Effect of Doping on High Temperature p-n Junction of NiO-ZnO System

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INTRODUCTION

High temperature p-n junction has been received much attention in intermetallic and oxide system. But during high temperature operation, the performance may degrade due to interdiffusion at the junction. The junction, which consists of thermodynamically equilibrated p-type and n-type materials, provides the long life p-n junction at high temperature. Kurokawa et al. [1] have reported that the junction of NiO-ZnO system exhibited the rectifying behavior and rectifying property was stable for long time at 673 ~ 973 K. However, further improvement of rectifying property is required. The purpose of this study is to improve the rectifying property of high temperature p-n junction of NiO-ZnO system by doping.

EXPERIMENTAL

Sample preparation

Based on the reported phase diagram[1], NiO with 40 mol% ZnO (z40) and NiO with 90 mol% ZnO (z90) were chosen as p-type and n-type semiconductors. Powders of NiO (99.97 %, High Purity Chemicals) and ZnO (99.99 %, High Purity Chemicals) were thoroughly mixed in appropriate ratios. The aqueous solution of Li_2CO_3 was added to the z40 mixture to dope it with 0.5 mol% Li_2O (z40+0.5Li). The solution of $Al(NO_3)_3 \cdot 9H_2O$ was added to the z90 mixture to dope it with 0.5 mol% Al_2O_3 (z90+0.5Al). Both mixtures were dried and then pressed at 120 MPa. The pellets of z40+0.5Li mixture were reacted at 1273 K for 21.6 ks (6 h). The pellets of z90+0.5Al mixture were reacted at 1673 K for 21.6 ks (6 h).

Current-Voltage characteristics of the junction

The two samples were connected to make a p-n junction and *I-V* characteristics of the junction was measured in air at 673 K ~ 973 K. Stability of the junction was evaluated by long time measurement as shown in fig. 1. Starting from 673 K, temperature was fixed until the *I-V* characteristic was unchanged. After that, temperature was changed to next step. Finally, temperature was returned to 673 K.

RESULTS & DISCUSSION

Figure 2 (a) and (b) show *I-V* characteristics of z35 / z95[1] and z40+0.5Li / z90+0.5Al at the stage 1. Both junctions exhibited the rectifying behavior. Table 1 summarizes the forward current, reverse current and rectifying ratio respectively. The forward current of z40+0.5Li / z90+0.5Al was 66 times as large as that of z35 / z95. The reverse current of z40+0.5Li / z90+0.5Al was 2.4 times as large as that of z35 / z95. The rectifying ratio of z40+0.5Li / z90+0.5Al was 30 times as large as that of z35 /z95. These results can be explained by considering Fermi-level in p-type semiconductor approaches the top of the valence band and it in n-type semiconductor approaches the bottom of the conduction band.

Figure 3 shows the time dependence of *I-V* characteristics of z40+0.5Li / z90+0.5Al. *I-V* characteristic was unchanged at least for 172.8 ks (2 days). This indicates that Li_2O and Al_2O_3 scarcely diffuse over the junction at 673 K.

CONCLUSION

A p-n junction consisting of z40 doped with 0.5 % Li_2O and z90 doped with 0.5 % Al_2O_3 exhibited rectifying behavior. Rectifying ratio was improved from 6 to 175 by doping at 673 K. *I-V* characteristic of z40+0.5Li / z90+0.5Al was unchanged within 2 days at 673 K. This study indicates a possibility of high temperature long life p-n junction with equilibrated compounds.

REFERENCE

[1] H. Kurokawa, M. Nanko, K. Kawamura, and T. Maruyama, *proc. Ionic and Mixed Conducting Ceramics* **IV** (*ECS*), PV2001-28, 280-290(2001).

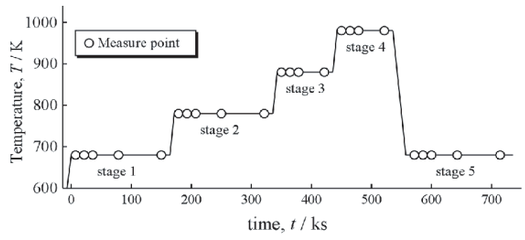

Figure 1. Temperature profile.

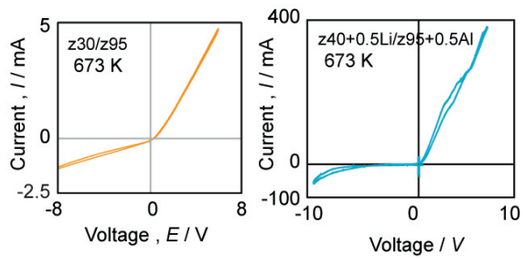

Figure 2. I-V characteristics at 673 K,
(a) z30 / z95, (b) z40+0.5Li / z90+0.58Al

Table 1. Electrical current at 4 V (673 K).

	z30 / z95	z40+0.5Li / z90+0.5Al
forward current (mA)	3	200
reverse current (mA)	0.5	1.2
rectifying ratio	6	175

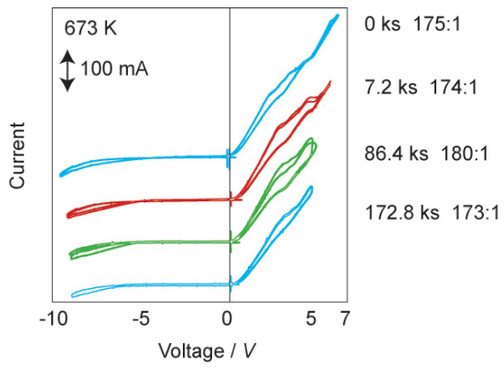

Figure 3. The time dependence of I-V characteristics of z40+0.5Li / z90+0.5Al (673 K).