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RESIDUAL STRESS IN RF MAGNETRON SPUTTERED ZnO THIN FILMS on GaP SUBSTRATES AND NANOWIRES

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Zinc oxide (ZnO) is a multifunctional optical material with semiconducting properties and found applications in blue and UV optoelectronic devices. Nanowire solar cells are promising devices for solar energy conversion because of the enhanced optical absorption on structured surfaces [1]. The GaP-NWs were prepared in an AIX 200 MOVPE low-pressure reactor by a vapour-liquid-solid (VLS) method [2]. In this paper, we discuss the deposition of ZnO thin layers on positioned GaP substrate and GaP nanowires by RF magnetron sputtering at different ZnO:Al target-substrate geometry, see Fig. 1. The surface morphologies of ZnO films and core-shell GaP/ZnO NWs were examined by XRD, AFM, SEM and TEM. The X-ray diffraction patterns for stress evaluation were measured in grazing incidence set-up, Fig. 2. The stress was evaluated by multi-reflection method [3] with correction for the refraction of X-rays. The layers of polycrystalline ZnO deposited on (111) oriented GaP substrates exhibit strong (001) texture without any pronounced azimuthal dependence as it is shown in Fig. 2. The strain at the surface of the layer strongly decreases and reaches about 75% of the value averaged across the whole layer thickness. The corresponding values of compressive stress are 1.7 and 1.3 GPa, resp., when the isotropic stress factor $E/(1+\nu) = 86.1$ GPa [4] is used. TEM images of a GaP/ZnO nanowires revealed that GaP nanowire has zinc blende crystal structure and growth axis [111] and the structure of the ZnO shell is polycrystalline (Fig. 3). We observed bending of the NWs after deposition of shell ZnO layer on fixed positioned NWs without the rotating the substrate with NWs as a result of the residual stress in the ZnO polycristalline coating. We simulated the influence of residual stress on bending of GaP/ZnO NWs using ANSYS software code and results of our calculations and values of stress taken from XRD analysis were used for calculations of the bending of the GaP beam. The results are compared with experimental observations and revealed the ability to utilize p-GaP/n-ZnO core-shell nanowires in the solar cells development.

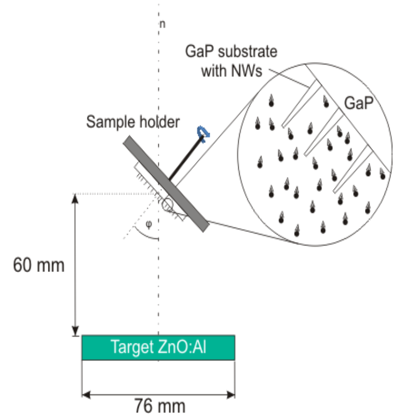

Fig.1. Magnetron sputtering geometry.

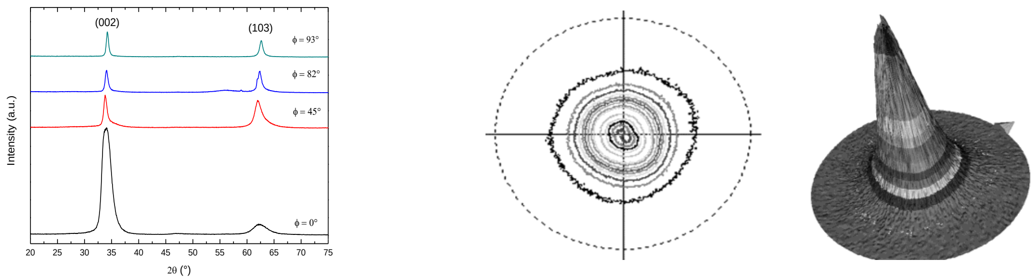

Fig. 2. Grazing incidence X-ray diffraction patterns of the ZnO layers (left) deposited at different tilting angles. The X-ray incidence angle α=1.5°. Pole figure 002 (middle) and the corresponding 3D view (right) of the textured ZnO film deposited at the tilting angle 82°.

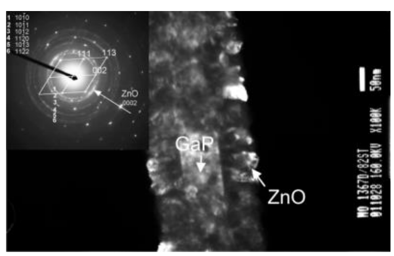

Fig. 3. TEM image of as grown GaP/ZnO NW. (Inset shows diffraction analysis of the sample).

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