Luminescence and scintillation properties of the Si doped InGaN/GaN multiple quantum wells

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The invention of first blue light emitting diodes led to the wide implementation of the heterostructures based on nitride semiconductors (e.g., the InGaN/GaN multiple quantum wells (MQW) structures [1, 2]) in various branches of human activities. In particular, relatively recently, they appeared in the cross-hair of the researchers engaged in the hot field of ultrafast scintillators due to high exciton binding energy, relatively wide direct bandgap (3.4 eV at room temperature), radiation and chemical stability.

The growth of InGaN/GaN heterostructures is more complicated than the growth of thick GaN layers due to the necessity of the low temperature growth of InGaN. There are few ways how to growth upper interface between InGaN quantum wells and GaN barriers. The growth of InGaN quantum wells with and without QW cap was tested. It has been found that InGaN excitonic luminescence band was increased by about one order of magnitude when the InGaN QW cap had been grown. The defects-related band was complex, composed of at least two contributions at about 2.43 eV (510 nm, cyan) and 2.2 eV (564 nm, yellow). The intensity of the cyan band has also been enhanced by about twice in the sample with the cap.

The samples with the Si or Ge doped GaN barriers were grown with different growth temperature of InGaN QWs to obtain different indium content and excitonic emission wavelength. The best way how to control indium content in InGaN QWs is to control growth temperature. For example, the 15°C temperature difference resulted in the 20 nm blueshift of the maximum of excitonic emission wavelength (maximum emission around 3.02 eV (410 nm)). The excitonic band is suppressed for 325 nm excitation wavelength measurement and there is stronger contribution of the defect cyan band compared to the Si- or Ge-free samples. This increase is probably connected with the stronger incorporation of accidental acceptor defect (zinc) when Si or Ge atoms (donors) are embedded. Comparison of luminescence spectra of the Si- or Ge-free and Ge or Si doped InGaN/GaN MQW samples shows that the defect band is weaker in the Si- or Ge-free samples. In general, it can be concluded that Si or Ge has similar character of influence on luminescent properties of MQW as discussed for the GaN thin films [1].

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[2] T. Hubáček et al., CrystEngComm 21 (2019) 356-362