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Oxygen Defect-Induced Metastability in Oxide Semiconductors Probed by Gate Pulse Spectroscopy

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Introduction

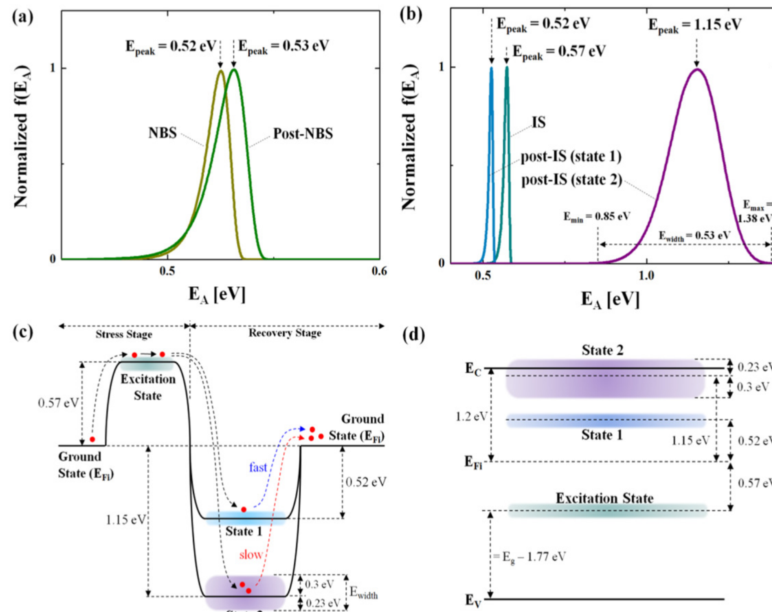
- Instability mechanisms in oxide TFTs investigated with stress and recovery experiments.
- Stretched exponentials and inverse Laplace transform employed to retrieve the defect distribution.

Results and Discussions

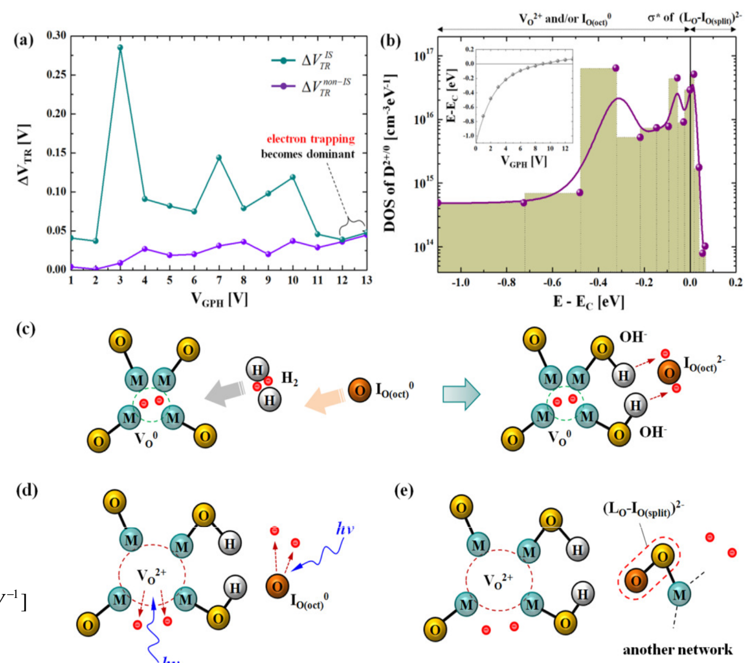
$$f(E_A) \approx \frac{\tau_{eff}\beta^{1+\gamma/2}}{\sqrt{2\pi\beta(1-\beta)}\left(\tau_{eff}\nu_{AE}\exp(-E_A/kT)\right)^{1+\gamma/2}}\exp\left(-(1-\beta)\beta^{\gamma}/\left(\tau_{eff}\nu_{AE}\exp(-E_A/kT)\right)^{\gamma}\right) \qquad F(t)=\exp\left(-(t/\tau_{eff})^{\beta}\right)$$

- Activation energy distributions:

$$L^{-1}\{F(t)\} \equiv f(S) = \frac{1}{2\pi j}\int_{-j\infty}^{j\infty}\exp\left(-(t/\tau_{eff})^{\beta}\right)\exp(St)\,dt \qquad S=\nu_{AE}\exp(-E_A/kT)$$

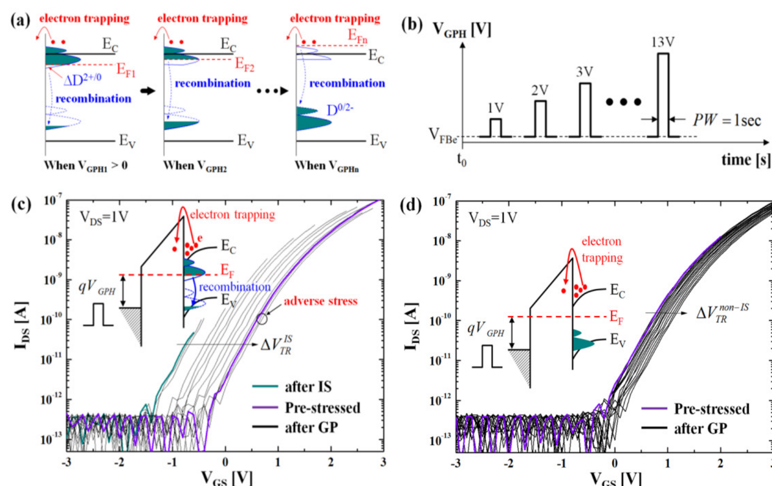


- Metastable defect distribution and reactions:



$$H_2 + 2L_O^{2-} \rightarrow 2OH^- + 2e^- \qquad 2e^- + I^0_{O(oct)} \rightarrow I^{2-}_{O(oct)}$$

- Gate-pulse spectroscopy: $N(D^{2+/0}) \approx \frac{\Delta n(\Delta D^{2+/0})}{\Delta V_{GPH}} \cdot \frac{\Delta V_{GPH}}{\Delta(E-E_C)}\ [cm^{-3}eV^{-1}]$



Conclusion

- Recovery process after illumination stress found to be persistently slow by virtue of defect states with a broad range, 0.85 eV to 1.38 eV, suggestion the presence of ionized oxygen vacancies and interstitials.
- A novel gate-pulse spectroscopy probed to reveal the post-stress ionized oxygen defect states distributed in a higher energy.

Related Publication: • Sungsik Lee *et al.*, ***Scientific Reports*** (NPG) 5, 14902 (2015).

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