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OPTICAL PROPERTIES OF ZINC OXIDE – EFFECTIVE PHOTOCATALYST

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Анотація

Розглянуто оптичні властивості цинк (II) оксиду з точки зору його застосування для фотокаталітичного вилучення барвників зі стічних вод.

Ключові слова: наноструктура, оптичні властивостті, цинк (II) оксид, валентна зона, фотолюмінесценція.

Abstract

The optical properties of zinc (II) oxide are considered from the point of view of its application for photocatalytic removal of dyes from wastewater.

Keywords: nanostructure, optical properties, zinc (II) oxide, valence band, photoluminescence.

Introduction

The optical properties of ZnO nanostructures have been widely studied due to their promising potential in optoelectronics. The optical properties of ZnO nanostructures are related to both internal and external effects. The internal optical transitions occur between electrons in the conduction band and holes in the valence band, including excitonic effects due to Coulomb interaction. External properties are associated with additives or defects that tend to create discrete electronic states in the band gap, and therefore affect both optical absorption and emission processes. ZnO is typically formed as an n-type semiconductor material in which electrical conductivity is due to excess zinc, presumably interstitially within the lattice and oxygen vacancies [14]. External defects, such as hydrogen, are more often included as minor donors [15]. In general, ZnO is a wide semiconductor bandgap material (3.4 eV), making it potentially useful for efficient UV laser diodes and low power thresholds for room temperature pumping. It is also one of the promising materials for high temperature and high-power devices. High-temperature operation requires a wide bandgap so that the internal carrier concentration remains. High-power operation is attractive for wide bandgap semiconductors because of the larger breakdown fields.

Results and discussion

The photoluminescence (PL) spectra of ZnO nanostructures have been widely reported experimentally. The room-temperature FL spectrum of ZnO typically consists of a near ultraviolet (380 nm) emission band due to the band-to-band transition and a green-yellow emission band associated with oxygen vacancy. In addition, a red emission band has also been reported, and this has been attributed to vacancies of doubly ionized oxygen [17]. The green emission intensity of ZnO was reported to increase with decreasing nanowire diameter. This indicated that the defect level was higher in thinner nanowires due to the increase in the surface to volume ratio. The constant decrease in the diameter of the ZnO nanowire leads to a quantum size effect, which is manifested in a blue shift of the edge band emission in the photoluminescence spectra (as shown in Fig. 1) [18].

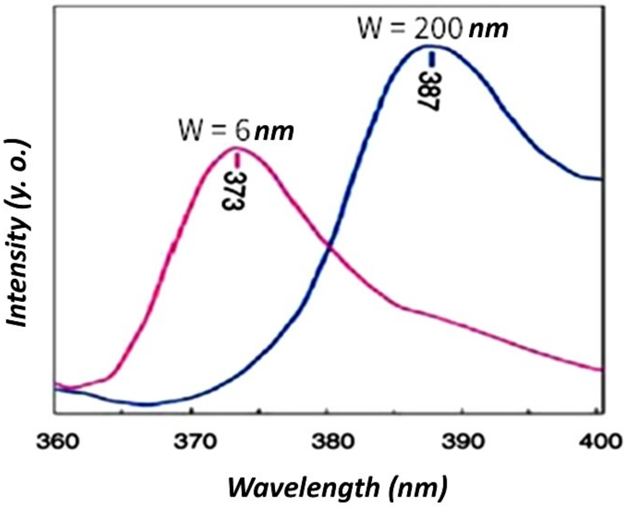

Fig. 1. Photoluminescence spectra of 6 nm and 200 nm wide ZnO nanoribbons

In addition, the most important advantage of ZnO nanostructures is the high exciton binding energy (60 meV), which is 2.4 times higher than the effective thermal energy (25 meV) at room temperature, resulting in effective exciton emission at room temperature. This is one of the key parameters by which ZnO exhibits room temperature power generation. Additional advantages of ZnO nanowire lasers are that exciton recombination lowers the generation threshold, and quantum confinement yields a significant density of states at the band edges and increases radiation efficiency. Moreover, due to its almost cylindrical geometry and high refractive index (~2.0), ZnO nanostructures are a natural candidate for optical waveguides [19].

Conclusions

It has been established that zinc (II) oxide is an effective and promising photocatalyst that allows the removal of a wide range of dyes from water and is environmentally friendly.

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