Pd decoration of on-chip grown ZnO nanorods for ethanol detection

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SUMMARY

We have decorated on-chip grown ZnO nanorods (NRs) with Pd particles by sputtering for better ethanol detection. Size of the sputtered Pd particles determines response of the ZnO NRs to ethanol. ZnO-Pd 2 nm sample is about twice to three times more sensitive to ethanol compared with ZnO-Pd 4 nm and ZnO-Pd 8 nm samples depending on temperature and concentration of ethanol. ZnO-Pd 2 nm responses and recovers also very fast, especially at 450 ℃. Bigger Pd particles will worsen and even terminate sensing performance of the sensor to ethanol, as seen with 4 nm and 8 nm Pd.

KEYWORDS: ZnO nanorods; gas sensor; ethanol

INTRODUCTION

ZnO nanostructures are usually made by hydrothermal [1] or CVD routes [2], and used for sensing of toxic gases [3]. Recently we grew ZnO NRs on-chip successfully with hydrothermal method using zinc as seed layer on a glass substrate. The sensor with these ZnO NRs was highly sensitive and selective to NO_2 [4]. Here, we decorated the similar ZnO NRs by sputtering Pd and test against ethanol gas.

EXPERIMENTAL

Our sensors are fabricated by using lithography, sputtering and lift-off technique. Electrodes of the sensors are made of Pt/Cr layer with thickness 100/10 nm. ZnO nanorods are then grown on-chip in an equimolar solution of 0,005 M $Zn(NO_3)_2$ and HTMA at 85 ℃ [4]. Pd particles with different sizes are sputtered directly onto the sensor chips and annealed at 650 ℃ in air for 1 h. The sensors then are tested against ethanol gas at different concentration at 350, 400, and 450 ℃.

RESULTS AND DISCUSSION

Figure 1A illustrates the structure of the gas sensor. Figure 1B shows ZnO NRs with sputtered Pd particles. As seen in Figure 2, Pd particle with the size of 2 nm is the optimal for ethanol sensing. ZnO-Pd 2 nm sample has superiorly higher response than the original ZnO NRs. As the size of Pd particles increases further, the response decreases. 8 nm Pd particles terminate the response of the original ZnO NRs to ethanol and even reverse sensing behavior of the sensor.

CONCLUSION

In this work, we have successfully demonstrated that Pd decoration can enhance the responses of ZnO NRs to ethanol to a large degree. The optimum size of Pd particles is 2 nm. Bigger size of Pd particles lowers the response to ethanol.

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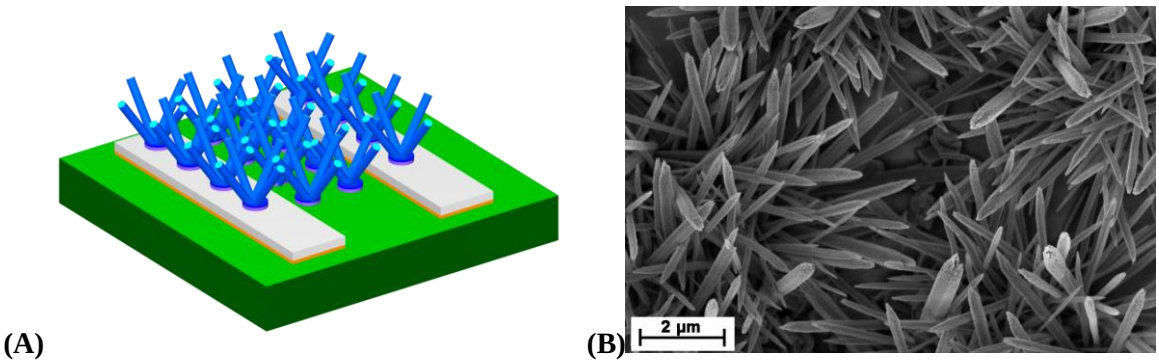

Figure 1. (A) Scheme of gas sensor, (B) SEM image of ZnO-PdO 2 nm.

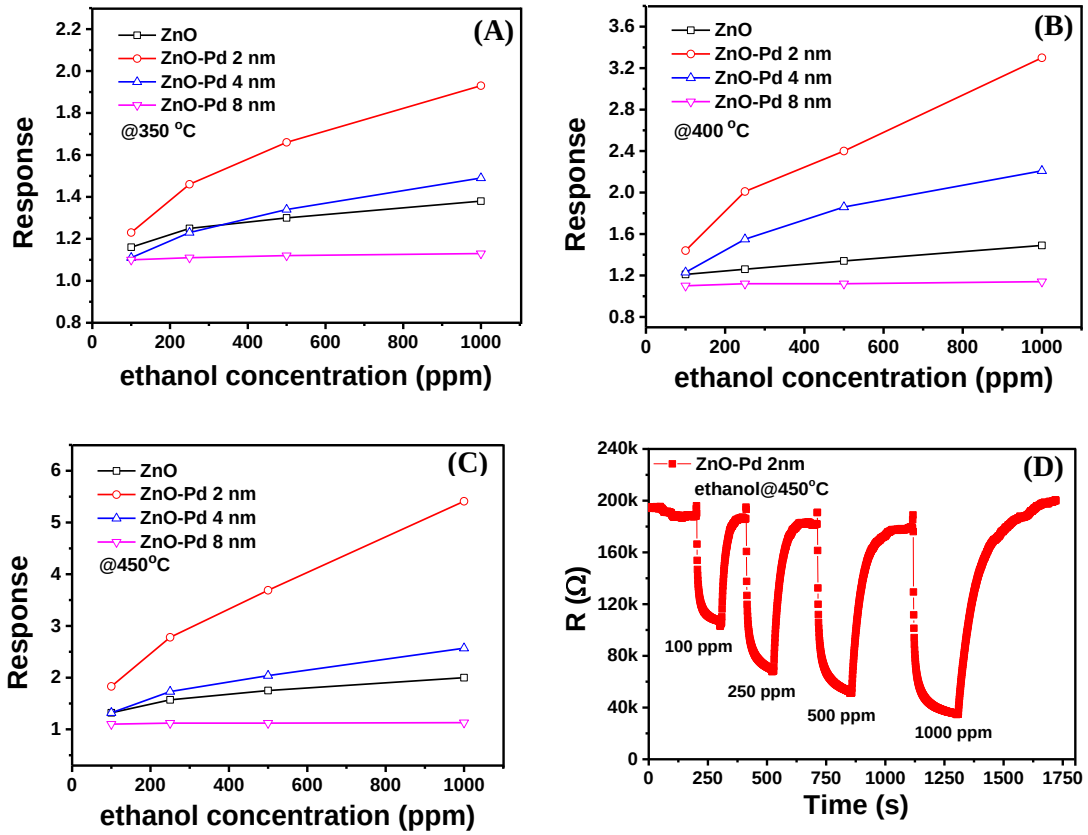

Figure 2. Sensing performance of original ZnO and ZnO-Pd samples to ethanol at temperatures: (A) 350 ℃, (B) 400 ℃, (C) 450 ℃, (D) dynamic gas sensing of ZnO-Pd 2 nm to ethanol at 450 ℃.