

600 V Switching Characteristics of GaN Polarization Super-Junction (PSJ) Transistors on Sapphire substrate

POWDEC K.K.,

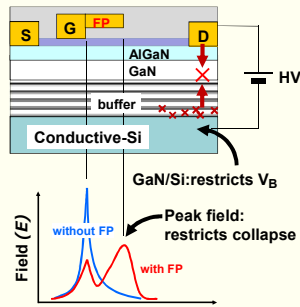
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[1. background]

Issues for commercialization of GaN power transistors

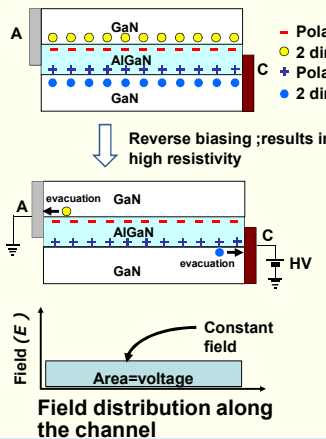
Current collapse, R_{on} increase during operation, is still a big issue. Conventional technique of the Field-Plate, FP, plus conductive Si substrate is insufficient to cease the collapse and causes the low breakdown voltage, V_B . Therefore, a new principle is needed.



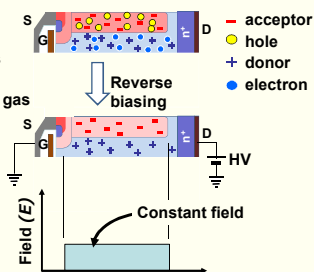
[3. what PSJ (Polarization Super-junction) ?]

Comparison to Si super-junction

GaN/AlGaN/GaN Polarization Super-junction (PSJ)



Si super-junction MOS (one pillar)



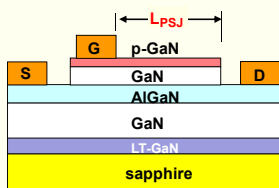
	GaN-PSJ	Si-SJ
formation	Lateral : surface GaN/AlGaN/AlGaN	Vertical : embedded p/n pillar stack
Carrier origin	polarization	Impurity doping
Thickness (1unit)	~10 nm	~ μm

[2. Purpose]

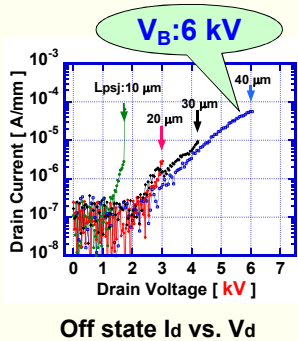
Propose the device principle and show the collapse-free switching at 600V of V_{dd} regime

[4. Transistor structure and DC characteristics]

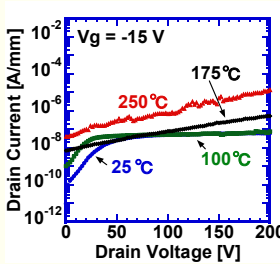
PSJ-FET on sapphire sub.



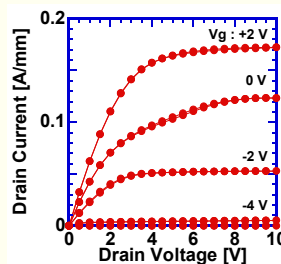
structure



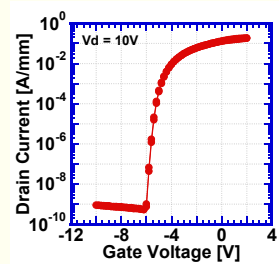
Off state I_d vs. V_d



Off state I_d - V_d ; temperature as a parameter

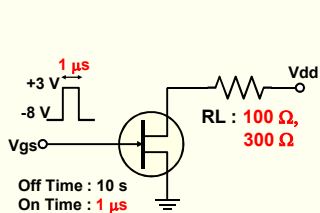


I_d - V_d

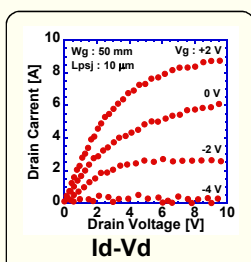


Transfer characteristics

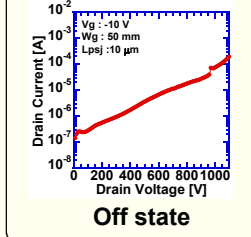
[5. Switching characteristics]



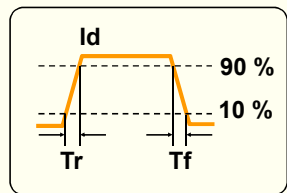
Test circuit



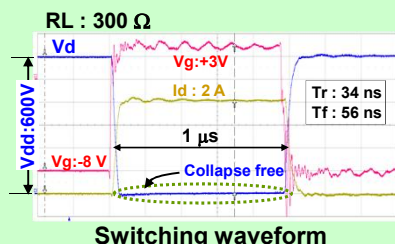
I_d - V_d



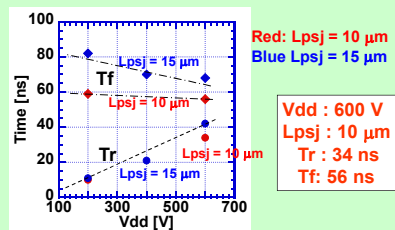
Off state



Switching at $V_{dd} = 600V$

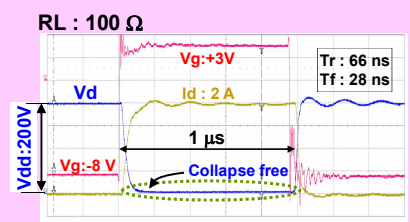


Switching waveform

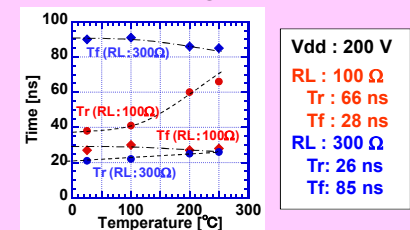


V_{dd} dependence of T_r and T_f

Switching at 250 degC



Switching waveform



Temperature dependence of T_r and T_f

[6. Experimental results]

- Breakdown voltage, V_B , was proportional to L_{psj} and reached 6kV at $L_{psj}=40\mu\text{m}$,
- The dynamic current collapse was not seen up to 600V of V_{dd} ,
- At 600V switching, rise-time, T_r and fall-time, T_f of the I_d were 34ns and 56ns, respectively,
- At 250 degC, the collapse was not observed too.

[8. Conclusion]

- The polarization super-junction FET, PSJ-FET, perfectly suppressed the current collapse at 600V switching regime, in spite of the use of the insulating substrate.
- The system of PSJ device on sapphire has the potential of exploring over 600V switching regime where the conventional FP/Si system could never realized.

[7. Only one issue for using sapphire]

Heat dissipation

Candidates:

- Sapphire removal
- Extreme thinning of sapphire
- Flip-chip
- Surface built-up block

材料	Heat resistance (W/mK)
Si	~ 140
GaN	~ 140
sapphire	~ 40

Acknowledgement :

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