Investigation of GaN p-Channel Transistors

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Abstract:

Impurity p-type doping is realized in molecular beam epitaxy (MBE) grown pGaN/un-intentional doped (UID) GaN/semi-insulating (SI) SiC. Depletion-mode p-channel field effect transistors (FETs) are demonstrated. Driven by the high hole density, a 2-µm-long D-mode FET shows improvement of drain current from 1.2 mA/mm ($V_{GS} = -2$ V, $V_{DS} = -10$ V) at 27°C to 4.6 mA/mm ($V_{GS} = -2$ V, $V_{DS} = -10$ V) at 100°C.

Summary of Research:

Devices were grown by plasma-assisted molecular beam epitaxy in a Veeco GENxplore under metal-rich conditions. The epitaxial structure includes a 100 nm UID buffer, followed by 200 nm of moderately p-doped GaN and 10 nm of heavily p-doped GaN. After device mesa isolation by the PT-770 ICP-RIE system, Pd-based ohmic contacts are deposited at source and drain and used as a mask to ICP etch the p+ GaN and a variable amount of the p GaN. The device is then coated in 10.9 nm of ALD (Oxford ALD FlexAL) aluminum oxide dielectric before a Ti/Au gate is deposited. The resulting structure is shown in Figure 1.

On the processed samples, TLM measurements demonstrated ohmic contacts with $R_c = 155 \, \Omega \cdot \text{mm}$ ($\rho_c = 1.5 \times 10^{-3} \, \Omega \cdot \text{cm}^2$), as shown Figure 2. $I$-$V$ and transfer characteristics were measured from 27°C to 100°C (see Figure 3 and 4), notably improving with increasing temperature. Room temperature on-currents on the order of 2 mA/mm are competitive with several of the 2DHG-based candidates [1-5].

References:

2016-2017 Research Accomplishments

Electronics

Figure 1: A device cross-section of the fabricated D-mode p-channel FET and an SEM image.

Figure 2: Ohmic characteristics for Pd-based contacts on p’GaN.

Figure 3: 27/100°C Id-Vds characteristics for p-channel FETs with Lg = 2 µm.

Figure 4: 27/100°C transfer characteristics for p-channel FETs with Lg = 2 µm.