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Nanostructured Metal-Oxide Based Hydrogen Gas Sensor Prepared by Magnetron Sputtering

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1 Introduction

Hydrogen is an inexhaustible, transportable and storable source of clean energy. The safe transportation and storage demand reliable and fast hydrogen gas sensors. Nanostructures of metal oxides are suitable candidates for gas sensors due to their large surface-volume ratio. This is advantageous for highly sensitive and rapid detection of the gases.

Nanostructured metal oxide semiconductors (MOS) are commonly employed as conductometric gas sensors. Among the huge range of these MOS, tungsten oxide offers potential applications in electro- and photochromic properties and is considered as a promising material for hydrogen gas sensing because it is capable to perform detection at the ppm scale. Generally, pure tungsten oxide is not used for sensing, noble metals (Pd, Pt) are used as catalysts [1]. They enhance the sensitivity and lower the working temperature.

The enhancement of sensitivity can be achieved also by combining more types of MOS together. Here, we investigate CuO clusters on top of WO_3 used as a conductometric sensor. And it was observed that presence of CuO clusters enhances the sensitivity of WO_3 film to hydrogen gas. One of possible explanation is, that CuO clusters and WO_3 thin film together form a P-N junction since CuO is p type semiconductor and WO_3 is n-type. It is difficult to identify the presence of P-N junction directly, since the diameter of clusters is about 10 nm.

Here, we overcame the problem by making a geometry of the diode using the clusters and thin film of CuO with WO_3 thin film as shown in Fig 1. The structure of the thin films is characterized and described. Finally, the I-V curves show the presence of diode behavior.

2 Experimental Details

Reactive magnetron sputtering techniques was used to deposit tungsten oxide (WO_3) thin films from metallic target (diameter 72 mm) on SiO_2 substrates at a power of 60 W for 3 minutes at 250 °C in a pressure of 0.59 Pa with flow rates 15 sccm and 3.75 sccm for argon and oxygen respectively. Cupric oxide (CuO) thin films were deposited by RF magnetron sputtering at room temperature with flow rates of 10 sccm and 2.5 sccm of Ar and O_2 respectively for 80 minutes at 228 W. CuO clusters were deposited by ex-situ using gas aggregated chamber cluster source (HVM plasma) [2].

The substrates were cleaned by sonication process in Isopropyl alcohol and D-I water before the deposition. The morphology and topology of as deposited thin films were observed by

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scanning electron microscopy (SEM) (SU-70, Hitachi). XRD patterns were measured using a diffractometer (X'pert PRO, PANalytical) in the Bragg-Brentano configuration. I-V curves were measured by standard four probe method using wires attached to surface by conductive paste.

3 Result

Fig.3 shows the XRD pattern of the deposited WO_3 films. The XRD pattern confirms the crystallinity of the films and the crystal structure is orthorhombic. For further use, the films with O_2:Ar ratio of 1:4 were used. The SEM images shows the WO_3 and CuO clusters on left and right most part of the specimen and overlap of CuO clusters on WO_3 films in middle of the specimen as shown in Fig 2.

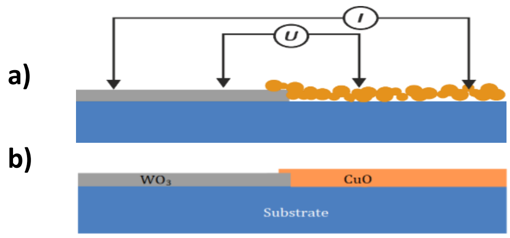

Fig 1: WO_3/CuO diode with CuO a) thin film and b) clusters

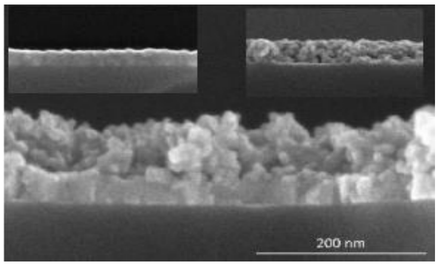

Fig 2: SEM image of CuO clusters on WO_3

The I-V curves of thin film diode, prepared by CuO clusters and thin film on WO_3 thin film were measured by four probe, have shown in Fig 4.

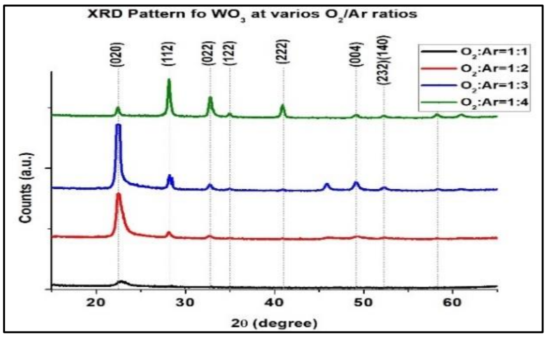

Fig 3: XRD pattern of WO_3 films prepared at different flow rates ratios of oxygen and

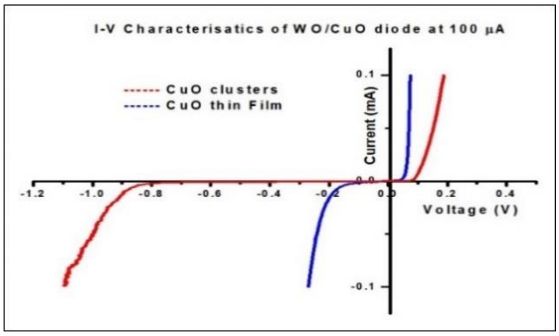

Fig 4: I-V curves for CuO/WO_3 diode with CuO clusters and thin film.

4 Conclusion

We found in I-V curves that the thin film of CuO deposited on WO_3 films show the diodic behavior and it also confirmed by the CuO clusters on WO_3 film when deposited at described conditions. We believe, that this diodic behavior of CuO/WO_3 is responsible for enhancing the hydrogen gas sensorial response of CuO/WO_3 system.

References

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