

Red luminescence from wide band gap semiconductors such as GaN is a key technology for realizing novel light-emitting devices such as integrated full-colour displays. To date, optoelectronic devices based on commonly used InGaN-compounds have achieved high performance in the UV to green spectral regions. Using InGaN in the red spectral ranges remains a challenge at the higher In content due to the degraded crystalline quality of InGaN quantum wells (QWs) and strong local internal piezoelectric fields in the case of c-oriented active layers commonly used in most of GaN-based devices including light emitting diodes, lasers and high mobility transistors. Due to the difficulties in obtaining efficient LEDs based on InGaN in this project we propose another approach to red emitters. We propose to use ZnO as a basic semiconductor material and its ZnMgO and ZnCdO alloys doped with europium. The characteristic high purity red emission of Eu ions can be used in optoelectronic devices. Properties of ZnO are more attractive for applications in optoelectronic devices than GaN. Another advantage of ZnO is its relatively low price in comparison to GaN and the possibility of to use crystalline ZnO as substrate for epitaxy. Recent studies of Eu-doped showed that locating Eu in GaN quantum wells in AlGaN/GaN/AlGaN structures is favourable for the high emission efficiency. However, the progress in studies in this direction has been slowed down due to temperature quenching of the emission at room temperature. On the other hand preliminary studies of the Eu PL in ZnO nano-rods showed that the red emission increases up to 200°C and above, which is really an unusual property. This valuable feature has motivated us to undertake a broad research of Eu impurity in quantum structures composed of semiconductors based on ZnO. Molecular beam epitaxy (MBE) is a well controlled, and highly precise and repeatable technology from process to process allowing to deposit complex structures atomic layer by atomic layer. Eu impurity can be located precisely in narrow single quantum wells and superlattices to obtain the intense emission. It seems that the basic mechanism of the emission enhancement is the increased density of charge carriers around impurities in quantum wells. Density of charge carriers in QWs increases because charge carriers generated in the barrier layers tunnel to quantum wells. Increasing the emission intensity of intra-atomic luminescence is a complex matter. To answer this question it is necessary to explain mechanisms of energy transfer to and from the 4f-shell of the Eu atoms. The energy of the excited Eu atom can be emitted as photons or back transferred to the host semiconductor. In this project we will study both energy transfer mechanisms. Basic aim of this project is search for optimal material in a family of ZnO-based semiconductors and to find an optimum structure for maximum emission intensity and minimum energy back transfer. To solve the problem several types of simple and complex quantum structures such as ZnMgO/ZnO:Eu/ZnMgO and ZnO/ZnCdO:Eu/ZnO will be examined. Technology of ZnMgO/ZnO/ZnMgO quantum structure is well controlled in our lab, whereas technology of ZnCdO is at its initial stage, because Cd reveals a tendency to out-diffuse from the material and segregate at surfaces. Therefore growth processes must be conducted in relatively low temperatures. It be detrimental for the crystallographic quality. Apart of intense studies of energy transfer mechanisms the final aim of the project is elaboration of the technology of LEDs emitting pure red light near 620 nm. Analysis of preliminary results shows that this practical part of the project is feasible. As the prosed research is innovative in many aspects it can be expected that the most important ideas and technological solutions will be patented.