Trap-Related Parametric Shifts under DC Bias and Switched Operation Life Stress in Power AlGaN/GaN HEMTs

S. G. Khalil[1], L. Ray[1], M. Chen[1], R. Chu[1], D. Zehnder[1], A. Garrido[1], M. Munsi[1], S. Kim[1], B. Hughes[1], K. Boutros[1], R. J. Kaplar[2], J. Dickerson[2], S. DasGupta[2], S. Atcitty[2], and M. J. Marinella[2]

[1] HRL Laboratories LLC, Malibu, CA 90265, USA, sgkhalil@hrl.com

[2] Sandia National Laboratories, Albuquerque, NM 87185, USA, rjkapla@sandia.gov

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- Opposite polarity V_T shift between Room-Temperature Operating Life (RTOL, Fig. 1) and Room-Temperature Reverse-Bias (RTRB, Fig. 2) measurements indicate competing electron trapping / de-trapping mechanisms.
- Trapping rate is increased at higher temperatures, implying energy-barrier limited trapping (Fig. 3)

- Drain-current transient measurements were used during off-state bias to monitor the competing mechanisms (Fig. 4)
- Trapping dominates for short-time stresses. However, for longer DC-like times, de-trapping becomes the predominant mechanism (Fig. 5)
- Electric-field-enhanced de-trapping results from a sufficiently long period of stress under RTRB conditions (Fig. 6)

- A 1-D electric potential and trapped electron density model was created to analyze trapping vs. time and position (Fig. 7); 2-D TCAD modeling is on-going to validate the model
- Incorporating field-enhanced emission via barrier lowering and phonon-assisted tunneling shows that a transition from trapping to de-trapping is physically plausible (Fig. 8)
- Electric field shaping using slanted field plate reduces V_T shift under RTOL stress (Fig. 9)

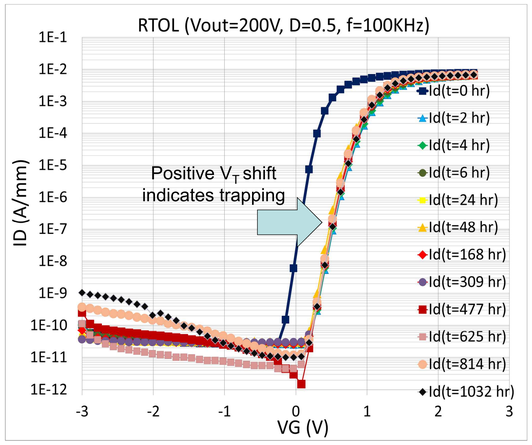

Fig. 1. Transfer curves for RTOL (switching) stress indicate that electron trapping dominates.

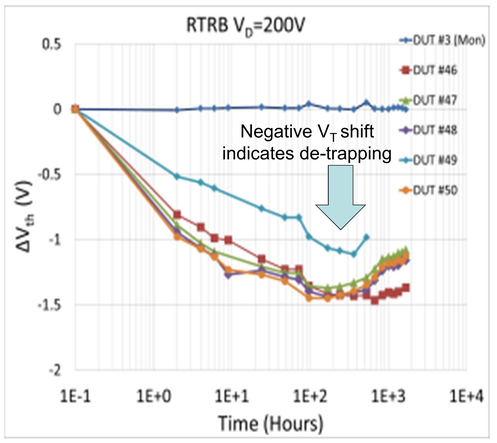

Fig. 2. V_T shifts during RTRB (DC) stress show that electron de-trapping dominates.

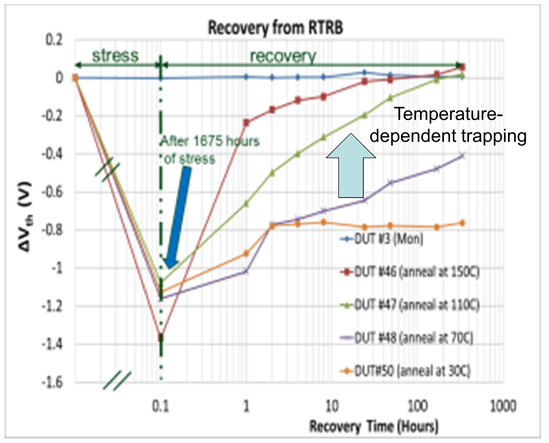

Fig. 3. Temperature-dependent recovery from RTRB indicates that electron trapping dominates at high temperatures, leading to positive V_T shifts.

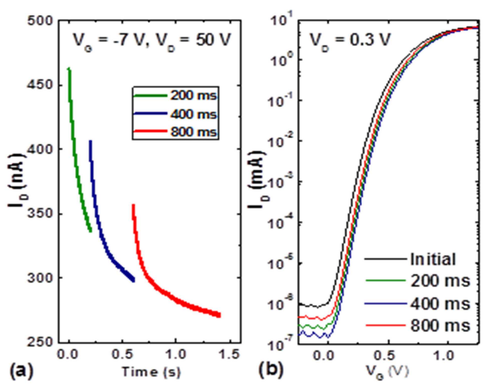

Fig. 4. (a) Drain current transients during RTRB stress. (b) Transfer curves measured after 200, 400, and 800 ms of RTRB stress.

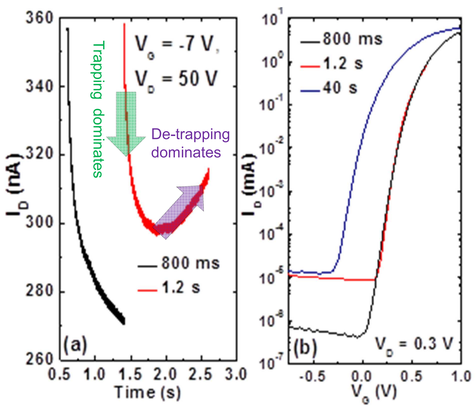

Fig. 5. (a) Drain current transients during 0.8 and 1.2 s RTRB stresses. (b) Transfer curves following 0.8, 1.2, and 40 s RTRB stresses.

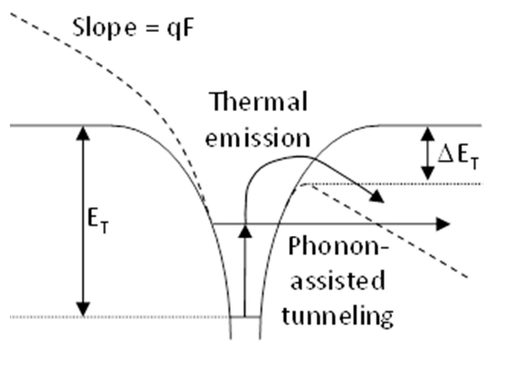

Fig. 6 Schematic illustration of enhanced emission from a deep-level trap due to a high electric field.

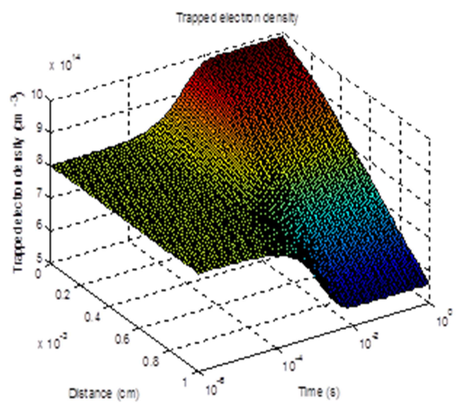

Fig. 7. Trapped electron density as a function of position and time for 1-D field-enhanced de-trapping model at 300 K

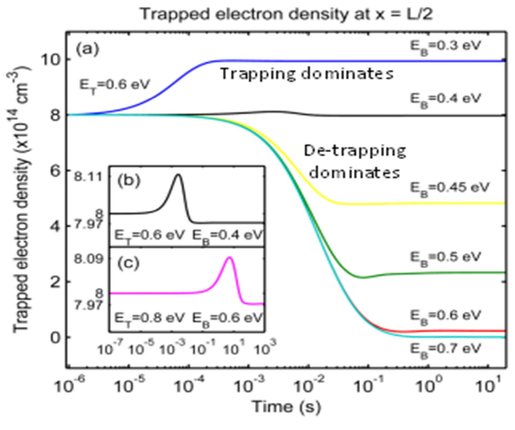

Fig. 8. Plots of trapped electron density at the mid-point of the spatial dimension from Fig. 7.

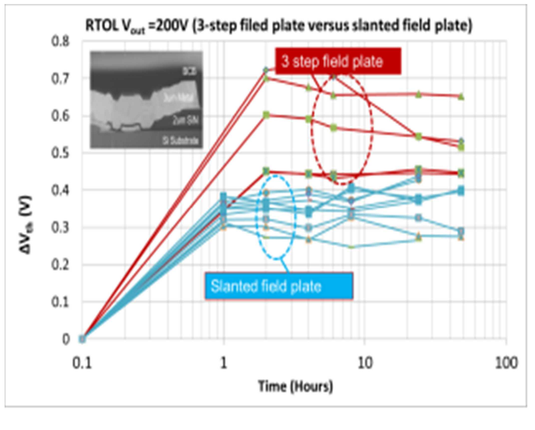

Fig. 9. V_T shift comparison for 3-step field plate design versus slanted field plate design.