Nano-lasers and nano-LEDs

Magnus Willander

Department of Science and Technology, Campus Norrköping, Linköping University
SE-601 74 Norrköping, Sweden

E-mail: magnus.willander@liu.se

Abstract. One-dimensional nanostructures have been of great interest for photonic devices. In this talk I will give a review of the one-dimensional ZnO nanostructures for ultraviolet and visible regions. I will discuss earlier and last results regarding room temperature and low temperature spontaneous and stimulated emission. For lasers we will discuss both optically and electrically pumped lasers. For the LEDs particularly I will discuss the white light emission from LEDs. Substrates like graphene, paper, textile and semiconductors will be discussed. Finally, also results from other devices based on hybrid materials will be analyzed.

1. Introduction and background

Zinc oxide (ZnO) with its self-organized growth property combined with a direct wide band gap (3.34 eV), relatively large excitons energy (60 meV), and deep band emission covering the whole visible range constitute an interesting material for the development of different photonic devices. In addition, the family ZnO nanostructures is one of the richest known families and it can be grown at low temperature and hence the fabrication of these photonic devices can be realized on non-conventional substrates, like e.g. glass, plastic, paper, etc.

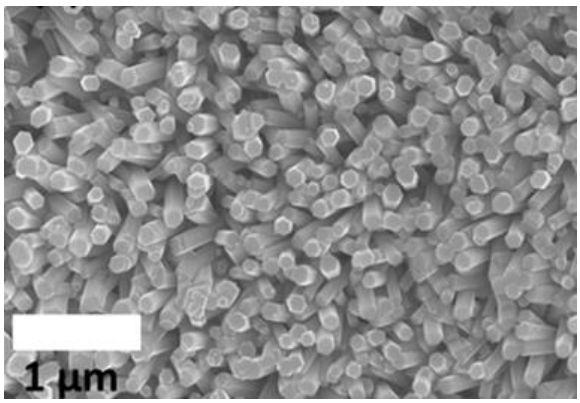

Figure 1. Scanning electron microscope (SEM) image of ZnO NRs grown on textile substrate using the low temperature chemical growth.

In addition, ZnO is bio-safe, biocompatible, and possesses piezoelectric property with relatively high electro-mechanical coupling coefficient [1]. The low temperature growth of ZnO nanostructures is rather simple and can be achieved on the above mentioned non-conventional substrates. Figure 1 shows a scanning electron microscope (SEM) displaying a typical example of ZnO nanorods (NRs) of high crystalline quality grown on textile substrates.

2. Results

The growth of the ZnO NRs is achieved as follows: as a first step a conducting layer, typically a metal like silver is deposited to provide the bottom contact to the ZnO NRs. To improve the ZnO nanorods growth quality, distribution and density a seed layer is spun-coated and baked for 20 min at 250 ^{o}C. Then zinc nitrate hexa hydrate ($Zn(NO_3)_2.6H_2O$) was mixed with Hexamethyl tetra-mine (HMT) ($C_6H_{12}N_4$) in equal molar concentartion and substrates were placed in the solution for four hours at 90 ^{o}C. Since the grown ZnO NRs are n-type by intnetional doping, a p-type polymer is used, either before the seed deposition or on top of the ZnO NRs after the growth. The fabricated white light emitting diodes (LEDs) have emitted white light of high quality. Figure 2 show a ZnO NRs based light emitting didoe under measurement.

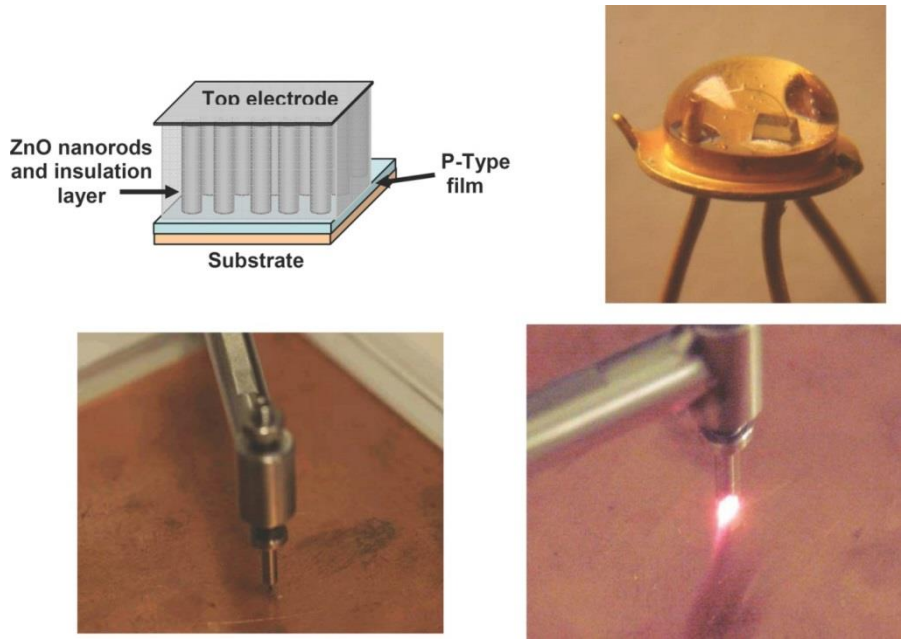

Figure 2. Schematic diagram showing one configuration of ZnO NRs based white light emitting diode (LEDs) (top left), a packaged white LED is shown also (top right side). The bottom two images show the white LED under measurement.

References

[1] Willander M et. al. 2009 Zinc oxide nanorods based photonic devices: recent progress in growth, light emititng diodes and lasers *Nanotechnology* **20** 332001