Morphology and electric properties of InGaN-based tunnel junctions grown by Plasma Assisted MBE system

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Application of tunnel junctions (TJ) to nitride based structures opens new possibilities for novel devices such as vertically integrated cascade multicolor LEDs and LDs [1,2]. Due to the challenges with the hydrogen diffusion through n-type layers, growth of efficient devices with TJ by Metal Organic Vapour Phase Epitaxy (MOVPE) is very problematic. Presence of the n-type GaN:Si above GaN:Mg prevents hydrogen diffusion and activation of Mg doped bottom layer grown by MOVPE. In case of Plasma Assisted Molecular Beam Epitaxy (PAMBE) we do not use hydrogen during growth and do not need to activate p-type layers which is great advantage of this technology. To obtain a good quality devices, achieving low series resistance and smooth morphology of TJs is very important. However, heavy doping, which ensures low series resistance, can lead to degradation of the morphology of nitride devices.

In this work we study the influence of heavy doping by Si donors and Mg acceptors of GaN/InGaN/GaN heterostructures grown by PAMBE on the morphology of p-n TJ and its electrical properties. An InGaN quantum well immersed between heavily doped p-type and n-type GaN decreases the depletion region and improves electric properties of TJ. This effect is caused by strong polarization field inside GaN:Mg/InGaN/GaN:Si junction [1]. We investigated n-p-n structures grown by PAMBE on bulk (0001) GaN where upper GaN:Mg/InGaN/GaN:Si diode was heavily doped to work as tunnel device.

We discuss the differential resistivity of n-p-n diodes, the built in voltage as a function of Si and Mg doping level. The influence of the width of InGaN quantum well inside p-n tunnel junction on tunneling currents will be also shown.

We found that the tunneling currents strongly depend on the Si doping of the n-type region. We demonstrate that the lowest resistance of p-n TJ can be achieved for very high Si doping (at the level of $2x10^{21}cm^{-3}$). However when we increased the Si doping level above 10^{20} cm^{-3}, the gradual deterioration of surface morphology is observed.

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