

Supporting Information

Enhancing Proton Irradiation Tolerance of a-IGZO Thin-Film Transistors through Hydrogen Doping

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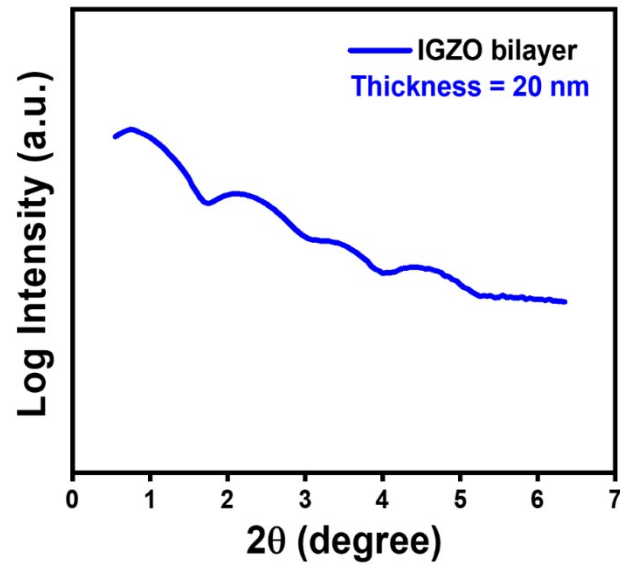


Fig. S1. X-ray reflectometry (XRR) of IGZO bilayer thin films.

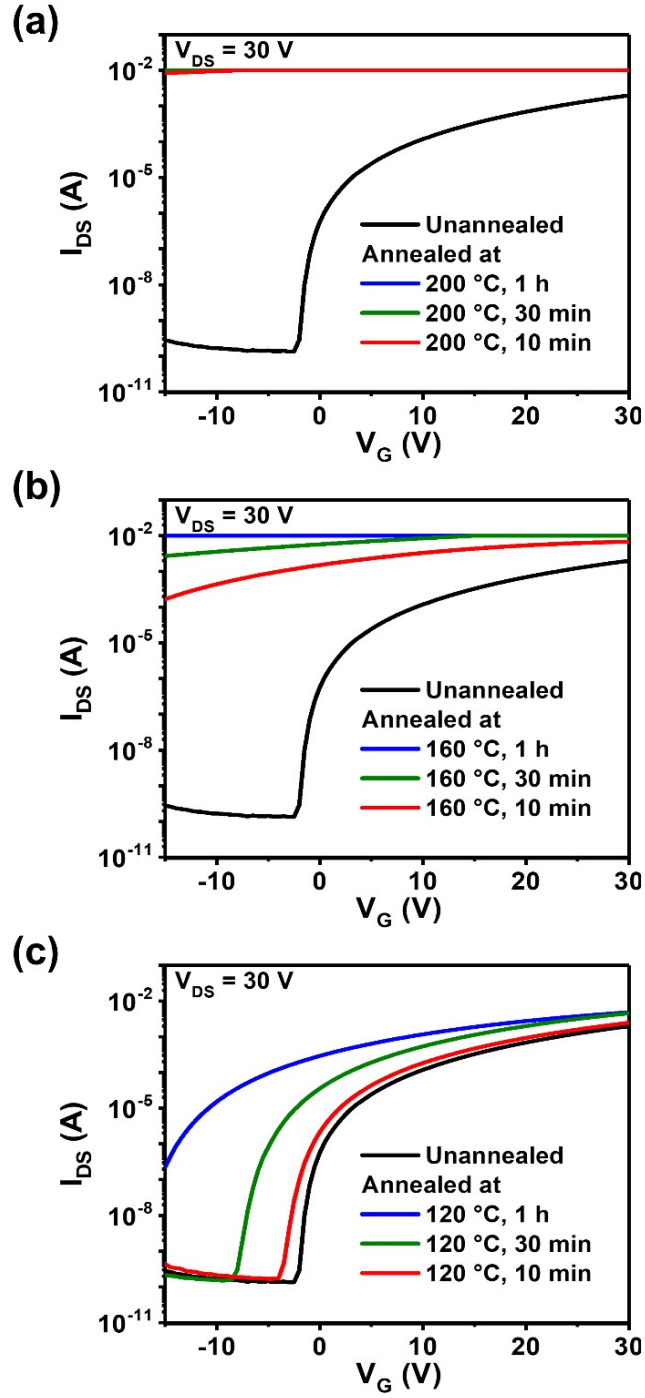


Fig. S2. Transfer characteristics of IGZO TFTs before and after post-annealing in a forming gas atmosphere composed of 5% H_2 and 95% Ar at different temperatures: (a) 200 °C, (b) 160 °C, and (c) 120 °C.

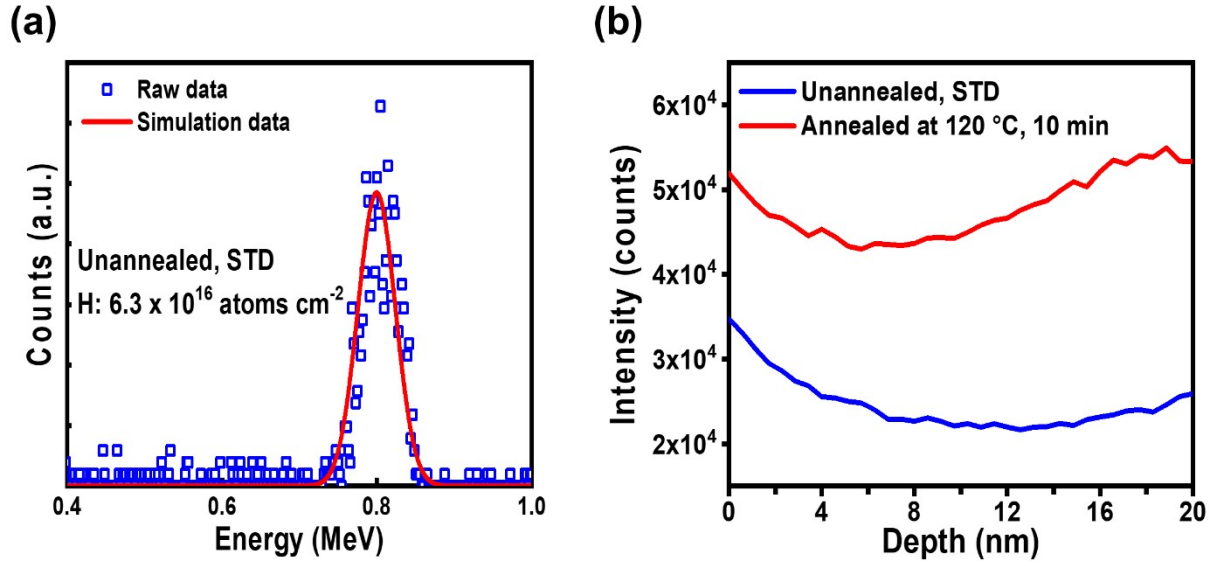


Fig. S3. (a) Elastic recoil detection (ERD) spectrum of the unannealed IGZO film used as the standard sample for time-of-flight secondary ion mass spectrometry (TOF-SIMS) hydrogen quantification. (b) Depth-resolved TOF-SIMS hydrogen intensity profiles of unannealed IGZO films and those post-annealed at 120 °C for 10 min.

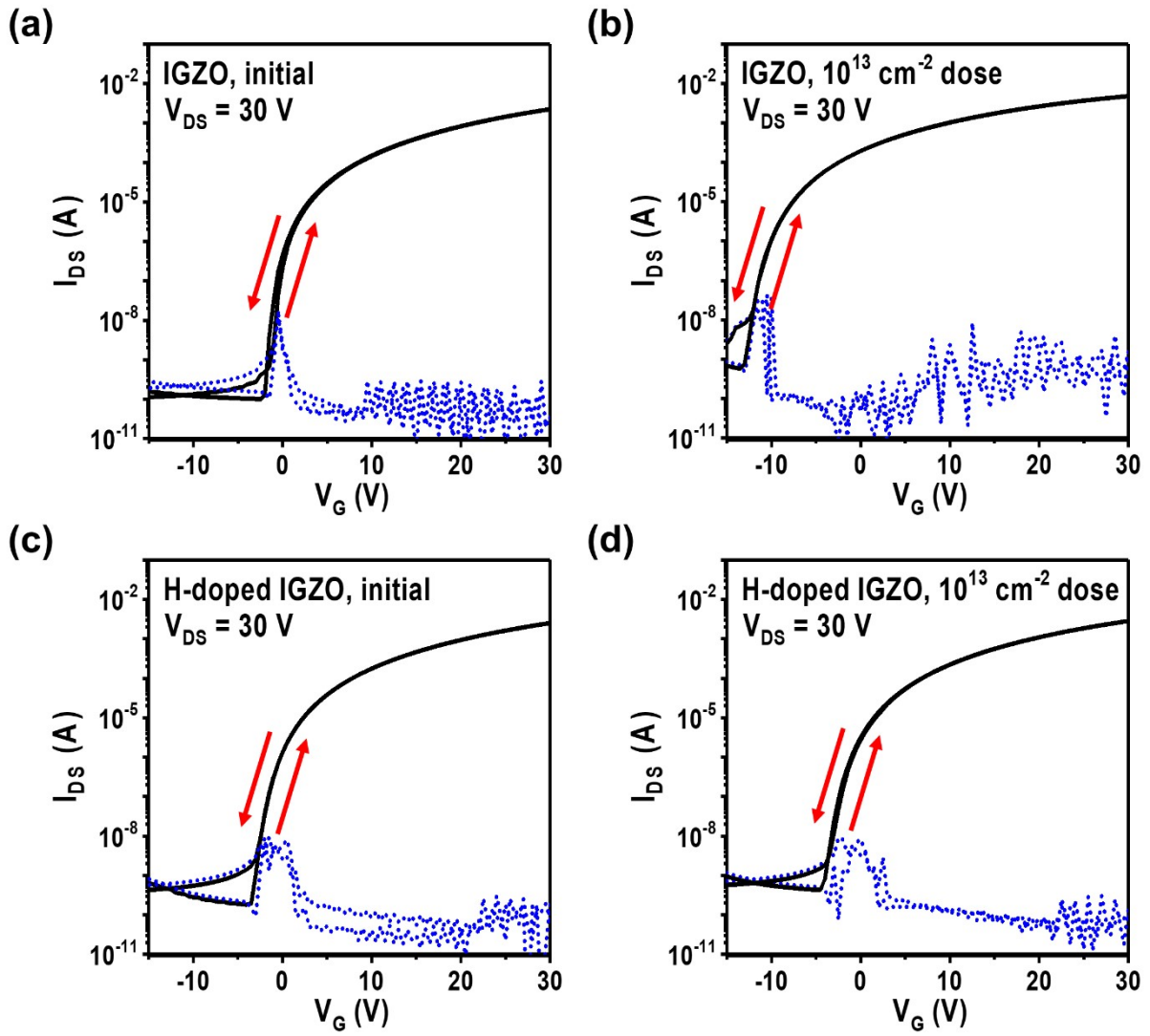


Fig. S4. Bidirectional transfer characteristics of IGZO and H-doped IGZO TFTs under proton irradiation (10^{13} cm^{-2} dose): (a) IGZO TFT before irradiation, (b) IGZO TFT after irradiation, (c) H-doped IGZO TFT before irradiation, and (d) H-doped IGZO TFT after irradiation. The gate leakage current is indicated by the blue line in each transfer curve.

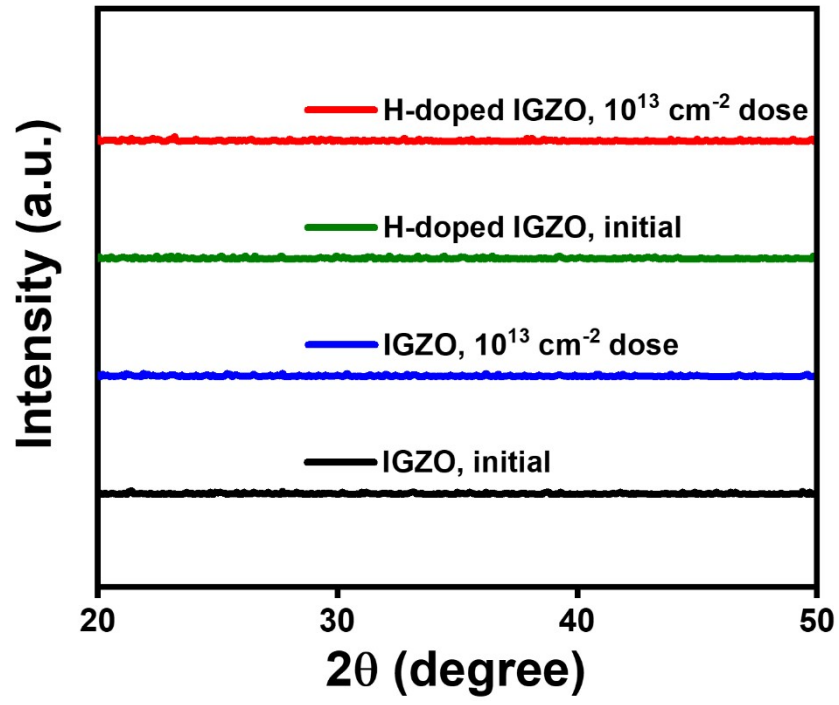


Fig. S5. Grazing-incidence X-ray diffraction (GIXRD) spectra of IGZO and H-doped IGZO thin films before and after 5 MeV proton irradiation at a dose of 10^{13} cm^{-2} .

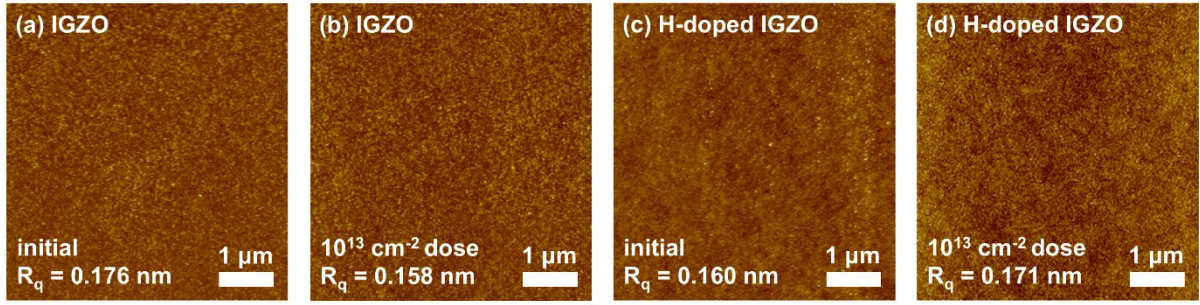


Fig. S6. Atomic force microscope (AFM) images of oxide semiconductor thin films before and after 5 MeV proton irradiation at a dose of 10^{13} cm^{-2} : (a) IGZO before irradiation, (b) IGZO after irradiation, (c) H-doped IGZO before irradiation, and (d) H-doped IGZO after irradiation. The scale bars correspond to 1 μm . R_q denotes the root-mean-square roughness.