Numerical Characterization Of InGaN Nanowire White-LED For Use In Nanophotonics

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Abstract

The semiconductor industry has seen an exponential growth in recent decades - initially due to its applications in microelectronics and integrated circuits, and recently with the ability to integrate optoelectronic components on a chip. This opens up the potential for faster and denser communication and computation systems. Alongwith these industries, lighting and display technologies have been recently boosted by the invention of the Light Emitting Diode (LED) and different colors allowing for the entire RGB spectrum. However, RGB is still relatively inefficient. A significant effort is being put into developing white light LEDs that emit over a broadband range of the visible spectrum.
Apart from standard III-V nanophotonics, Group-III-Nitride semiconductor technology has established its niche in the development of LEDs. More specifically, InGaN nanowire axial/radial heterostructures show promise for the future of solid-state lighting.
The development of cost and efficiency in LEDs is also leveraged by advancements in the semiconductor industry. The same can be seen in case of InGaN nanowire which has an output power of >5mW (almost more than 100 times stronger than conventional LEDs). This paper demonstrates a simulation of an InGaN nanowire LED heterostructure in the frequency domain with an analysis of its emission spectrum, bandwidth, transit time for the carriers and power efficiency. Mainly three COMSOL modules are used in this study - semiconductor module, RF and wave optics. We expect the PL intensity to be modeled as an exponential function $I(t)=I(0)\exp((-t/k)^b)$ where I(t) is the time varying PL Intensity, k is the lifetime and b is the stretching parameter. The semiconductor module will help to have a better characterization model.
The direct implication of this technology is in the use of white light as a source for information and communication (similar to that of wifi), data transfer and lighting.

Figures used in the abstract

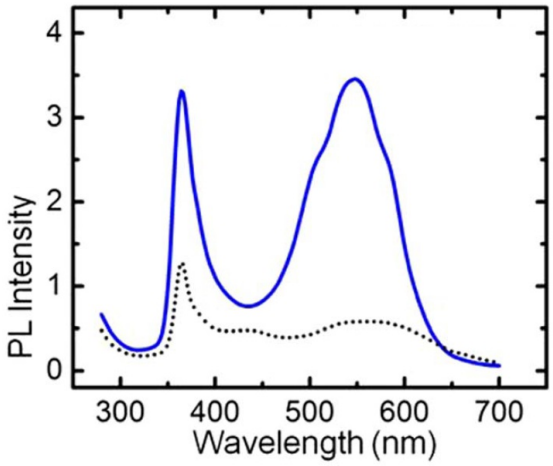

Figure 1 : A pictorial representation of the expected PL intensity profile (solid line - InGaN/AlGaN and dotted line - InGaN/GaN). [Reference: Nguyen, Hieu Pham Trung, et al. "Engineering the carrier dynamics of InGaN nanowire white light-emitting diodes by distributed p-AlGaN electron blocking layers." Scientific reports 5 (2015).]