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Improved current dispersion effect and DC performance of AlGaN/GaN HEMT with Ar$^+$ implanted device isolation

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AlGaN/GaN heterostructure field-effect transistors(HFETs) have received significant attention due to their superior device characteristics such as high current and frequency/speed operations with high breakdown voltage. However, there are still many problems to be solved in term of gate leakage and current dispersion. Low leakage current is a key issue in realizing high performance device. The active region of the HFET is generally realized by mesa etching using wet or dry processes. The mesa processes lead to side-wall leakage current path, which can cause gate leakage current and low breakdown voltage. In this paper, AlGaN/GaN HFET was fabricated using Ar$^+$ ion implantation and we investigated effects of the Ar$^+$ ion implantation for the device characteristics. All samples were grown on c-plan sapphire (0001) substrate by metal organic chemical vapor deposition (MOCVD). Ta/Ti/Al/Ni/Au (10/30/120/40/50 nm) metallization layers for ohmic contacts were deposited using an electron-beam evaporator and annealed by RTP at 750°C for 30sec. The active regions of the devices were masked with photoresist and Ar$^+$ ion was implanted on the samples with energy of 55KeV and dose of 7X10^{14}/cm^2. Finally, The Schottky gates were formed using Ni/Au(40/50nm) with gate lengths 0.8μm. the source drain spacing was 6.6μm. The cross-sectional schemes of the conventional mesa- and Ar$^+$ implantation-isolated devices in the experiment are shown in figure 1. The DC and pulse I-V characteristics of the fabricated device were measured by a dynamic I-V analyzer(Accent DIVA D255) at room temperature. Figure 2 show the current dispersion characteristics. Ar$^+$ -implanted HFET exhibits higher DC current and much improved current dispersion characteristics while the conventional mesa-isolated HFET experiences significant dispersion effect. This is because the proposed HFET does not have an etched side-wall, where the gate metal crosses in the mesa-isolated device, and thus does not suffer from plasma damage which generates the surface traps and defects on the etched region. Figure 3(a) and (b) show the gate leakage and buffer (source to source) leakage, respectively. The gate buffer leakage currents of the Ar$^+$ ion-implanted device was 2.29 X 10^{-6} A/mm at V_g=-10V and 8.44 X 10^{-6} ant -10V, decreased approximately 3 and 2 orders low in magnitude, compared to the mesa-isolated device, respectively. We demonstrated that the use of Ar$^+$ ion-implanted device isolation is a good alternative to improvement in electrical characteristics of the AlGaN/GaN HFET, which shows not only increase $I_{D.max}$ and much reduced gate leakage current, but also suppressed dispersion effect compared to conventional AlGaN/GaN HFET.

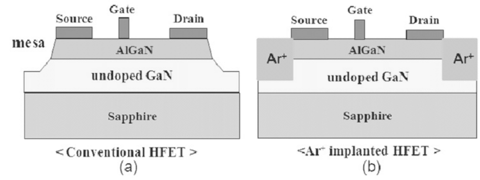

Figure 1. Schematic illustrations of (a) Conventional HFET, (b) Ar$^+$ implanted HFET.

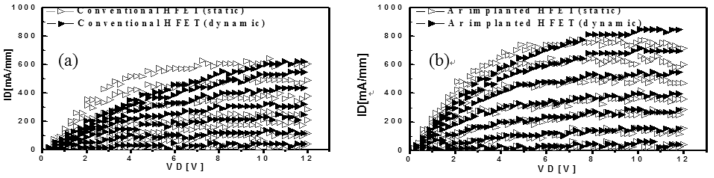

Figure 2. Pulsed *I–V* characteristics of HFET devicesstatic (▷)and dynamic (▶) (*a*) Conventional HFET and (*b*) Ar$^+$ implanted HFET.

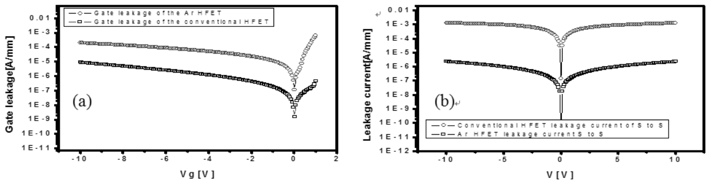

Figure 3. Comparison of gate leakage current (a) and Comparison of isolation property(source to source leakage current) (b)