

Supplementary data

Capacitance Electrochemical pH Sensor Based on Different Hafnium dioxide (HfO₂) thicknesses

Table S1. Fitting data for HfO₂ sensing substrate with a thickness of 15.0 nm for pH response:

pH	Solution resistance (Ω)	Constant phase element (μF)	Charge transfer resistance (kΩ)	Fitting error
3	38.67± 0.271	0.265 ± 0.0017	27.743 ± 3.53	0.007
5	38.96 ± 0.204	0.258 ± 0.0074	30.978 ± 4.467	0.004
7	38.86 ± 0.266	0.268 ± 0.007	33.585 ± 3.281	0.006
9	39.28± 0.271	0.265 ± 0.0017	35.743 ± 5.53	0.007

Table S2. Fitting data for HfO₂ sensing substrate with a thickness of 19.5 nm for pH response:

pH	Solution resistance (Ω)	Constant phase element (μF)	Charge transfer resistance (kΩ)	Fitting error
3	36.21± 0.316	0.232 ± 0.052	49.531 ± 0.905	0.014
5	36.53 ± 0.204	0.225 ± 0.042	56.823 ± 0.969	0.015
7	36.56 ± 0.280	0.231 ± 0.037	65.605 ± 0.741	0.006
9	35.73± 0.271	0.235 ± 0.032	80.825 ± 0.571	0.005

Table S3. Fitting data for HfO₂ sensing substrate with a thickness of 39.9 nm for pH response

pH	Solution resistance (Ω)	Constant phase element (μF)	Charge transfer resistance ($\text{k}\Omega$)	Fitting error
3	26.21 ± 0.322	0.132 ± 0.012	90.892 ± 1.015	0.007
5	26.53 ± 0.204	0.139 ± 0.013	108.345 ± 1.033	0.005
7	26.56 ± 0.280	0.133 ± 0.037	138.205 ± 1.023	0.006
9	26.62 ± 0.309	0.135 ± 0.008	156.835 ± 1.003	0.005

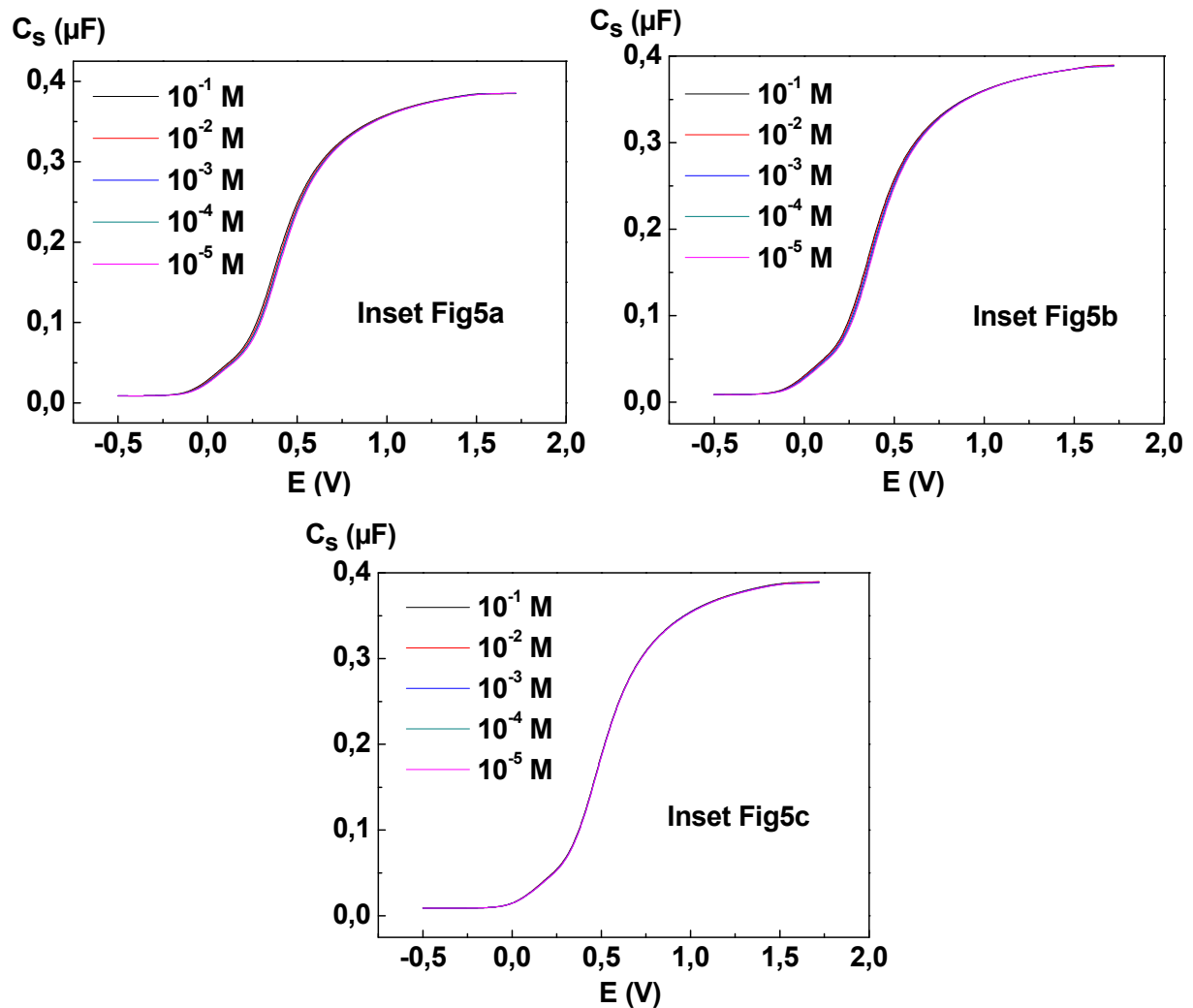


Figure S1 Typical C(V) for capacitance measurements of Si/SiO₂/HfO₂ structure 15nm using interfering ions (a) K⁺, (b) Li⁺, and (c) Na⁺ with concentrations from 10⁻⁵ M to 10⁻¹ M. The flat band potential V_{FB} variation was too weak when compared with Figure 1a.

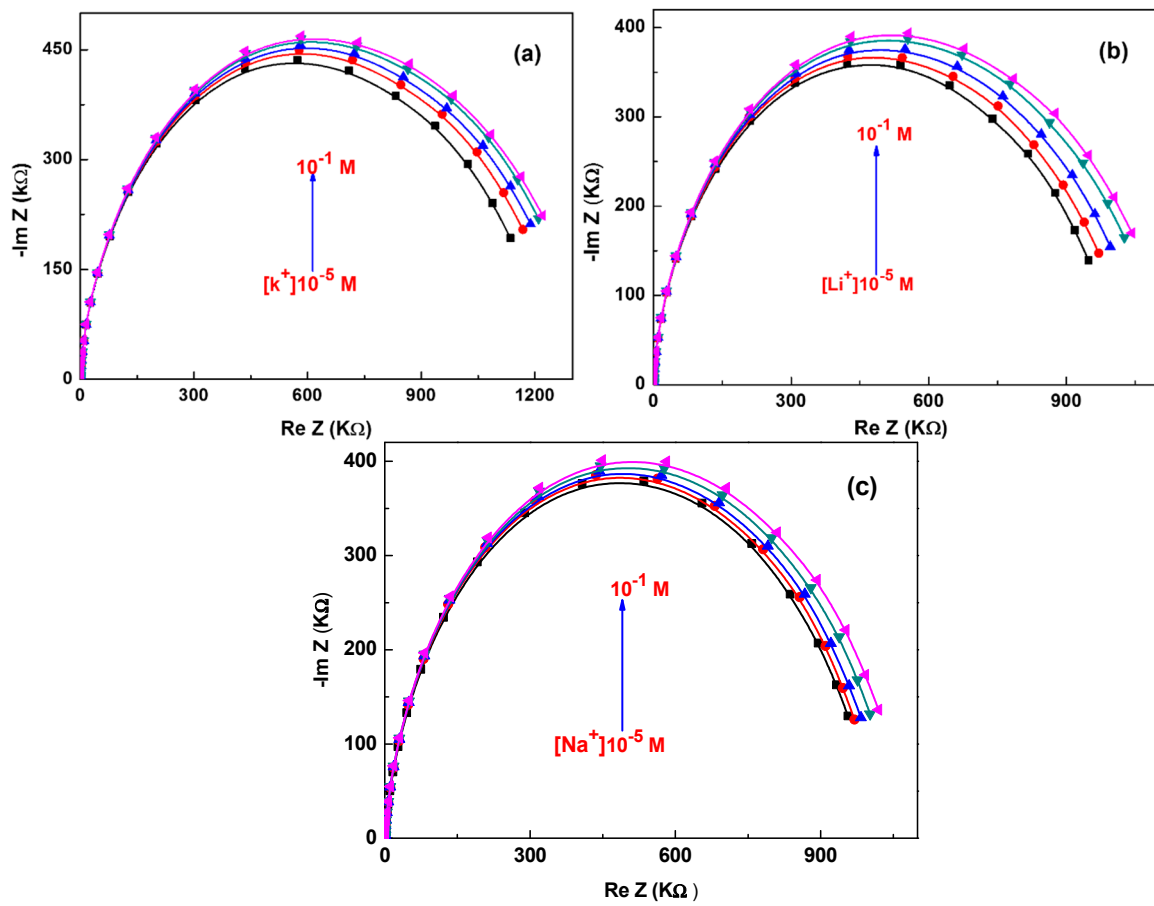


Figure S2. The impedimetric response of Si/SiO₂/HfO₂ structure (thickness 15 nm), versus (a) K⁺, (b) Li⁺, and (c) Na⁺ concentrations from 10⁻⁵ M to 10⁻¹ M