Light emitting diodes (LED) based on the InGaN material system are nowadays found in wide areas of our daily life, e.g. display illumination, automotive lighting or general lighting. Central to such a LED is the region where an electrical current is converted to light emission, occurring in a very thin (2-3 nm) thick InxGa1-xN film, denoted as quantum well. In theory, the emission wavelength of this quantum well should be easily tunable by varying the composition x between 0<x<1 which should allow to cover emission from the near UV (x ~0) down to the new IR range (x ~1). However, this concept is impeded by two main issues: First, the highest conversion efficiencies are yet only achieved for a very limited part of the optical spectrum, i.e. about 80 %-90 % in blue region. As soon as x is increased to reach longer wavelengths, the conversion efficiency drops. Second, compositions of x >0.3 are entirely inaccessible since they cannot be stabilized in a conventional growth process. These two issues increase power consumption and limit LED design strategies thus leaving a huge potential of the material system unexploited.

One major reason for the above-mentioned difficulties is connected to the fact that the InN lattice is much larger (about 11 %) as compared to GaN. Thus, increasing the In content x in the quantum well results in an huge amount of compressive strain, which (a) deteriorates the structural quality of the quantum well and (b) limits further incorporation of In above x 0.3. In this proposal, we aim to reduce the compressive strain in the InGaN quantum well via growth on a relaxed InGaN buffer layer, which has a larger lattice constant. The fabrication of such buffers, with a high structural perfection, is ambitious since it requires a detailed understanding of the plastic relaxation processes, which has so far not fully been accomplished. The reason is that a direct access to these processes, though highly desirable, is experimentally challenging. However, benefitting from very recent improvements with regard to experimental setups, we aim to tackle this issue by means of in-situ x-ray diffraction (XRD) and in-situ transmission electron microscopy (TEM) experiments. TEM allows to study very local plastic relaxation phenomena on the scale of a few nm, while complementary, in-situ XRD, enables to investigate these issues at much larger scales (hundredth of microns)

Hence, from these results, we expect novel insights into the processes governing the complex plastic relaxation of InGaN. The gained information at hand, will enable the growth of structurally high-quality buffers with a substantially higher in-plane lattice constant. Subsequently, we plan to perform structural studies on quantum well structures deposited with the lower compressive strain state, grown on these InGaN buffers. We expect to gain an answer for the fundamental question in how far compressive strain is actually responsible for the reducing conversion efficiency for LEDs operating in the green or red spectral range. Lastly, we plan to overcome the In composition limit of x=0.3 which will be the very first layers of such kind.