Influence of annealing on optical properties of ZnO nanorods obtained by the microwave-assisted hydrothermal process

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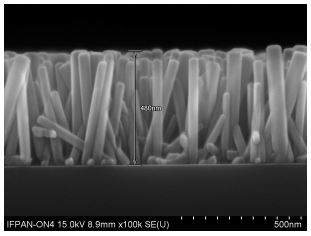
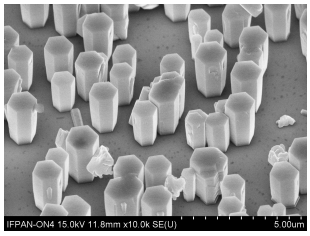
Zinc oxide is extensively studied II-VI semiconductor with a direct energy gap of about 3.37 eV at room temperature and possible defect-related emission in visible light spectral region. Due to these properties, ZnO is an attractive material for applications in photovoltaic, electronic and optoelectronic devices. ZnO nanorods, due to a well-developed surface, have potential of applications in sensor technology. Disoriented nanorods can also be applied in photovoltaic as anti-reflective layer.

In this work we present a new inexpensive method of the ultra-fast growth of ZnO nanorods from the aqueous solution. This environment friendly and fully reproducible method allows growth of nanorods in few minutes time on various substrates, without any catalyst or complexing agent. Growth temperature does not exceed 50ºC and growth can be performed at atmospheric pressure. Moreover the method is also very safe, it requires organic, non-toxic and low-price precursors [1]. ZnO nanorods were obtained on silicon and gallium nitride substrates. As nucleation layer we used ZnO nanoseeds obtained by the ALD (Atomic Layer Deposition) method. Received nanorods take the hexagonal form, which is characteristic for the structure of wurtzite. The nanorods form mixture with pH=8 have smaller sizes than those formed from pH=7.5 in the case of the silicon substrate. For GaN-based nanorods all crystallographic directions overlap.





Picture on the left presents nanorods made on silicon substrate. Picture on the right shows nanorods on GaN substrate.

Prepared samples were annealed in different temperatures: 200ºC, 400ºC and 800ºC in the presence of two types of gases: oxygen and nitrogen. The process was carried out in a RTP oven. On the GaN substrate, when nanorods are heated in nitrogen, red light is received, when in oxygen, there appears UV luminescence. It is also possible to obtain mixed light. On silicon substrate luminescence of nanorods consists only from UV range, suggesting that in this case the nanorods are not as highly defected as those on the GaN substrate. On a silicon base there are no defects such as oxygen vacancies or the formation of zinc interstitial. It is possible to control the light intensity, but there is no influence on a range of emission. The higher the pH of the reaction mixture is, the greater light intensity is received. Detailed information about experiments will be presented.

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1. B. S. Witkowski, et al., *Ultra-fast growth of the monocrystalline zinc oxide nanorods from the aqueous solution*, Int. J. Nanotechnol., Vol. 11, Nos. 9/10/11, 2014