

### Supplementary figures:

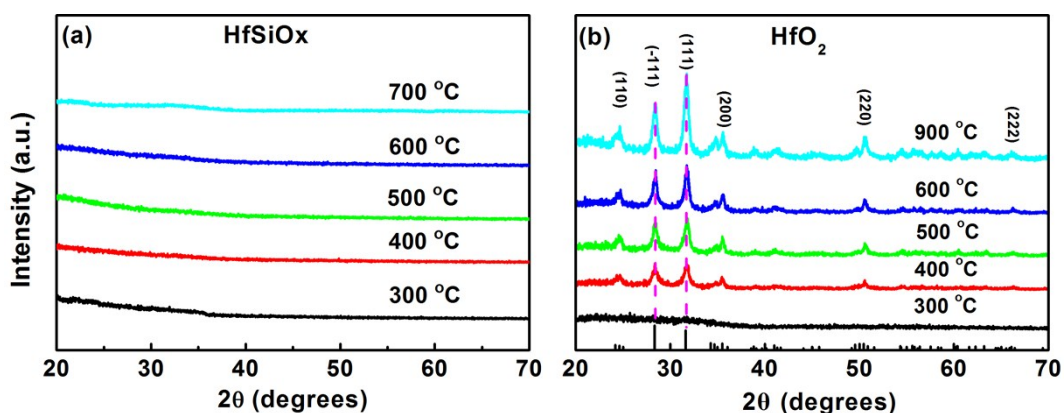


Figure S1 (a) XRD patterns of HfSiOx films annealed at different temperatures. (b) XRD patterns of HfO<sub>2</sub> films annealed at different temperatures.

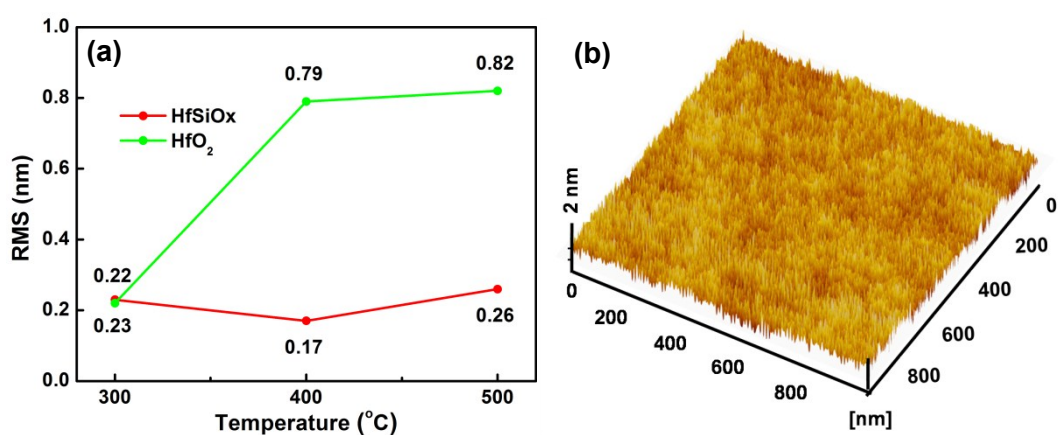


Figure S2 (a) Surface root mean square (RMS) roughness of HfO<sub>2</sub> and HfSiOx films annealed at different temperatures. (b) Typical AFM image of HfSiOx films annealed at 500 °C.

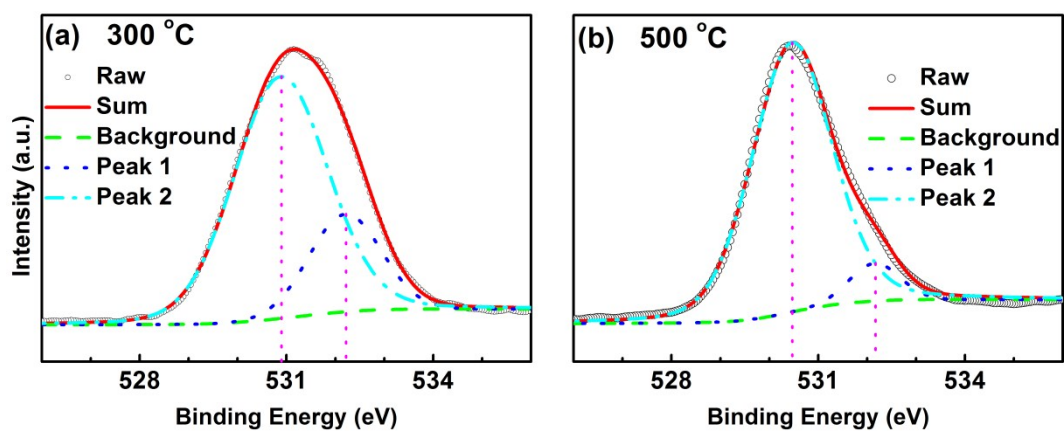


Figure S3 O 1s XPS spectra of HfSiOx films annealed at 300 °C and 500 °C, respectively.

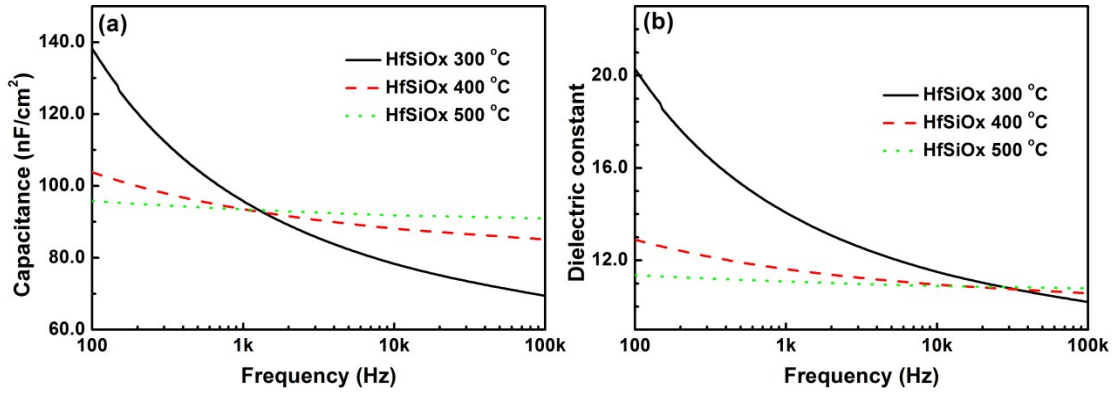


Figure S4 Capacitance-frequency and dielectric constant-frequency plots of HfSiOx films annealed at different temperatures.

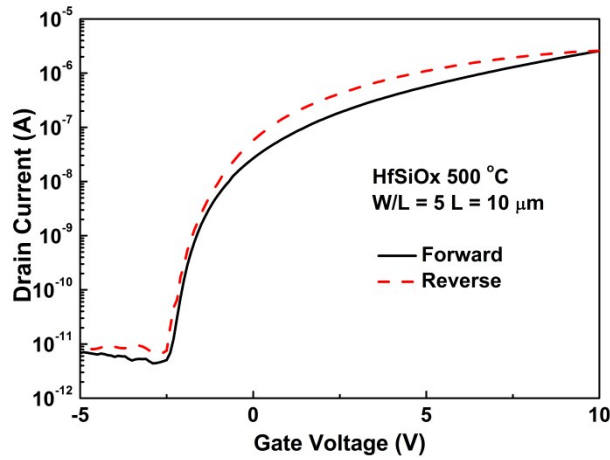


Figure S5 The hysteresis data of TFTs including HfSiOx layers annealed at 500 °C

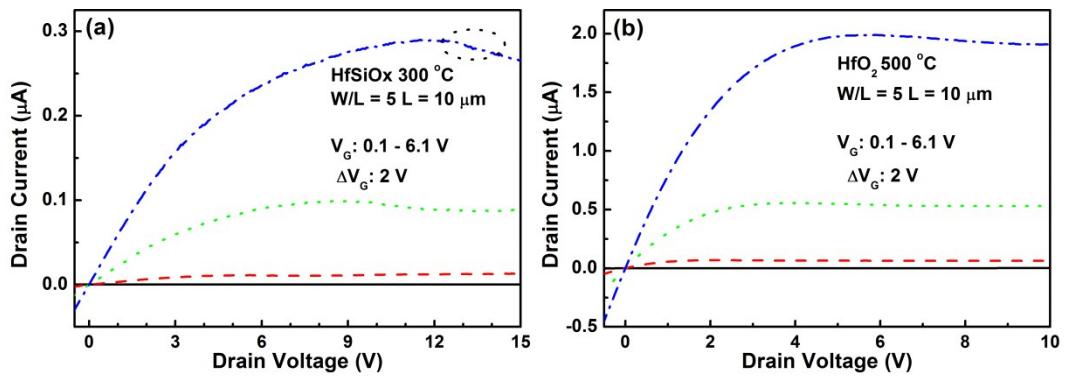


Figure S6 Output characteristics of HIZO TFTs with HfSiOx dielectrics annealed at 300 °C and HIZO TFTs with HfO<sub>2</sub> dielectrics annealed at 500 °C.

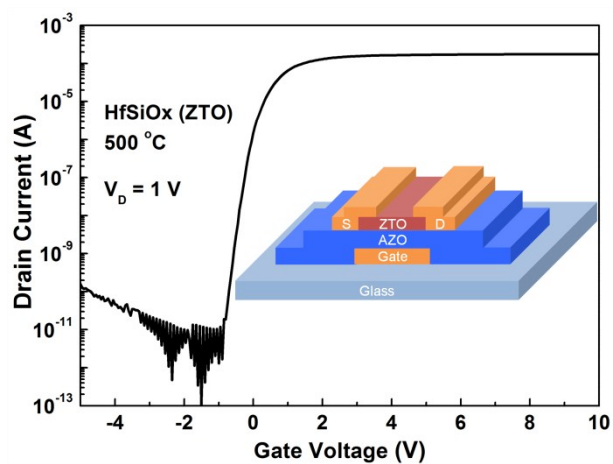


Figure S7 Transfer characteristics of ZTO TFTs with HfSiOx dielectrics annealed at 500 °C. Inset was the structure schematic of the ZTO TFTs.