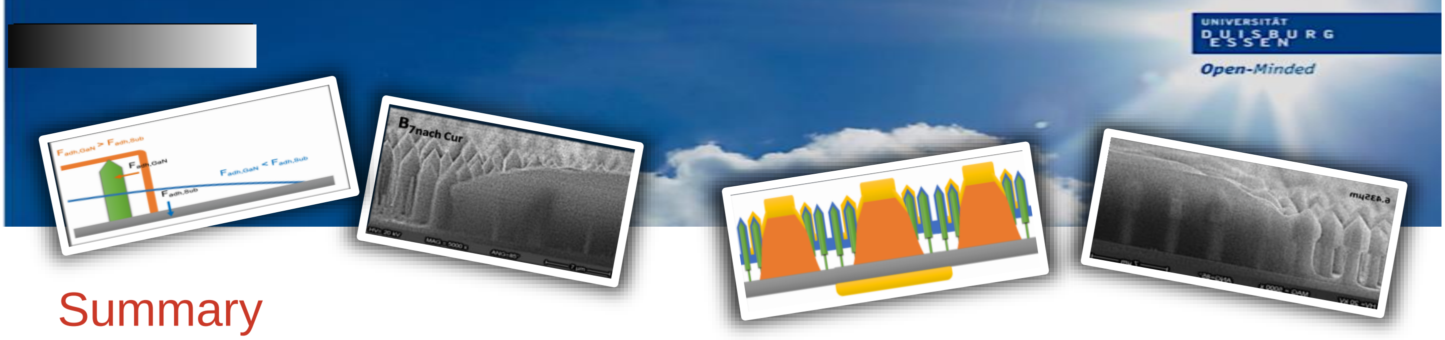
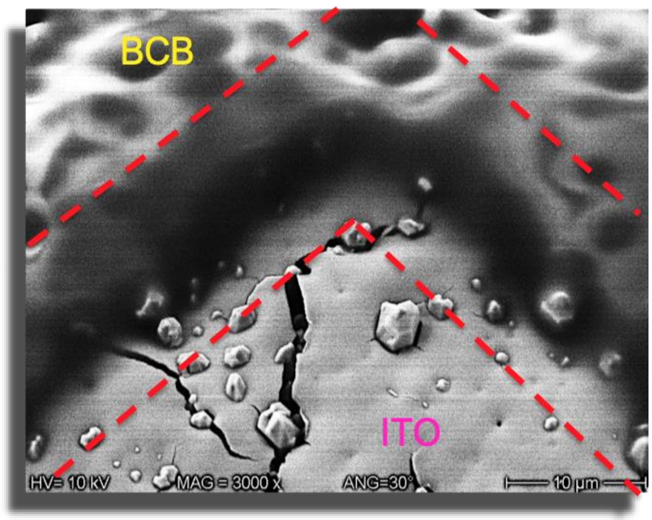
Process development for the contacting of GaN Nanowire-LED arrays



Summary

The aim of this work is development of high-frequency light emitting diode (LEDs), which are compact and energy efficient. Those properties could be useful in many applications like light fidelity (Li-Fi) and car-to-car communications. High-frequency LEDs are often fabricated from GaN as a planar LED. Typically, planar LEDs are grown in $\vec{c}$ direction of the crystal structure. In this direction a polarization field $\vec{p}$ is present. Multi quantum well structures grown in $\vec{c}$ direction are thus subject to the quantum confined stark effect (QCSE). The $\vec{m}$ direction of the crystal structure is nonpolar and consequently no QCSE appears. This direction is applicable in a coaxial nanowire (NW) core-shell geometry. However, contacting these 3D structures requires a more complex technology in comparison to planar structures.



The contacting process of coaxial InGaN/GaN NW-LED arrays was further developed. In this work the focus lies on the establishment of a BCB-technology. Spin-coating of BCB on NW sample differs fundamentally from spin-coating on planar layers because BCB is accumulated at the 3D structures. Individual steps of the process and parameters concerning the desired structures were investigated and optimized. Requirements were firstly that BCB should completely embed the NW-LEDs, and secondly the BCB structures should have an edge with a shallow slope. In this context, the parameters of spin coating, exposure doses, development time, and Pre- and Post-Develop Bake parameters were investigated in detail. It was possible to achieve a planar embedding of NW-LEDs by rotation speed between 750-1000 rpm with ca. 1.5 µm thick BCB layer above the NW-LEDs. This layer is sufficiently thick to avoid a breakdown at a typical operating voltage. By variation of the exposure time, no trend to influence the slope could be observed. Furthermore, varying the development time has shown that selective overdevelopment causes the edges to be less steep. For the cross-linked BCB a dark ablation rate of 60 nm/s was determined. Leaving BCB in liquid or gelation state for a prolonged time, for a possibly reduced slope, increases the steepness of the slope. BCB contracts on the surface of the NW instead of covering the surface of the substrate. For this reason, rapid drying at a slightly higher temperature in the Post-Develop Bake impacts the edges' slope positively. The obtained slope of BCB edges of 1.08 µm/µm is appropriate to implement the passage from BCB to ITO-top contact. Summarizing the above, in this work a total BCB process for NW-LEDs is established, an entire variation and optimization of the parameters accomplished. A technology has been achieved to entirely cover the NW-LEDs with BCB with a suitable thickness and simultaneously convex edges. This BCB structure is enabling the new contact scheme for the NW-LEDs.