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Rapid thermal annealing induced change of the mechanism of multiphonon resonant Raman scattering from ZnO nanorods

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Abstract

Multiphonon Resonant Raman scattering (RRS) excited by 351.1 and 363.8 nm lines of an Ar^+ laser was studied at temperatures from 10 to 300 K in as-grown and rapid thermal annealed (RTA) aluminum doped ZnO nanorods synthesized by an aqueous chemical deposition method using zinc sulfate, aluminum sulfate, and ammonia hydroxide as precursors. RTA of ZnO nanorods at temperatures 650–750°C was found to result in changing the mechanism of RRS from incoming to outgoing. This change is suggested to be related to the RTA induced improvement of the optical properties of the nanorods.

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1. Introduction

Nanosized semiconducting oxides have been focal points of great interest during the last ten years owing to their electrical and optical properties that are suitable for the fabrication of nanoscaled electronic and optoelectronic devices. Due to the multiple and switchable growth directions of Wurtzite structures and the high ionicity of polar surfaces [1], it assures conditions for the ZnO formation of a very rich micro/nanostructure diversity in comparison with other materials. Among ZnO nanostructures the arrays of nanorods attract special attention as microcavities for microlasers [2–4] owing to the large exciton binding energy in ZnO (60 meV) which ensures that excitonic emission is significant at room temperature. Apart from that, aluminum-doped zinc oxide (AZO) nanostructures are promising for nanoscopic research and various applications including gas sensors [5], solar cells [6], optical waveguide and exciton related devices [7]. One-dimensional ZnO nanorods with their high carrier mobility serve as direct conduction pathways for excitons.

Over the last ten years, different methods have been used to fabricate high-quality AZO thin films, such as RF thermal plasma evaporation, pulsed laser deposition, metalorganic chemical vapor deposition and sputtering, solution-liquid–solid growth in organic solvents, vapor–liquid–solid and vapor–solid processes. At the same time, the aqueous chemical deposition method became widely used for the fabrication of AZO nanostructures due to their economical and ecological advantages, low-temperature processing and the flexibility to tailor the properties by doping and modeling impurity distribution in the end product — nanorods and mesoporous films [8].

Resonant Raman scattering (RRS) has been proven to be an important tool for the study of basic physical properties of semiconductors, including nanostructured materials. It provides information pertaining to the electronic structure [9,10], electron–phonon coupling [11,12], radiation induced crystal damage [13], etc. However, one needs to take into account the mechanism of RRS when extracting this information. In this letter, we show that rapid thermal annealing (RTA) of

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