Selective area growth of well-ordered ZnO nanowires on (111) oriented masked substrates by electrochemical method

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Due to many excellent properties, ZnO nanostructures have become promising functional materials for various applications such as solar cells [1], laser [2], and spin field-effect transistors [3]. Developing a simple and effective synthesizing method for ZnO nanowires is highly desired to maximize the mass efficiency. In this study, we reported selective area growth of ZnO nanowires by electrochemical method combined with e-beam lithography (EBL) to control positions and orientations of nanowires.

The electrolyte used in this article is a mixture of 0.025 M zinc nitrate hexahydrate $(Zn(NO_3)_2 \cdot 6H_2O)$ and 0.025 M hexamethylenetetramine $(C_6H_{12}N_4)$ solution. The growth temperature, time and applied potential were 90 °C, 2 hours and -0.8 V, respectively. The nucleation site, density, position and the orientation of the nanowires were controlled by EBL and using (111) oriented different substrates. The ZnO nanowires were characterized by scanning electron microscopy (SEM), Raman spectroscopy, and photoluminescence (PL).

Figure 1 shows an SEM image and diameter distribution of as-synthesized ZnO nanowire arrays grown on p-type InP (111)B substrate. Uniform crystal structures and morphology, and well-ordered orientation can be seen. Figure 2 shows Raman scattering spectra at room temperature excited by a semiconductor laser having the wavelength of 532 nm. Since the peak positions are almost same as bulk ZnO, that indicates high crystalline quality of the ZnO nanowires. Also a PL measurement result shows an UV emission near ZnO band-edge accompanied by no defect emissions.

These all results indicate a better quality type of ZnO nanowires grown on patterned InP (111)B substrate compared to Si (111) substrate, which will be useful for many potential applications.

[1] M-L Zhang et al., RSC Adv. 4 (2014) 10462.

[2] J. M. Szarko et al., Chem. Phys. Lett. 404 (2005) 171.

[3] X. Hu et al., J. Mater. Chem. C 4 (2016) 150.



Fig 1. SEM image and diameter distributions

Fig 2. Raman spectra