Tungsten Oxide based Hydrogen Gas Sensor Prepared by Advanced Magnetron Sputtering

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Hydrogen Sensors

Motivation

In recent years, H_2 is getting much attention as a potential clean energy source of upcoming generation of fuel based systems and household appliances.

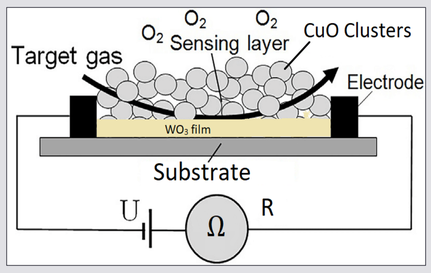
Metal oxide semiconductors are most widely studied gas sensing materials due to their fast and high sensitivity toward gases like H_2, NO_x, NH_3 etc.

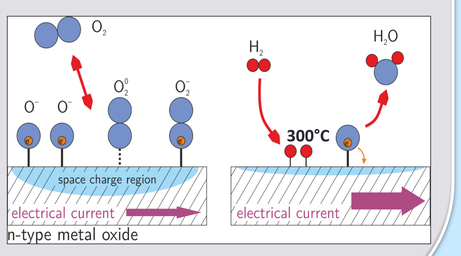
The enhancement of sensorial response can be done by addition of suitable materials and/or by changing geometrical properties of sensor assembly.

Conductometric Sensors

Sensing Mechanism

- preadsorbed O_2 gather free electrons
- hydrogen is adsorbed at surface (may be assisted by catalyst)
- H_2 and O_2 reaction returns electron back to the semiconductor → increased conductivity





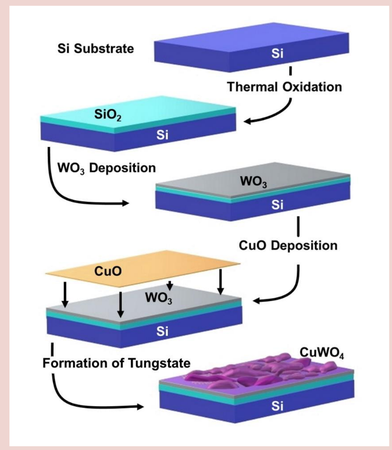
Specimen Preparation

WO_3 Thin Film

- Reactive Magnetron Sputtering from W target in DC and HiPIMS mode.

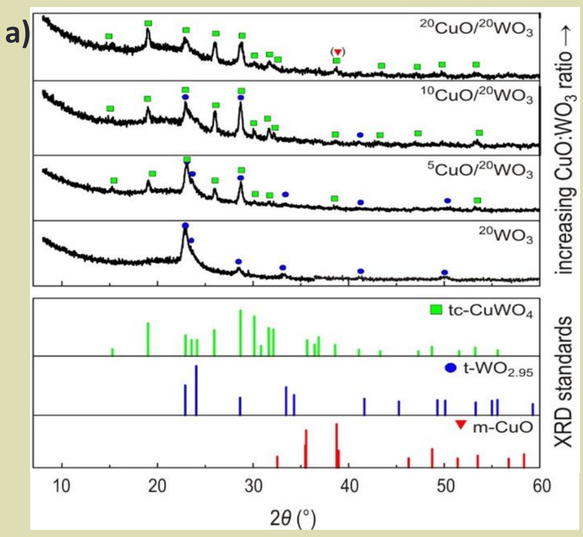
CuO Thin Film and Pd Clusters

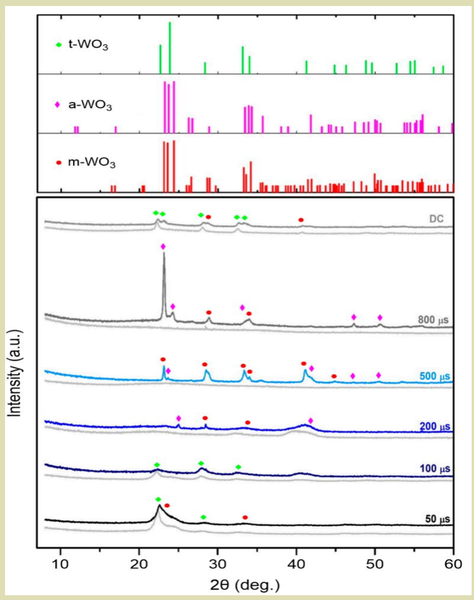
- Reactive magnetron sputtering from Cu and Pd targets in RF mode.



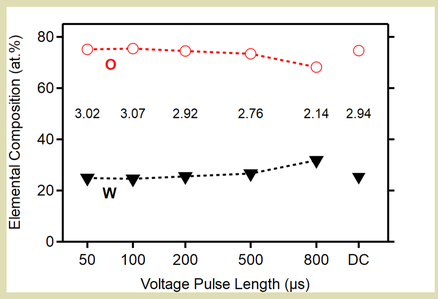
WO_3 Thin Film Structure

XRD





- As deposited WO_3 thin films, $CuWO_4$ loaded WO_3 (a), Pd Loaded HiPIMS deposited WO_3 measured film up to 350 °C, (colored curves in (b)) and Change in Stoichiometry with Voltage Pulse length (c).

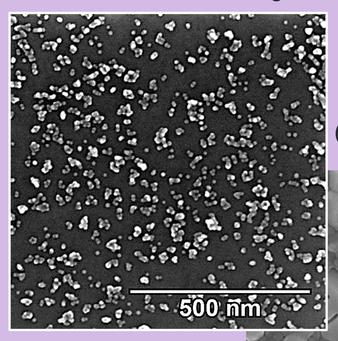


Morphology

SEM

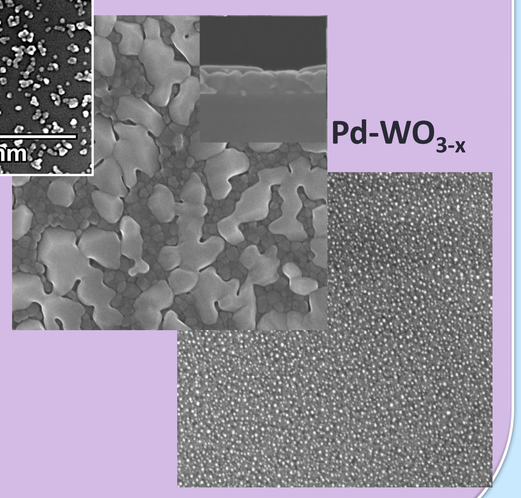
- 3 different architectures and combinations on WO_3 films
- Density of Cu nanoclusters and $CuWO_4$ nano-island on WO_3 thin film varied.
- Formation of heterojunctions

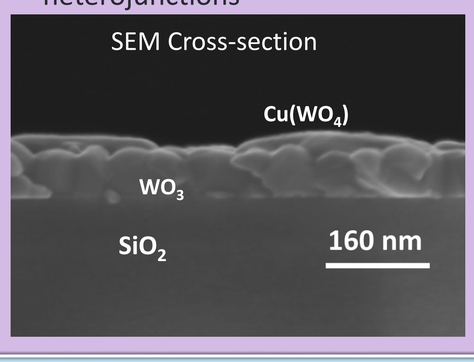
Cu Clusters/WO_3



$CuWO_4$/WO_3

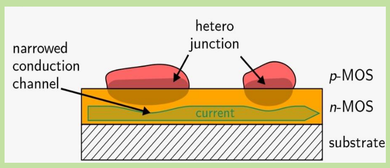
Pd-WO_{3-x}

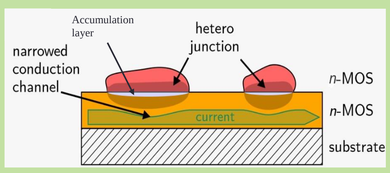




Explanation: Formation of Homo/Heterojunction

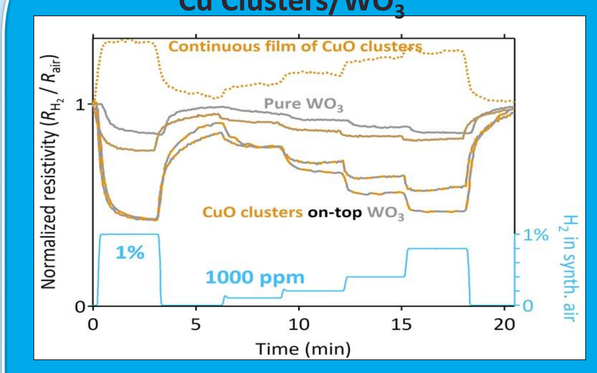
- Cu Clusters and WO_3 formed PN nano-junctions at the interface which alter the resistance and enhance the response
- Cu(WO_4) and WO_3 formed NN-type junction which give depletion and accumulation layers and change the response.
- Variation in Oxygen vacancies by HiPIMS and Crystalline structure enhanced the sensor response.



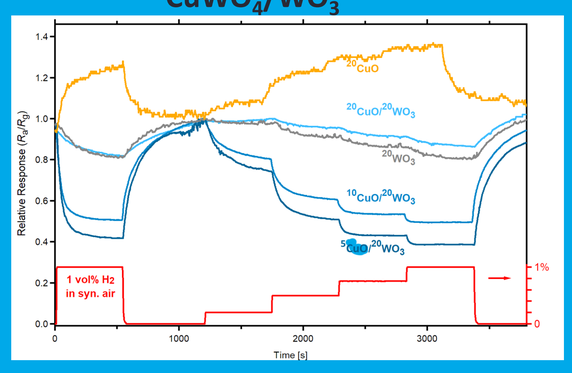


Sensorial Response

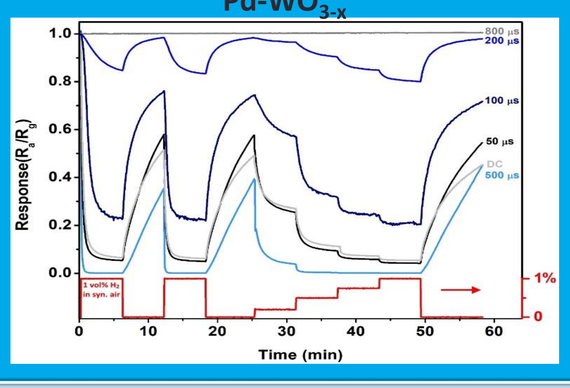
Cu Clusters/WO_3



$CuWO_4$/WO_3



Pd-WO_{3-x}



Specimen	Response	Method
Cu Cluster/WO_3	2	DC
$CuWO_4$/WO_3	5	RF/DC
Pd/$WO_{2.76}$	60	RF/HiPIMS

Conclusion

- Nanoclusters has been prepared by magnetron sputtering
- Ternary Oxide successfully prepared by a two-step deposition process by Magnetron Sputtering.
- Combinations of Various metal-oxide semiconductors can improve the sensory response.
- Nanostructures and Pd nanoparticles enhanced response significantly.

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