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51^{st} Internationales Wissenschaftliches Kolloquium
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V. Cimalla, V. Lebedev, F. M. Morales, M. Niebelschütz, G. Ecke, R. Goldhahn, and O. Ambacher

Origin of n-type conductivity in nominally undoped InN

Indium Nitride is a low band-gap material, which received an increasing attention over the last years due to its very prospective properties. In particular, the high electron mobility [1] should predestine the material for high frequency devices. A major drawback, however, is the high electron concentration in InN layers, which up to date prevents the development of any kind of electronic device. Despite of the remarkable progress in the growth of InN by different techniques (plasma-induced molecular-beam epitaxy, pi-MBE [2]) and metalorganic chemical vapour deposition, MOCVD) all layers appear to be degenerated with electron concentrations higher than 10^{17} cm^{-3} and the exact mechanisms of its origin are still under debate. Several n-type doping mechanisms were identified for InN , whose influence will be discussed in the following. However, no single mechanism can explain the observed dependence of the electron concentration on the layer thickness for a series of InN films grown at similar growth conditions [2]. The aim of this work is to evaluate the influence of the different doping mechanism and to demonstrate the influence of threading dislocations (TD).

The different possible contributions to the apparent electron concentration can be classified by three models (i) a localized electron accumulation with specific sheet carrier concentration (ii) a homogeneous background volume concentration, and (iii) an inhomogeneous carrier distribution over the InN film. These contributions determine the apparent electron concentration on different thickness scales (Fig. 1). First, the accumulation of electrons at the surface [3] and the interface clearly dominates the electronic properties of InN for thin layers with thickness < 300 nm. For non-degenerate InN an electron concentration below 10^{17} cm^{-3} would be necessary and already the accumulation layers would prevent to achieve this for InN films up to ~5 µm. Second, layers in the micron range are strongly affected by threading dislocations. Finally, the background concentration of InN is already well controlled and would influence the apparent carrier concentration only for films with thickness > 10 µm. However, the influence of such point defects might have substantial influence on the mobility. As a consequence, for an application of InN films for electronic devices both, the reduction of the density of threading dislocations and the suppression of the electron accumulation at the interfaces is of crucial importance.

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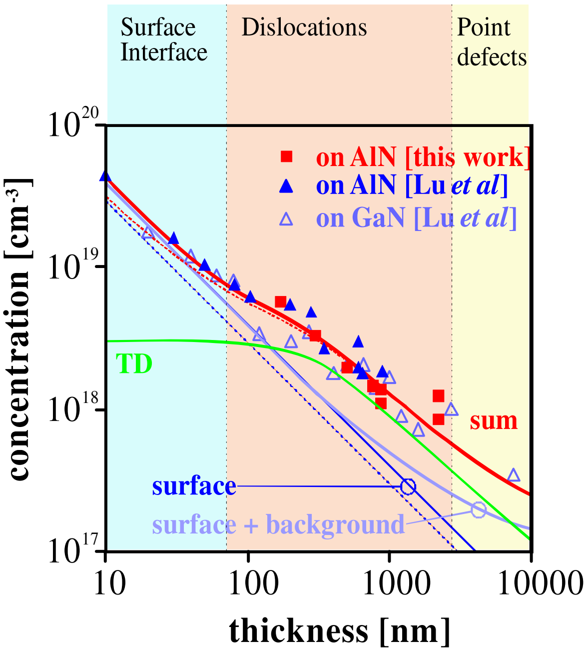

Fig. 1: Average electron carrier concentration in dependence on the InN film thickness on AlN buffer in comparison to the discussed models. Data from Lu are from Ref. [2].

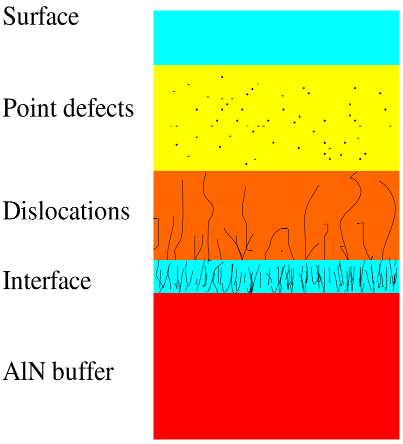

Fig. 2: Layered model for the dominant contributions on n-conductivity in a thick InN layer.

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