# Carrier confining mechanisms in axial $In_xGa_{1-x}N$/GaN nanowire heterostructures

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The ternary alloy $In_xGa_{1-x}N$ represents the materials system of choice for the production of red–green–blue (RGB) emitting LEDs, as its band gap spans the whole visible spectrum [1]. However, it has been proven difficult to synthesize planar $In_xGa_{1-x}N$/GaN heterostructures with the In content required for red emission while still retaining a high internal quantum efficiency, due to the tendency of phase separation and the large lattice mismatch between InN and GaN.

GaN nanowires (NWs) with axial $In_xGa_{1-x}N$ insertions are currently discussed as a promising alternative to planar layers [2] as their free side facets facilitate elastic strain relaxation and thus accomodate the larger In contents required for red emission. In fact, axial $In_xGa_{1-x}N$/GaN NW heterostructures have been reported to emit in the green, amber, red and infrared spectral range. On the other hand, it was observed that the photoluminescence (PL) intensity of such structures decreases with decreasing In content, and it was found to be difficult to obtain light emission in the blue or violet spectral range [3] – a behavior which is exactly the opposite of what is commonly observed in planar heterostructures.

We present detailed studies of the different charge confining mechanisms in axial $In_xGa_{1-x}N$/GaN NW heterostructures. In particular, we take into account surface potentials originating from unintentional doping and Fermi level pinning – a specific feature of NWs – which significantly modify the three-dimensional potential landscape of a NW. We identify an interplay between surface and polarization potential as the origin of the counterintuitive reduction of PL intensity with reduced In content based on the model assumption of a homogeneous doping charge distribution [4]. In a next step, we consider irregular surface potentials computed from realistic, randomly distributed dopants and present a statistical description of the electronic properties of 2000 microscopically different $In_xGa_{1-x}N$/GaN NWs. Finally, we discuss the consequences of our findings for NW-based LEDs as well as for single-photon emitters for quantum cryptography and computing applications and propose strategies to reduce the detrimental influence of surface potentials arising from dopants in NWs [5].

## References

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