Abstract

This thesis focuses on the design, the fabrication and the characterization of GaN-based high electron mobility transistors (HEMTs) including the localised regrowth of highly doped n-type GaN to side contact the bi-dimensional electron gas (2DEG). These regrowth regions have the particularity of being in direct contact with the 2DEG, resulting in lower ohmic contact resistances. The approach developed here also ensures better lateral definition of the contacts by avoiding or reducing the high-temperature anneal of ohmic contacts, which is responsible for metal diffusion. This allows the reduction of the distance between source and drain contacts, resulting in an increase of the operating frequency and of the efficiency of the transistors.

This thesis covers three main topics: the study of the localized growth of heavily n-doped GaN regions by two epitaxy techniques widely used in the field (MBE and MOVPE), the development of the technological manufacturing process and the electrical characterization of transistors with n-GaN regrowth at the ohmic contacts. The study was carried out on different HEMT structures with ternary (AlGaN) and quaternary (InAlGaN) alloy barriers. We took into account and studied several parameters, including the topology of the devices, the metallization schemes, the doping level and the conductivity of the n-GaN layers. In addition, we studied suitable surface preparations before the regrowth as well as the impact of the n-GaN growth conditions on the critical interface zone between the 2DEG and the n-GaN.

We extracted the contact resistances on a large number of samples from the measurements of Transmission Line Method (TLM) patterns in order to quantify the different contributions, including the quality of the interface. We then used the best sets of parameters to fabricate GaN-based RF devices and we investigated their DC characteristics and RF performances.

Keywords: High Electron Mobility Transistors (HEMT), Gallium Nitride (GaN), ohmic contacts, regrowth, epitaxy, MOVPE, MBE, AlGaN, InAlGaN, n-GaN, doping, TLM