

# **Supplementary Information for Low-Temperature Growth of High-Quality Bi<sub>2</sub>O<sub>2</sub>Se for High-Performance Photodetection**

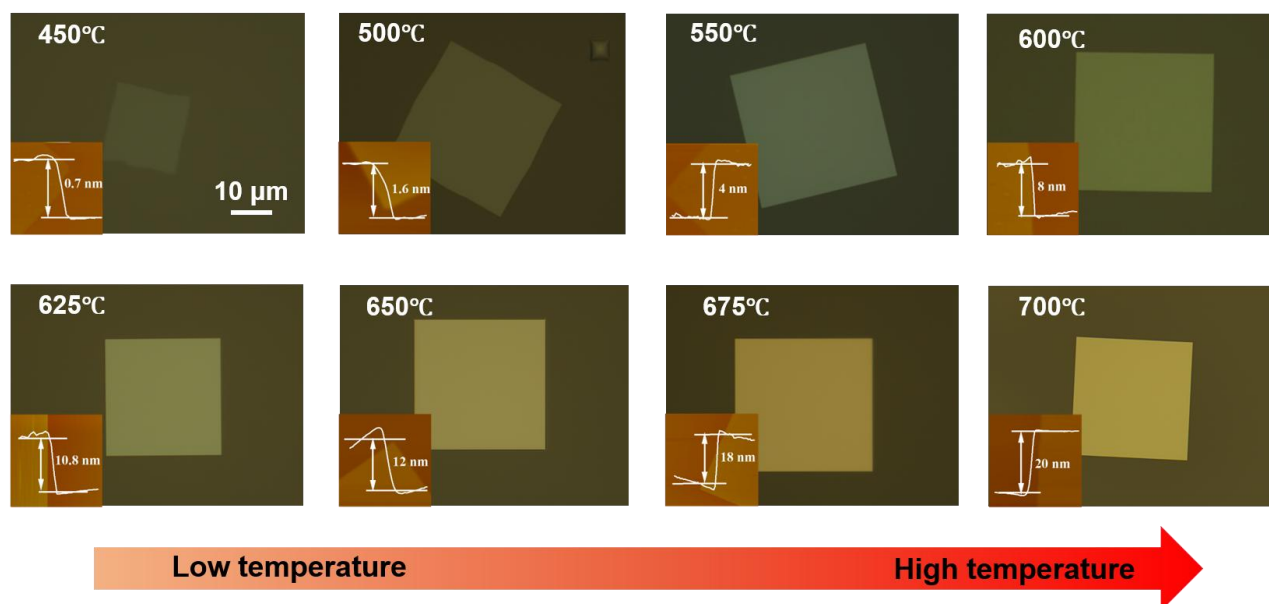
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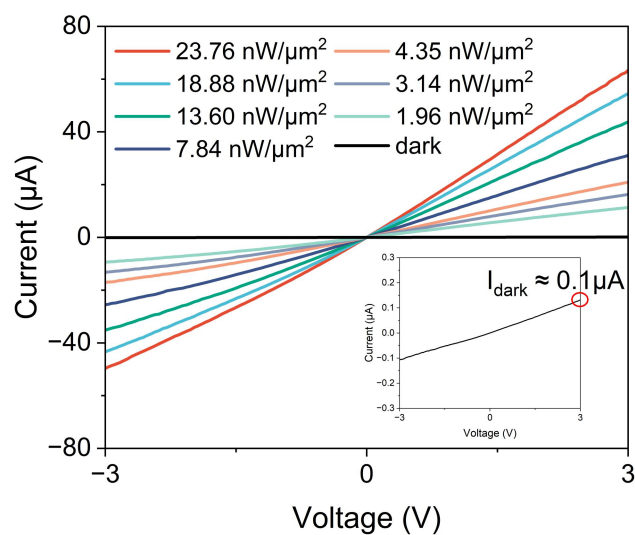
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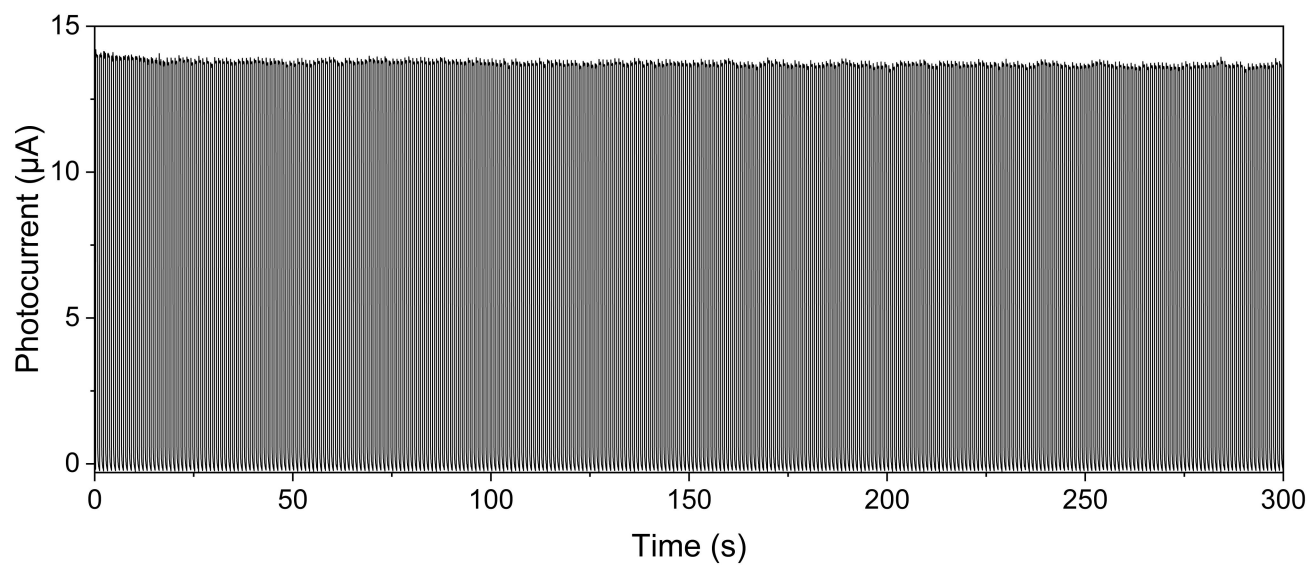
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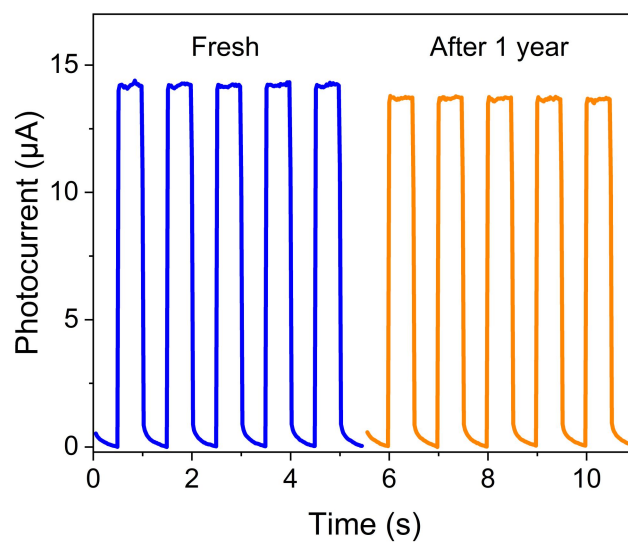
**Figure S1.** Temperature-dependent growth of  $\text{Bi}_2\text{O}_2\text{Se}$  nanosheets. Optical images of  $\text{Bi}_2\text{O}_2\text{Se}$  nanosheets grown at temperatures ranging from 450 to 700 °C. The insets show the corresponding AFM height profiles, revealing an increase in nanosheet thickness from approximately 0.7 nm at 450 °C to 20 nm at 700 °C.



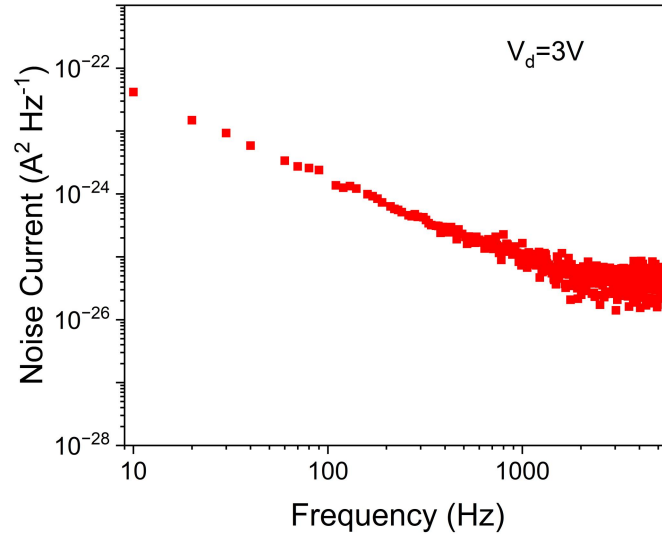
**Figure S2.** I–V characteristics of the Bi<sub>2</sub>O<sub>2</sub>Se photodetector under 1550 nm illumination at different incident power densities ranging from 1.96 to 23.76 nW μm<sup>-2</sup>. The inset shows the dark-state I–V characteristic, with a dark current of approximately 0.1 μA at a bias voltage of 3 V.



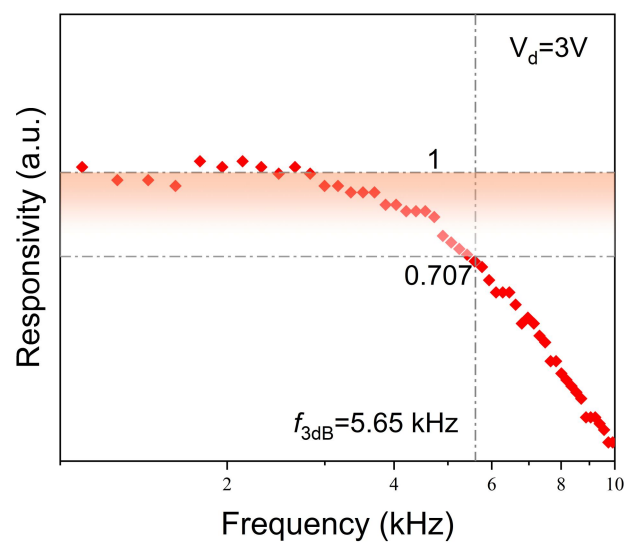
**Figure S3.** Long-term cycling stability of the Bi<sub>2</sub>O<sub>2</sub>Se photodetector under repeated light on/off switching. The device maintains a stable and reproducible photocurrent response over a measurement duration of 300 s, indicating good operational stability and repeatability of the photodetection performance.



**Figure S4.** Comparison of the time-resolved photoresponse of the Bi<sub>2</sub>O<sub>2</sub>Se photodetector measured in the fresh state and after one year of ambient storage. The device maintains a stable and reproducible photocurrent response after one year, with only a slight change in photocurrent amplitude, demonstrating good long-term environmental and photoresponse stability.



**Figure S5.** Noise power spectra of  $\text{Bi}_2\text{O}_2\text{Se}$  nanosheets photodetector at 3 bias. The noise characteristics of the device were measured using a Keysight N9010B signal analyzer over a frequency range of 10 Hz–5.8 kHz. The resolution bandwidth (RBW) and video bandwidth (VBW) were both set to 1 Hz. The spectra were averaged over 30 measurements using an average detector to suppress random fluctuations.



**Figure S6.** Frequency-dependent responsivity of the photodetector.