

Design of Interface Formation Process for Superior Ferroelectricity and Enhanced Fatigue Resistance in $\text{Hf}_x\text{Zr}_{1-x}\text{O}_2$ -Based Ferroelectric Devices

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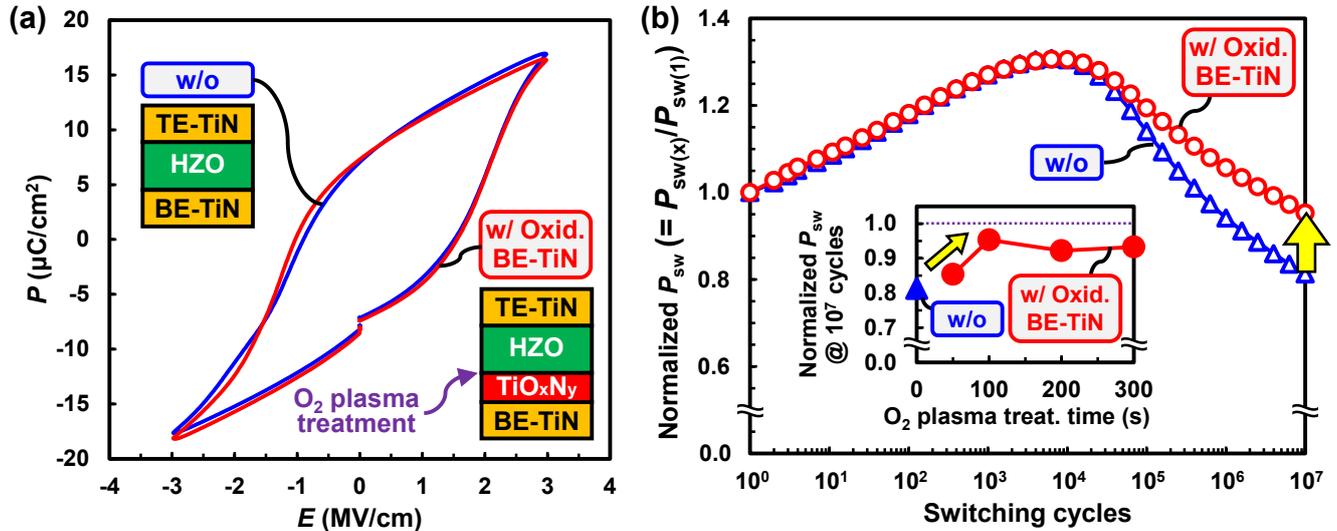


Fig. 1 (a) Polarization–electric field (P – E) hysteresis curves and (b) endurance properties with normalized P_{sw} for the w/o and w/ Oxid.-BE-TiN capacitors. The inset of Fig. 1(b) shows the normalized P_{sw} as a function of the O₂ plasma treatment time of the BE-TiN surface. In the pristine state, no significant difference in P_{sw} ($\sim 15 \mu\text{C}/\text{cm}^2$) was observed between the w/o and w/ Oxid.-BE-TiN capacitors as shown in Fig. 1(a), due to almost the same crystal structure of both HZO films evaluated by XRD patterns. In the fatigue state, on the other hand, the P_{sw} degradation of the w/ Oxid.-BE-TiN capacitor was suppressed by $\sim 14\%$ compared to that of the w/o capacitor as shown in the Fig. 1(b). In the fatigue state after 10⁷ field cycling, the normalized P_{sw} for the w/ Oxid.-BE-TiN capacitor increased as the O₂ plasma treatment time increased up to 100 s, beyond which it tended to saturate as shown in the inset of Fig. 1(b). These results indicate that fatigue of HZO-based capacitors was improved by using the Oxid.-BE-TiN with oxygen-rich TiO_xN_y -IL, which could play a role as an oxygen blocking IL.

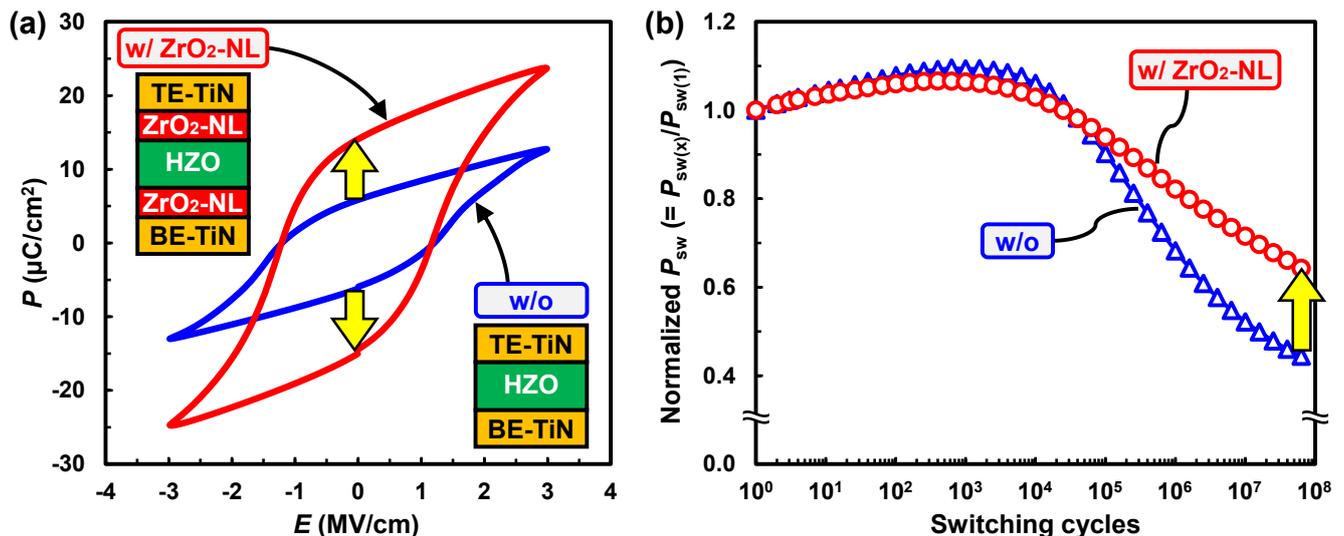


Fig. 2 (a) P – E hysteresis curves and (b) endurance properties with normalized P_{sw} for the w/o and w/ ZrO₂-NL capacitors. In the pristine state, the w/ ZrO₂-NL capacitor showed 2.3 times higher P_{sw} (29 $\mu\text{C}/\text{cm}^2$) compared to that of the w/o capacitor (12 $\mu\text{C}/\text{cm}^2$) as shown in Fig. 2(a) because of higher fraction of the ferroelectric O phase. For the fatigue state, the w/ ZrO₂-NL capacitor exhibited less P_{sw} degradation ($\sim 33\%$) compared to the w/o capacitor ($\sim 52\%$) as shown in Fig. 2(b). Therefore, it was found that high P_{sw} and high fatigue resistance was achieved simultaneously by using the ALD-ZrO₂-NLs because ALD-ZrO₂-NLs are effective not only in enhancing P_{sw} but also in suppressing fatigue by acting as an oxygen-blocking IL.