Three-dimensional periodic ZnO nanostructures fabricated by templating process using solution-derived ZnO

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Introduction

Zinc oxide (ZnO) is a wide direct band gap semiconductor with high electron mobility and is a promising thermoelectric material because of its non-toxicity, high thermal stability, and comparatively high Seebeck coefficient (S) among metal oxide semiconductors. Nevertheless, because of a high thermal conductivity (>40 W/mK), ZnO has an enormously low figure of merit (ZT), and limits the thermoelectric application of the material[1]. Recently, nanostructures have been proven to work as an effective way to increase ZT[2,3]. In this work, ZnO three-dimensional (3D) nanostructures are fabricated with an all-solution based process without using vacuum processes.

Experimental

In this research, the 3D periodic nanostructure of negative photoresist (SU-8) formed by the proximity nanopatterning process[4] as a template as shown in Fig.1. The ZnO infiltration process starts by first depositing the ZnO precursor solution (SYM-ZN20, Kojundo Chemical Lab. Co., Ltd.) on the top of template[5] with different concentrations: 0.23, 0.3, and 0.47 mol/L, defoamed 3 times for 5 min. After this, spin-coated at 2000 rpm for 20 sec and then dried under an oxygen atmosphere at 220 °C for 1 h. In addition, the above infiltration process was repeated for 6 times. Finally, post-baking was performed at 410 °C for 4 h in an oxygen atmosphere; the ZnO 3D inverse nanostructure was fabricated through baking the ZnO precursor and removed the 3D template.

Results and Discussion

Figure 2 shows the ZnO 3D nanostructure with various concentrations at same fabrication conditions. The ZnO nanostructure was successfully achieved without the residue on the surface – which is very helpful for accurate measurement of the electrical and thermal properties. Moreover, the higher resistance (>100 MΩ) of ZnO nanostructure was decreased to lower than 20 kΩ by high temperature annealing at 400 °C under the atmosphere of N_2 (98%) and H_2 (2%) for 2 h which can increase the oxygen vacancy in the film. In the conference, we will report the estimated electric conductivity, Seebeck coefficient, and power factor with these three different samples as well.

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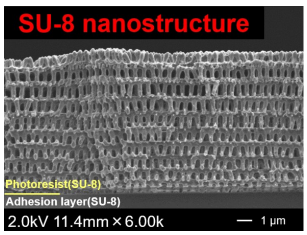

Fig.1 SU-8 template

Fig.2 ZnO 3D nanostructures with different precursor concentration