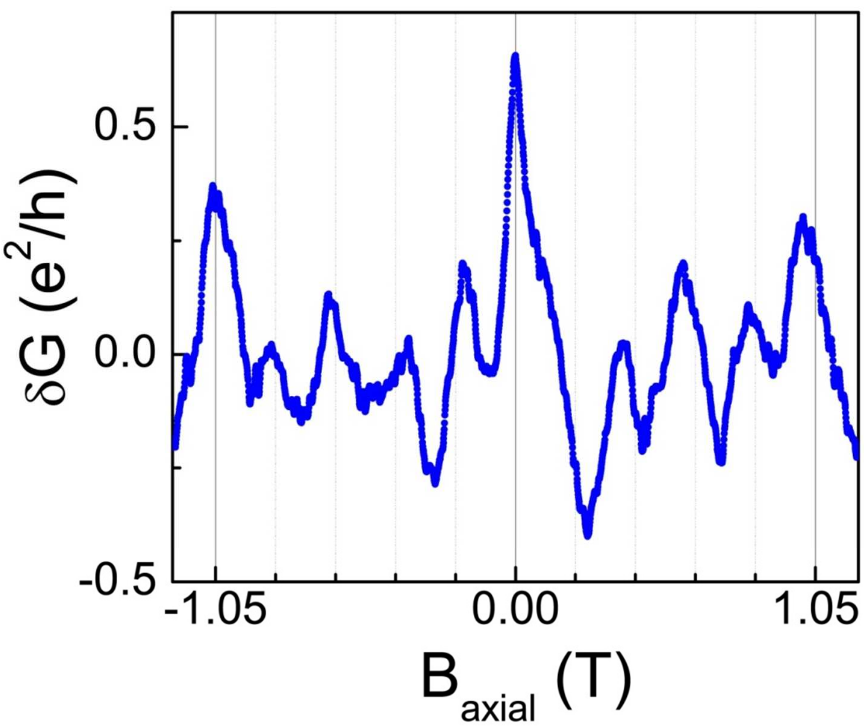

Figure S5. Differential MC obtained from sample **D5** at T = 2.0 K. A smooth background MC was subtracted out. The dotted lines indicate an average period ΔB_{axial} = 0.21 T for the δG oscillations. Assuming that the nanowire has a rectangular cross section, the area becomes 2.10×10^{-14} m^2. Thus, the oscillation period corresponds to a magnetic flux $\Phi = 1.07\Phi_0$, where $\Phi_0 = h/e$ is the magnetic flux quantum. The flux can be overestimated by the approximation of the cross sectional shape.

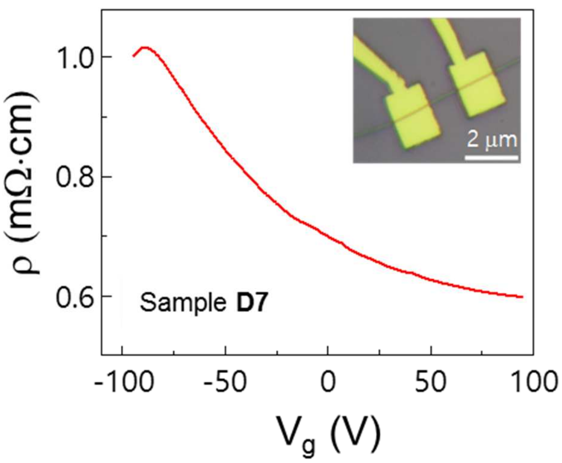

Figure S6. Resistivity vs. gate voltage curve of β-Ag_2Se nanowire. Sample **D7** shows a signature of an ambipolar gate dependence near V_g = -80 V. The optical microscope image for the sample is displayed in the inset.

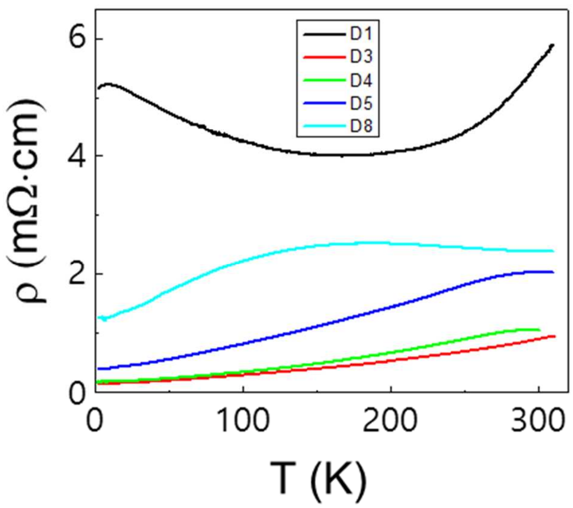

Figure S7. Resistivity vs. temperature curves. Insulating behavior is observed in the samples of **D1** and **D8**, while metallic behavior is observed at low temperatures below the hump (~10 K for **D1**, ~170 K for **D8**, ~300 K for **D5**). Relatively weak insulating behavior is attributed to the contribution of the bulk conductivity.

References

1. Hikami, S.; Larkin, A. I.; Nagaoka, Y. Spin-Orbit Interaction and Magnetoresistance in the Two Dimensional Random System. *Progr. Theor. Exp. Phys.* **1980,** *63*, 707-710.