Influence of the substrate on the photoluminescence of single gallium nitride nanowires

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Excellent physical and optical properties of gallium nitride (GaN) make it an important semiconductor for current optoelectronic technology. Nowadays mainstream experiments on GaN are focused on low dimensional structures, like quantum wells, quantum dots, microcavities and nanowires (NWs). In the case of nanowires, the role of surface effects, electric fields fluctuations and defects in optical processes is still not well understood.

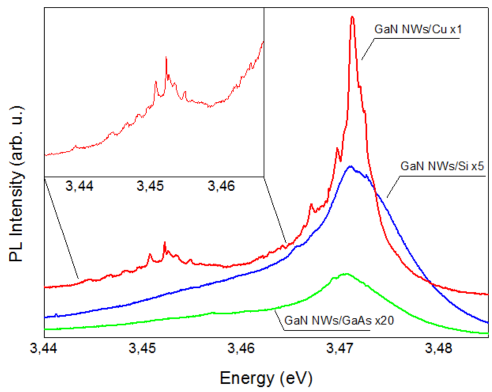

Fig. 1: Low temperature PL spectra of GaN nanowires deposited on different substrates.

In this communication low temperature photoluminescence (PL), time-resolved photoluminescence (TRPL) and scanning electron microscopy (SEM) experiments performed on ensemble of GaN NWs as well as on single GaN NWs deposited on various substrates including silicon, gallium arsenide and copper are presented.

The GaN NWs were grown by MBE without use of any catalyst on Si(111) (a length of about 1 μm and a diameter of 50 nm) [1]. Then they were cut off from the Si substrate using methanol ultrasonic bath and deposited on a desired substrate. SEM studies showed that main part of NWs formed self-arranged groups, however it was possible also to find single NWs.

Emission was observed in the energy range from 3.3 eV to 3.5 eV. The low temperature PL spectra for NWs on different substrates are plotted in Fig. 1. The position of the main PL peak indicates its excitonic origin. The difference in the intensity of photoluminescence for NWs deposited on different substrates was clearly observed. At low temperature NWs deposited on gallium arsenide and silicon substrates gave a very weak emission, as compared to those deposited on a copper plate. In spite of strong differences in intensity, the PL decay time was similar (τ = 0.15 ns) for all substrates. We attribute this effect to plasmonic interaction between NW’s and the particular substrate. Interestingly, for NWs deposited on the copper substrate several narrow emission lines, with a width of 0.3 meV, appeared in the energy range of 3.45 eV. Their origin is discussed in terms of excitons emission related to single dopants and defects located at different distances from the NW surface.

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