ROOM TEMPERATURE ORGANOPHOSPHATE DETECTION BY THERMALLY OXIDIZED METAL OXIDE THIN FILMS

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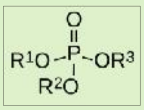
ABSTRACT

In the present age, pesticides are used broadly in the unindustrialized sector in order to certify the safety of crops from pests and insects. This work mainly emphases on the evolution and chemical sensing nature of CuO thin films for organophosphate recognition. Cu films were deposited on p-type Si substrate [1–10 Ω cm (100),] using RF sputtering at 50 W power and 4×10^{-3} mbar pressure. Oxidation of the films was carried out in air atmosphere at a temperature range from 200 °C to 800 °C. The structural research were carried out by X-ray diffraction (XRD) technique. At a lower temperature of 200 ° combine phase of CuO and Cu_2O was observed. The FESEM images have shown a even grainy surface pattern at the oxidation temperature of 600 °C without any presence of crashes. In order to study the sensing properties, current-voltage measurements were carried out in an secluded sensing chamber at room temperature. A substantial upsurge in current was observed for the oxidized films in presence of organophosphate pesticide.

INTRODUCTION

- Organophosphate (OPs) based pesticides have adverse effect on human health, food chain as well as on the ecosystem.



- OPs are highly toxic even at very low concentration and irretrievably inhibit the working of acetylcholinesterase (AChE), an important enzyme in human body.
- *There is a necessity for faster, simple and low-cost method for real-time detection of OPs for its controlled utilization*

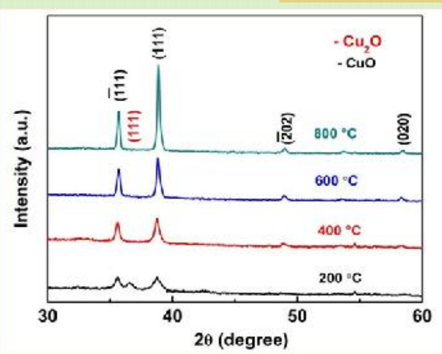
ADVANTAGE OF COPPER OXIDE THIN FILM

- Copper oxide is one of the potential candidate among different metal oxides, and has drawn significant interest as a sensor material due to its diverse properties as an antioxidant and catalyst.
- Cu is available in abundance and the formation of oxide layer is easier as compared to other metal oxides .
- In addition, Cu based compounds have good affinity towards OPs.

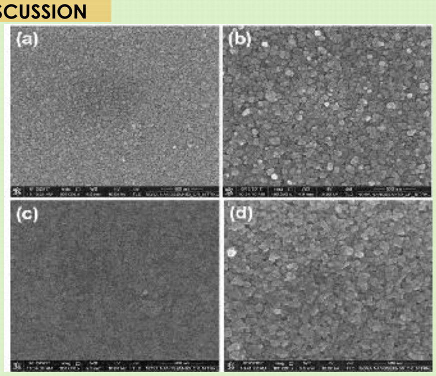
EXPERIMENTAL AND GROWTH PARAMETERS

Growth parameter of RF sputtered Cu thin film	
RF Power	50W
Pressure	4 x 10^{-3} mbar
Ar flow Rate	45 sccm
Deposition Rate	4.25 nm/min
Temperature	Room Temperature
Thermal Oxidation of Sputtered Cu Films	
Annealing Temperatures	200 °C, 400 °C, 600 °C and 800 °C
Annealing Time	1 hr
Heating Rate	5 ° C/min

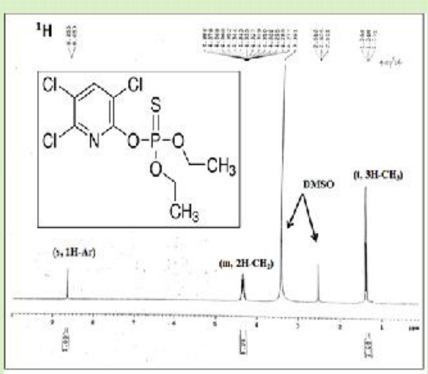
RESULTS AND DISCUSSION



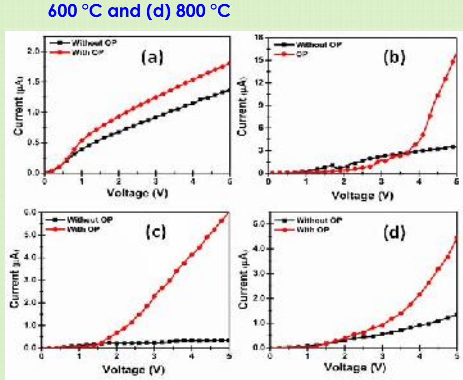
X-ray diffraction patterns of thermally oxidized Cu films in air ambient at various temperatures



FESEM micrographs of thermally oxidized Cu films in air ambient at (a) 200 °C, (b) 400 °C, (c) 600 °C and (d) 800 °C



Chemical structure and ^1H NMR spectra of Chlorpyrifos (Organophosphate)



I-V characteristics of copper oxide films in presence (red) and absence (black) of organophosphate for (a) 200 °C, (b) 400 °C, (c) 600 °C and (d) 800 °C

- XRD pattern shows a mixed phase of CuO and Cu_2O for oxidation temperature of 200 °C.
- FESEM micrographs have shown a uniform granular surface pattern for the oxidation temperature of 600 °C without any appearance of cracks.
- A considerable increase in current was observed for all the oxidized films in presence of OP pesticide, which is attributed to the superior number of free electrons present in CuO.
- Three prominent peaks were observed in ^1H NMR spectra, for two peaks due to the ethoxy carbons and one broad resonance intensity in the aromatic region.

CONCLUSION

- ✓ For higher oxidation temperature, the peak corresponding to Cu_2O disappeared and pure CuO phase attributed to the monoclinic structure of CuO was obtained.
- ✓ I-V study shows better sensing property for the film oxidized at 600 °C which indicates that low cost OP sensors can be fabricated by using CuO thin film.
- It would be useful as an alternative to enzyme-based inhibition sensors as well as a promising system for environmental monitoring.

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