Recent advances in Nitride heterostructures for RF and power devices

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Since more than 20 years, III-Nitride based heterostructures have been developed for ever-increasing performance devices with applications in the field of RF and power switching. The main reasons are the large bandgap of GaN and related compounds like AlGaN, and the possibility to build heterostructures providing large density two-dimensional electron gases (2DEGs) with high saturation velocity and able to carry large currents which can be modulated at GHz-range frequencies. The other reasons for this success are the mastering of the epitaxy on foreign substrates such as sapphire, silicon carbide and silicon, and the progress in the device technological process which open the way to industrial productions. Furthermore, these domains benefit original solutions proposed to enhance performance and reliability or to provide new functionalities such as the enhancement-mode (normally-off) transistors in replacement or combined with depletion-mode (normally-on) devices or the arrival of new nitride compounds. Indeed, heterostructures built with alloys like ScAlN are very interesting for high electron mobility transistors (HEMTs). ScAlN presents large piezoelectric and spontaneous polarization coefficients ensuring a much higher carrier density at the interface with GaN compared to standard AlGaN/GaN HEMTs especially in the sub-10 nm barrier thickness range. Furthermore, the alloy can be grown with the same in-plane lattice parameter as GaN provided the scandium fraction is around 18%, which ensures a low mechanical stress and should be an advantage for reliability. After the first developments of thick ScAlN films by sputtering for RF filters, molecular beam epitaxy (MBE) and the metal-organic vapor phase epitaxy (MOVPE) techniques are used to grow ScAlN/GaN HEMT heterostructures with better crystal quality. This work on NH_3-MBE growth is partly supported by Labex GaNeX (ANR-11-LABX-0014) and ECSEL JU project GaN4AP under Grant Agreement No. 101007310.