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Normally-Off GaN-PSJ FETs

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powGaN for Green Future

【1. Background】

The high V_B, collapse-free and high current GaN PSJ (Polarization super-junction) FETs have been fabricated and the next step will be the realization of the N-off mode ones.

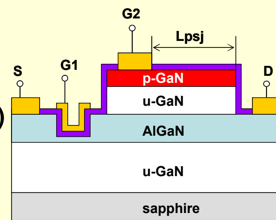
【2. Purpose】

To achieve GaN PSJ-FETs having V_{th} higher than +1V and V_B > 1,200V

【4. N-off Device Structure】

Double Gates

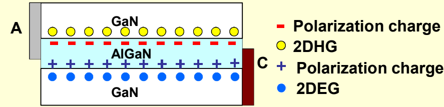
- G1, MIS, Lg1=1.5μm Au.Ni/SiN(10nm)/AlGaN(1~3nm)
- G2, p-Ohmic, Lg2=5μm
- Lpsj=15μm



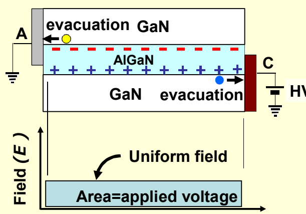
【3.What PSJ (Polarization Super-Junction) is】

Comparison with Si super-junction

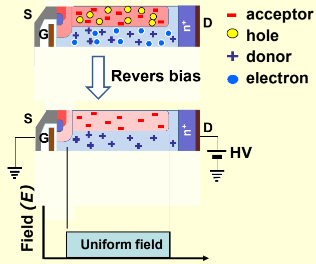
GaN/AlGaN/GaN
Polarization Super-junction (PSJ)



Appling reverse bias
➡ evacuation of 2DHG and 2DEG



Si super-junction MOS
(one pillar)

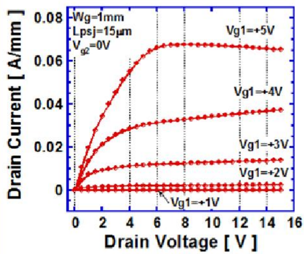


Contrast GaN-PSJ with Si-SJ

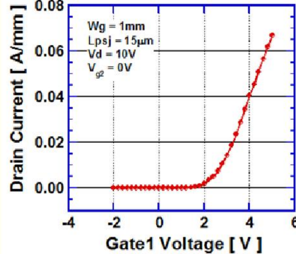
	GaN-PSJ	Si-SJ
Formation	Surface (Lateral) GaN/AlGaN/GaN	Inside(Vertical) p/n pillar stack
Origin of carriers	polarization	Impurity doping
Thickness	A few 10s nm	A few μm

【5. Static Characteristics 】

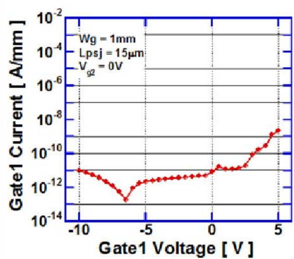
(Wg=1mm, L_{g1}=1.5μm)



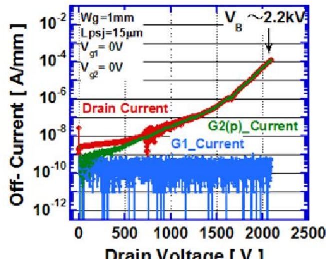
Id-Vd characteristics.



Transfer characteristics.



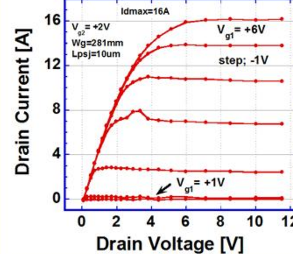
Gate-leak characteristics.



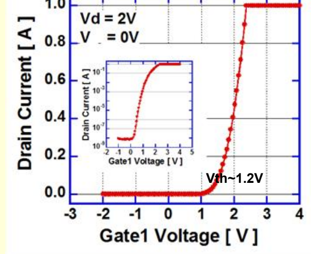
Off-leak characteristics.

【6. Large Device 】

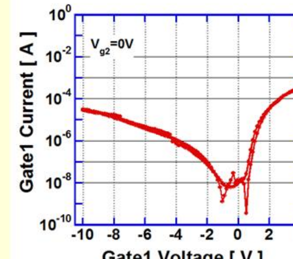
(W_g=281mm, L_{g1}=1.5μm)



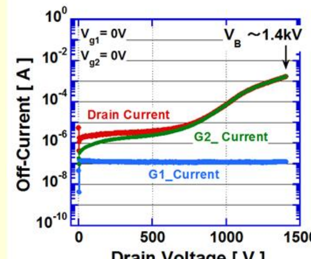
Id-Vd characteristics.



Transfer characteristics.



Gate-leak characteristics.



Off-leak characteristics.

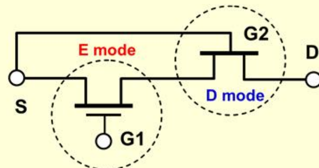
【7. Discussion】

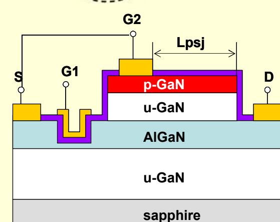
-- Both Normally-off and high V_B obtained result from the formation of the Cascode circuit between source and drain.

-- The field in the AlGaN next to the G1 is kept small with increasing drain voltage, which results in the constant and small G1 leakage current.

-- The drain leakage was originated from the G2-leakage due to the unknown mechanism.

built-in Cascode





【8. Summary】

1. N-off type PSJ-FET was achieved by implementing a trench MIS gate in front of the PSJ gate, and its V_{th} obtained was >+1 Volt.
2. The large device with W_g=281mm and L_g=1.5μm exhibited the maximum drain current, $I_{d,max}$ of 16A.
3. The breakdown voltage, V_B, of the small device (Wg=1mm) was >2.2 kV and that of the large one (Wg=281mm) was >1.4kV.

【9. Conclusions】

1. The double gate N-off PSJ-FET exhibited very high breakdown voltage due to the internal Cascode conformation.
2. GaN PSJ-devices using established GaN-on-sapphire gorwth technique are expected to become a new type of GaN power devices.