Monolithic bipolar junction transistor driving LED in group III nitrides material system

The group III-nitride semiconductors: GaN, InN, AlN and its alloys: InGaN and AlGaN, show tremendous potential for wide variety of next generation semiconductor devices, possessing superior material parameters as compared to silicon and GaAs earning name of third-generation semiconductor. Nitrides are materials suitable for light emitting devices due to its unique capabilities to emit violet-blue light. This led to a breakthrough in efficient blue solid state light emitting diodes (LED) which has enabled bright white light sources what resulted in 2014 Nobel Prize in Physics for Isamu Akasaki, Hiroshi Amano and Shuji Nakamur. Currently GaN established itself as a crucial material for cheap and efficient light emitters which can be found in every home. In recent years nitrides got recognized as valuable materials also for electronic applications such as transistors. Important consequence is that nitrides now offer unique possibility to combine electronics and optoelectronics in the same material system.

It is highly desired to merge advantages of GaN-based transistors and light emitting devices into one. Such integration can result in smaller footprint and higher power efficiency as compared to instruments made of separated discrete elements.

The goal of this project is to obtain a platform with bipolar junction transistor which will be monolithically integrated with an LED (see Fig. 1) and to investigate the influence of material and geometric order on device performance.

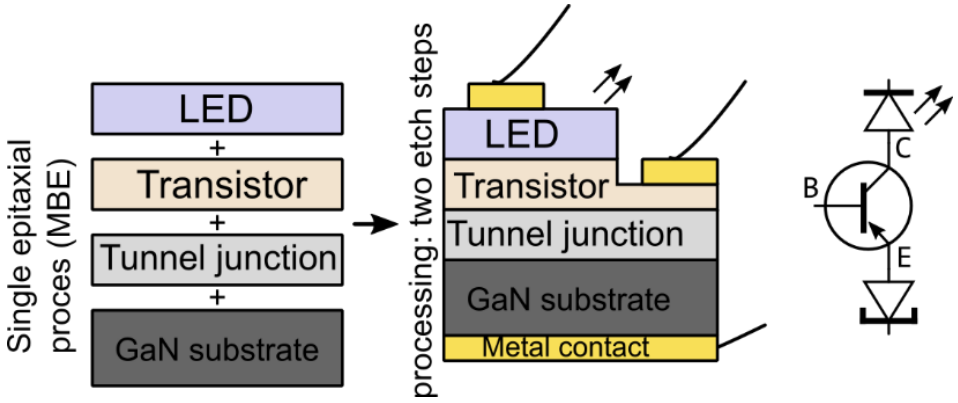

Figure 1 Schematic summary of the project. First, tunnel junction, transistor and LED will be grown in one process. Second, metal contacts will be put on the device. This results in the circuit where transistor drives a LED.

Stacked transistors with light emitters offer many attractive applications in both ever day life and in research filed. Transistor acting as a switching device allows for high frequency operation of LED without loses on metal interconnectors which are necessary for joining discreet devices. This is crucial for tightly integrated matrices of LED. Conventional matrix of LED needs two electrical leads both of which have to pass high alternating voltage causing crosstalk effect between device. Such matrices were already presented in GaN material system. In case of LED integrated with transistor needs one additional electrical path but now one operates as power supply with constant voltage for the on-state of LED and one as signal path with small alternating switching voltage. Matrices can further enhance both bandwidth and intensity and may find application in inorganic displays market. Such displays may achieve high resolution, colour fidelity, durability and long lifetime compared to popular organic LED (OLED) displays. Proposed monolithic integrated HBT with LED are first step in researches of matrices.