IMPROVEMENT OF GAS SENSING SELECTIVITY OF VANADIUM PENTOXIDE NANO-STRUCTURES TOWARDS SULPHUR DIOXIDE BY GOLD DOPING

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ABSTRACT

Vanadium pentoxide (V_2O_5) is a semiconductor metal oxide material with properties that makes it suitable for gas sensing applications. These properties are strong catalytic activity, high conductivity and structural ability. Despite this, literature showed that low selectivity and high operating temperatures still limit its functionality in practice. Sulphur dioxide (SO_2) is a highly toxic greenhouse gas with an unpleasant odor that is emitted primarily by the combustion of fossil fuels and volcanic eruptions. Even at concentrations as low as 5ppm, SO_2 can cause serious health issues to human lives. Fabrication of highly selective and low operating temperature SO_2 gas sensors are of utmost importance. This review presents current drawbacks and recent advances of V_2O_5 nanoparticles for gas sensing application (paying close attention to Au/V_2O_5 towards SO_2 in anticipation of the study that follows). Possible gas sensing mechanisms of V_2O_5 and Au/ V_2O_5 in the presence of SO_2 gas are also presented.

BACKGROUND

Introduction

- Air pollution and its impact in society [1]
- Gas and chemical sensors play a crucial role in monitoring harmful gases (toxic, explosive and poisonous) in the atmosphere [2]
- Semiconductor metal oxides (SMOs) viewed as potential gas sensing materials[3]
- Vanadium pentoxide is an inorganic compound with the chemical formula V_2O_5 [4].

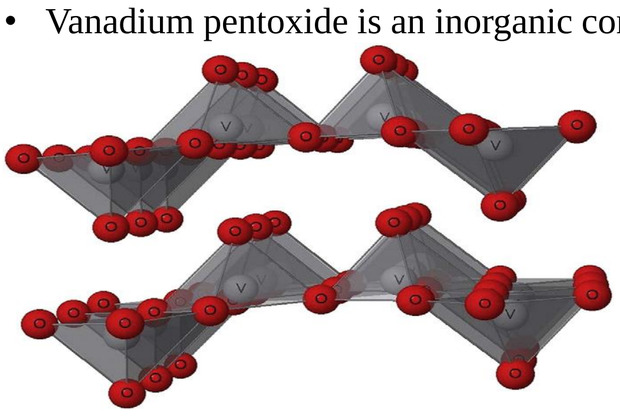

Figure 1: Perspective view of two layers of V_2O_5. V atoms are represented as grey balls, O atoms as red balls. Weak van der Waals bonds are omitted for clarity[6].

Figure 2: https://www.reade.com/products/vanadium-oxide-pentoxide-powder-vo-vo2-v2o3-and-v2o5/2020.

V_2O_5 is exceptional in gas sensing

- Excellent electrical, optical and magnetic properties
- Surface adsorption characteristics and catalytic activities [6]
- The most stable compound in the V-O scheme [7]
- A metal-to-insulator (MIT) (375˚C)

Possible gas sensing mechanism of V_2O_5 (n-type material) upon exposure to reducing gases: e.g.

$CO + O^-_{ads} \rightarrow CO_2 + e^-$

Type of reaction anticipated when V_2O_5 and Au/ V_2O_5 is exposed to SO_2 gas:

$SO_2 + O^-_{ads} \rightarrow SO_3 + e^-$

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RESULTS AND DISCUSSIONS

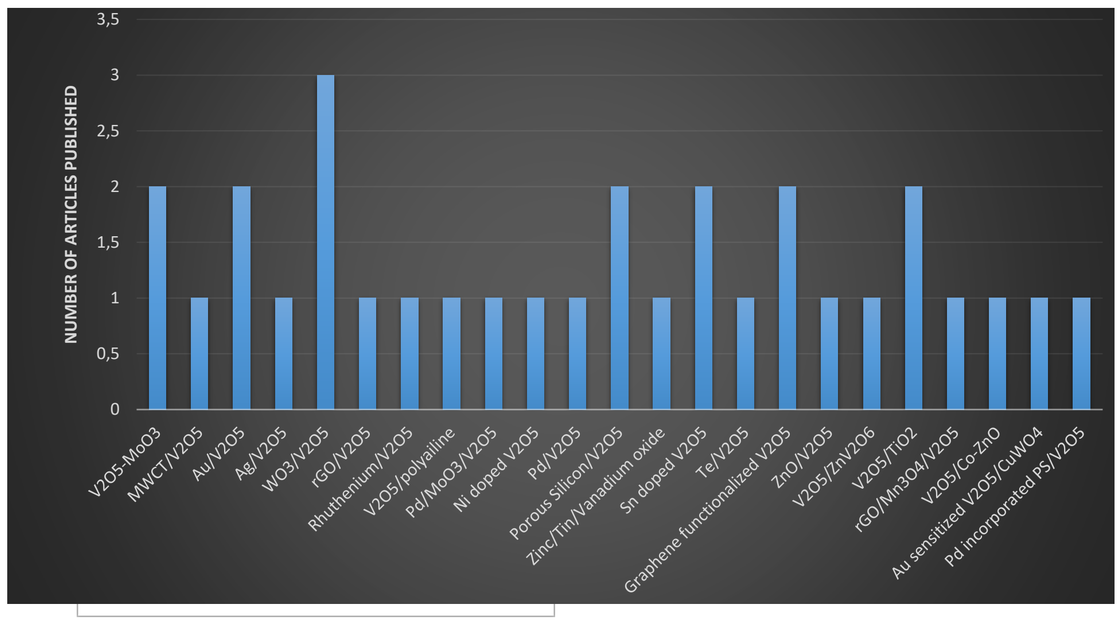

Figure 3: Shows number of papers where V_2O_5 is doped/functionalised/ decorated with different material to improve its gas sensing performance

Table 1: The profile of V_2O_5 based sensor materials and their sensing

Sensing material	Synthesis method	Operating temperature(◦C)	Analyte gas	Concentration(ppm)	Sensor response	Response/recovery times(s)
V_2O_5 and V_2O_5 /Au nanotubes	Emulsion - electrospinning	200	ethanol	100	-	5s/5s [8]
Au/VOx films	Dc magnetron sputtering	25	CH_4	1500	-	-/- [9]
V_2O_5 nanorods	Chemical spray pyrolysis	200	NO2	100	20.3%	17s/185s [10]
WO_3-V_2O_5	Chemical spray pyrolysis	350	SO_2	5-50	77.84%	-/- [11]

Common synthesis methods of V_2O_5 for gas sensing application

- Pulsed laser deposition (PLD)
- Magnetron sputtering
- Chemical spray pyrolysis
- Hydrothermal
- Sol-gel

CONCLUSIONS

The effect of doping/decoration/functionalizing and composite structures of pristine V_2O_5 nanostructures has improved the gas sensing performance greatly. Not much work has been done on improving gas sensitivity of pristine V_2O_5 towards SO_2 gas. 2-dimensional V_2O_5 nanostructures have been synthesized using various methods for various applications but are yet to be considered for gas sensing application.

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