Supplementary information for:

Chemical Vapor Deposition of Hexagonal Boron Nitride on Germanium from Borazine

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Supplementary Note 1: Borazine purification via freeze-pump-thaw

Prior to growth, borazine is purified via freeze-pump-thaw cycles. First, ~5 mL of borazine (contained in a Pyrex tube attached to our CVD system) is frozen via submersion into a liquid nitrogen dewar for 5 minutes. To remove hydrogen and residual gases, the borazine is purged with 100 sccm of Ar for 5 minutes and then evacuated with no Ar flow for 5 minutes with a dry scroll pump, reaching a pressure of approximately 9×10^{-3} torr. Then, evacuation is stopped, and the borazine is allowed to thaw by removing the liquid nitrogen dewar and submerging the Pyrex tube in room temperature water for approximately 3 minutes. This process is repeated three times before growth. Note, only a small fraction (<10%) of our Pyrex tube is filled with borazine, and the unfilled space gives borazine room to expand during thawing.

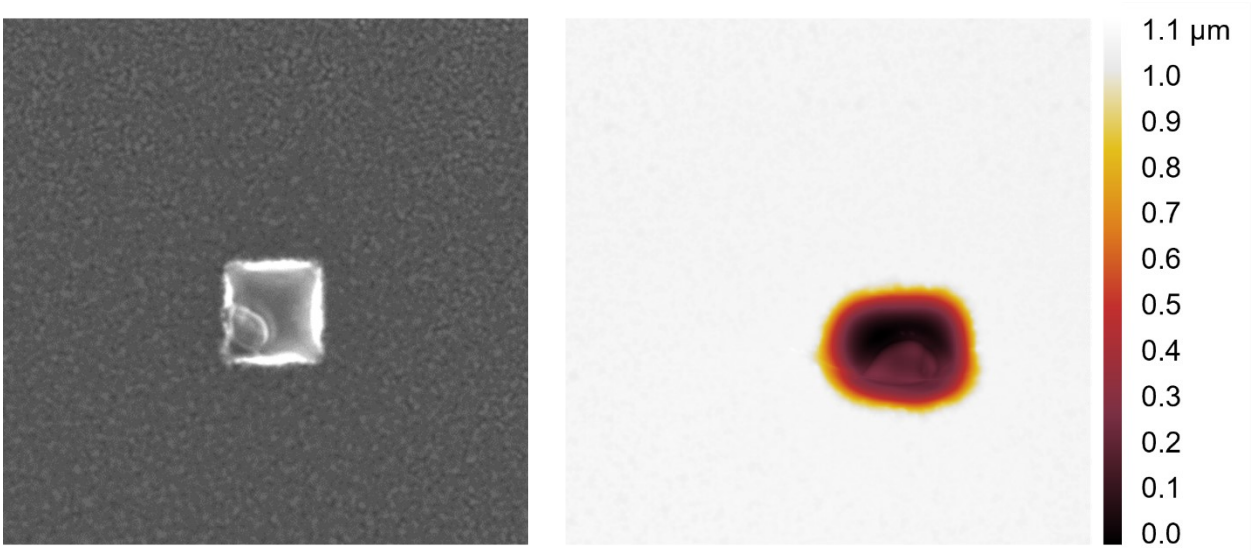

Figure S1: a) SEM image (20 µm by 20 µm) and b) AFM height map (20 µm by 20 µm) showing an etch pit in the Ge(001) surface after high-vacuum annealing in the face-up sample configuration for 30 min.

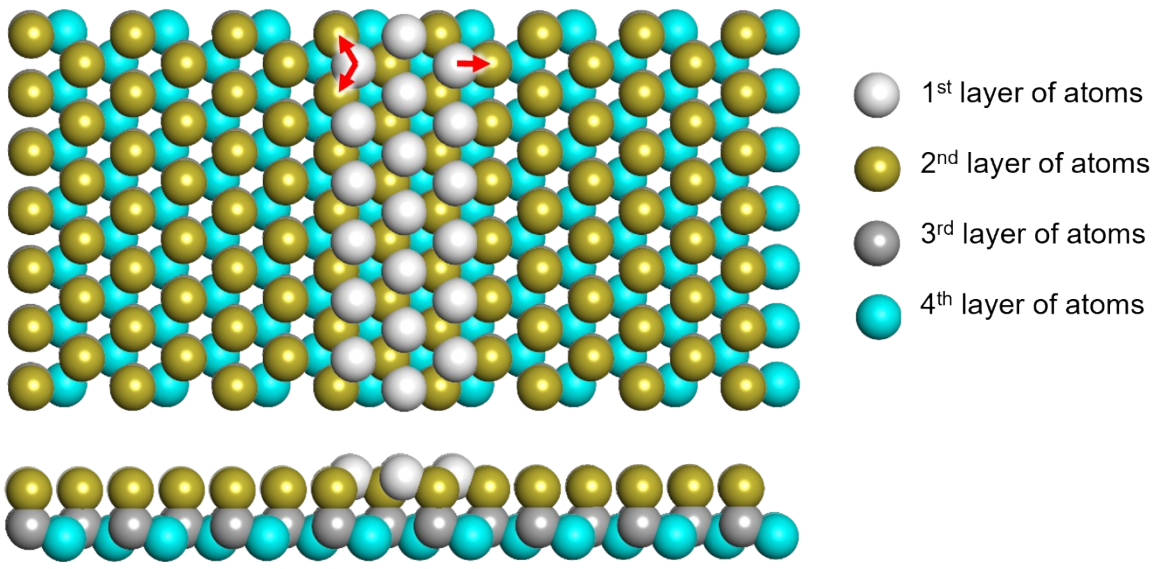

Figure S2: Schematic showing asymmetry of step edges on Ge(111), highlighted by red arrows.

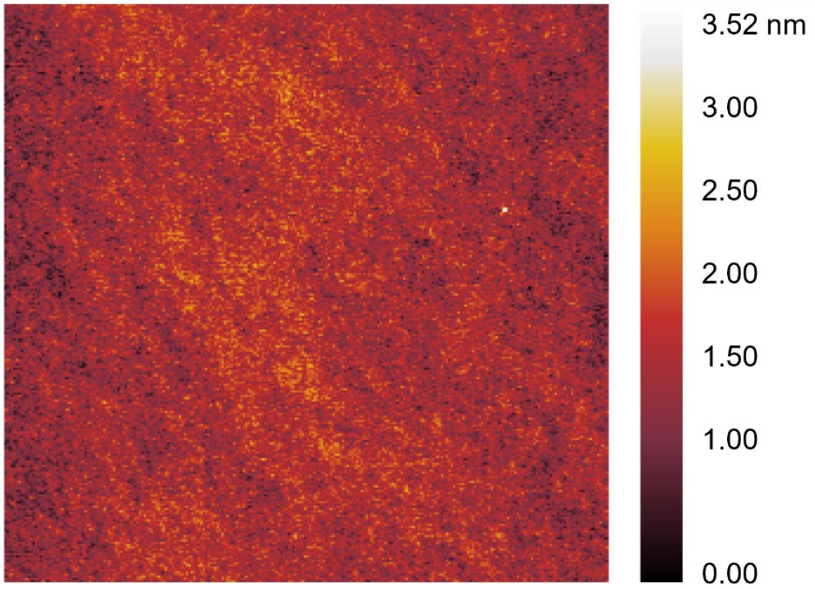

Figure S3: AFM scan (10 μm × 10 μm) of a bare Ge(110) substrate exposed to 0.02 M $FeCl_3$ for 1 minute, showing a lack of etch pits.

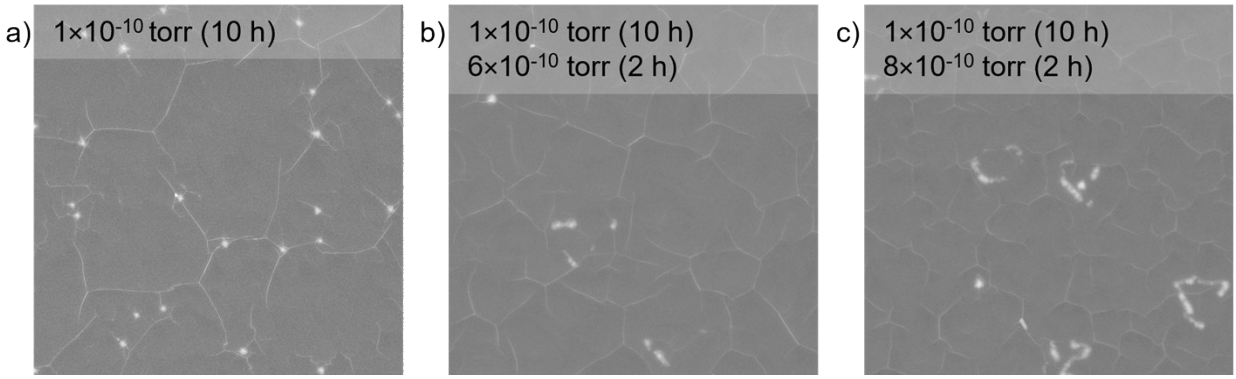

Figure S4: SEM images (10 μm × 10 μm) of monolayer hBN grown on Ge(110) with borazine partial pressures of a) 1×10^{-10} torr for 10 h, b) 1×10^{-10} torr for 10 h and then 6×10^{-10} torr for 2 h, and c) 1×10^{-10} torr for 10 h and then 8×10^{-10} torr for 2 h.

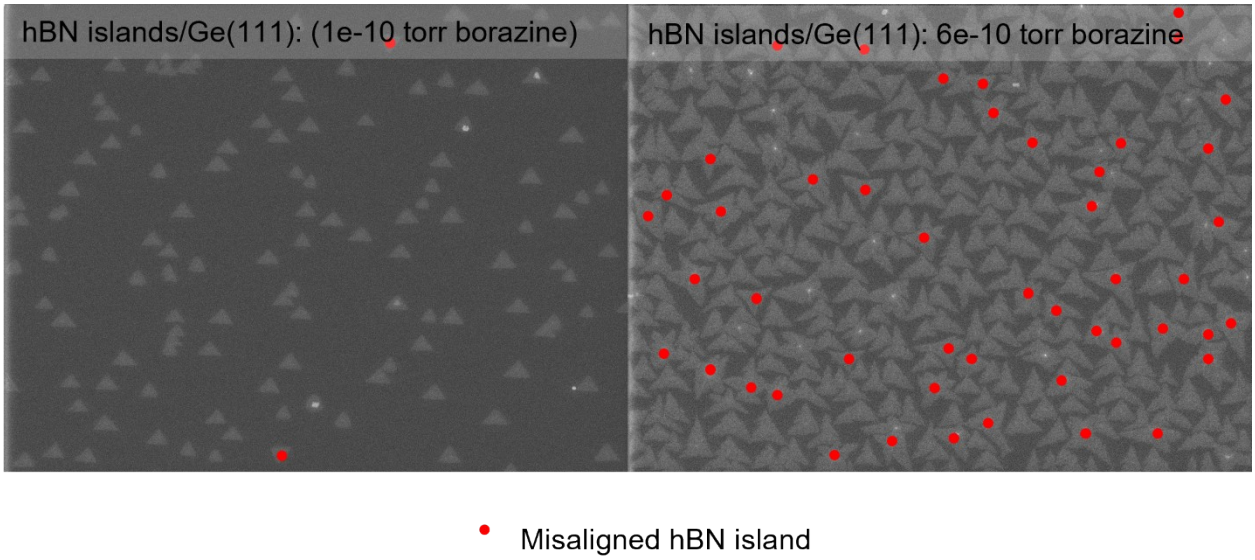

Figure S5: SEM images (11.25 μm × 8.44 μm) comparing hBN islands grown on Ge(111) with 1×10^{-10} and 6×10^{-10} torr for 30 minutes. Misaligned hBN islands are marked with a red dot.

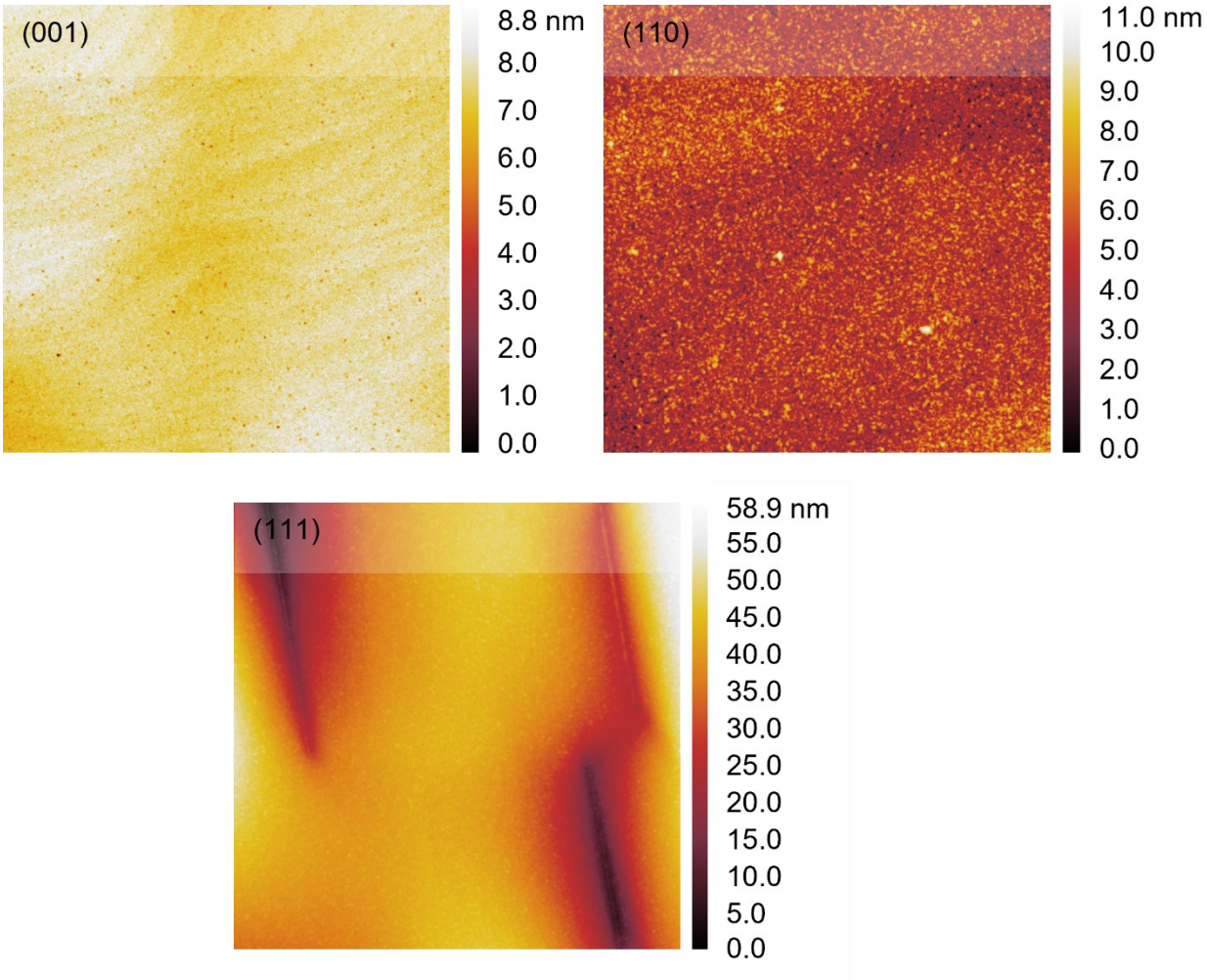

Figure S6: AFM scans (5 μm × 5 μm) showing initial roughness of the Ge/Si wafers.

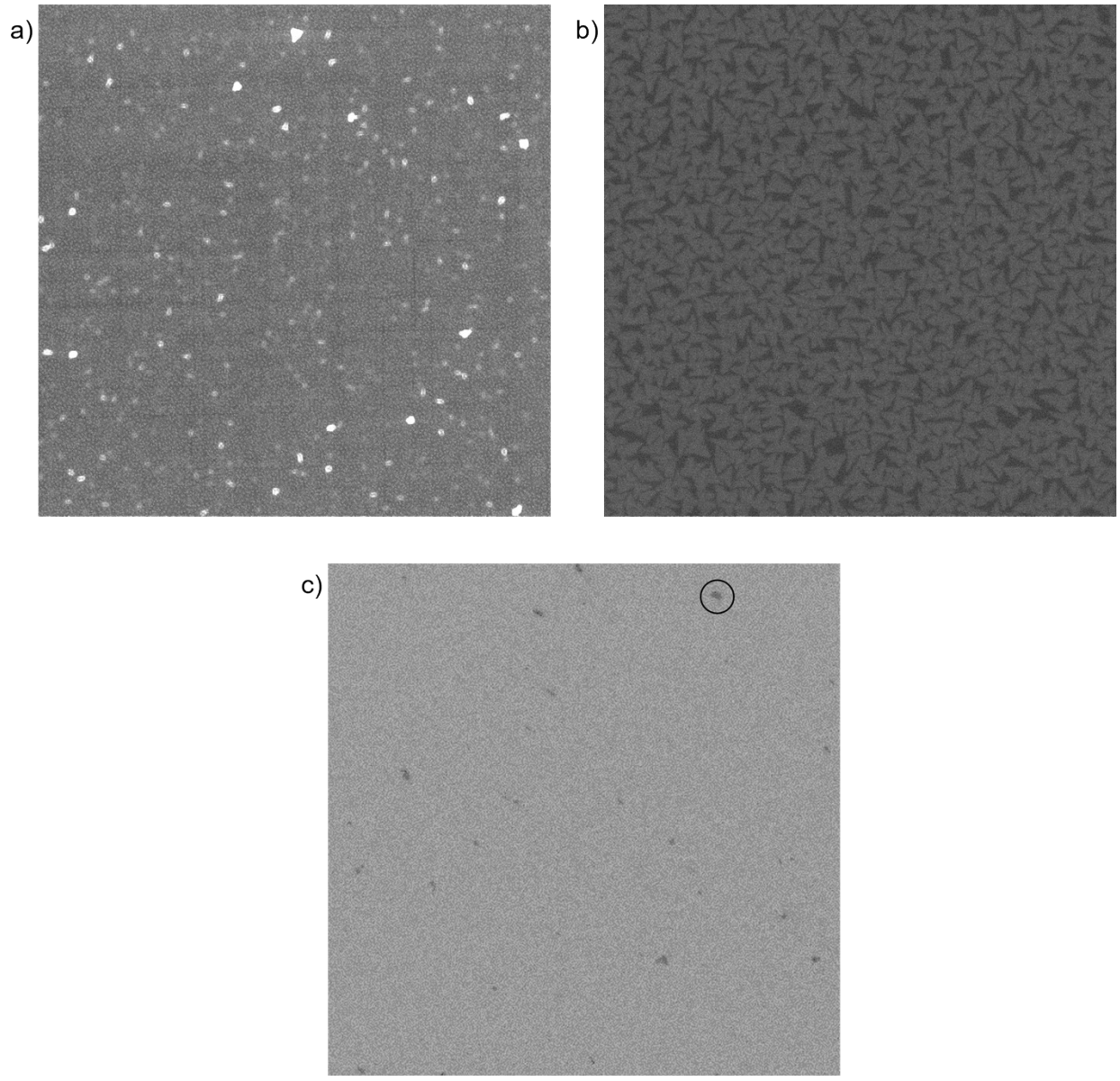

Figure S7. SEM images (10 μm × 10 μm) of hBN grown on Ge/Si(001) using 6×10^{-10} torr borazine for 30 minutes. The Ge/Si(001) substrates were annealed in Ar and H_2 at 920 °C for a) 9 hours and b) the typical 45 minutes. c) SEM image (10 μm × 10 μm) of hBN grown on Ge/Si(001) using 1×10^{-10} torr borazine for 10 hours. The circle marks one region where the film is incomplete.