CHAPTER - 5

STUDY OF Cu DOPED ZnO THIN FILM IN METHANE SENSING

5.1 Introduction

This chapter deals with the application of 8 % Cu doped ZnO ($Zn_{0.92}Cu_{0.08}O$) thin film in methane sensing. The testing of methane sensing in detection concentration range of 100 - 500 ppm between 75 ^{o}C - 200 ^{o}C was carried out along with selectivity with hydrogen.

5.2 Results and Discussion

Fig.5.1, show the $Zn_{0.92}Cu_{0.08}O$ thin film based sensor response for 500 ppm methane at 200 ^{o}C. In the graph, point A show to the gas inlet and point C show the outlet conditions. The resistance of the sensor decreases in the presence of methane from point A to B and is stable form point B to C and between point C to D, the sensor recovers to its original status in the absence of methane. Point A to B indicates the sensor response of the film for methane. The approximate response and recovery time were 90 sec, 190 sec respectively for 500 ppm methane at 200 ^{o}C.

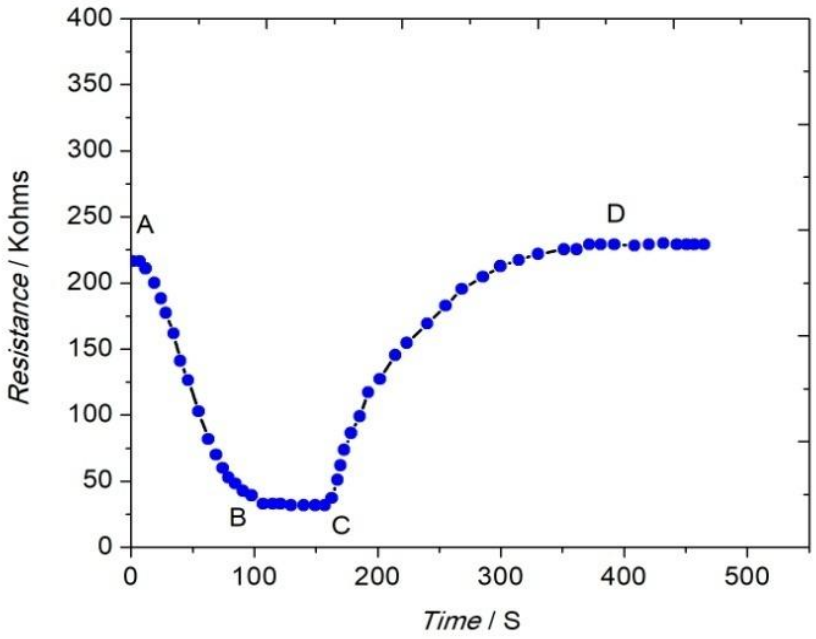

Fig.5.1. Sensor response of $Zn_{0.92}Cu_{0.08}O$ thin film with methane as target gas at 200 °C.

The response of the sensor was determined by using Equation (13) in chapter 1. Response in percentage at different operating temperatures, ranging from 75 ℃ to 200 ℃ with various concentrations of methane such as 100 ppm, 200 ppm, 300 ppm, 400 ppm and 500 ppm is shown in the Fig.5.2. In this graph shown to the response increasesed with increases in temperature and gas concentrations. Fig.5.3**,** shown to resultant value of response for 100 ppm, 200 ppm, 300 ppm, 400 ppm and 500 ppm methane at 75 °C, 100 °C, 125 °C, 150 °C, 175 °C, 200 °C operating temperatures. The lowest value was 7 % for 100 ppm at 75 °C and highest value was 88.63 % for 500 ppm at 200 °C. The response was better than both undoped ZnO flat thin film and nano-wrinkled $Zn_{0.92}Fe_{0.08}O$ based thin film sensors.

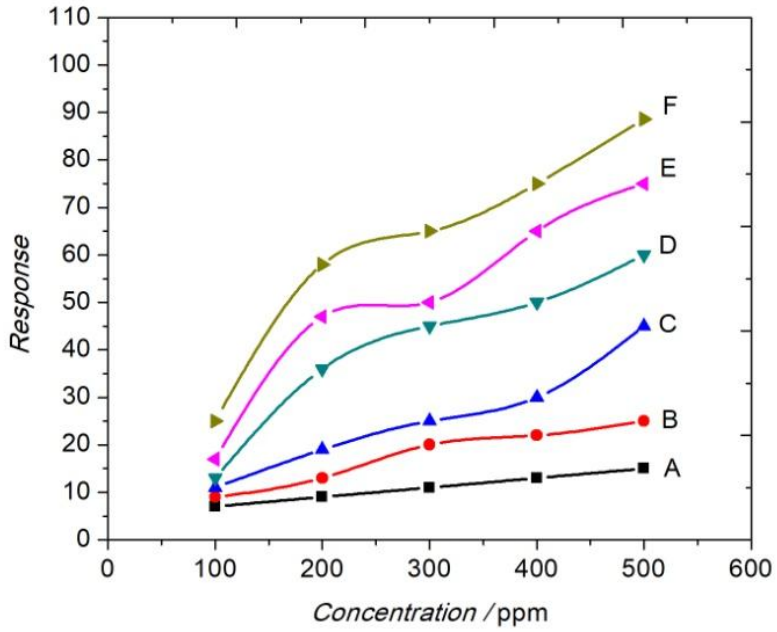

Fig.5.2. Response of the sensor on various concentrations and curve A, B, C, D, E, F as 75 °C, 100 °C, 125 °C, 150 °C, 175 °C, 200 °C respectively (Response versus Concentration).

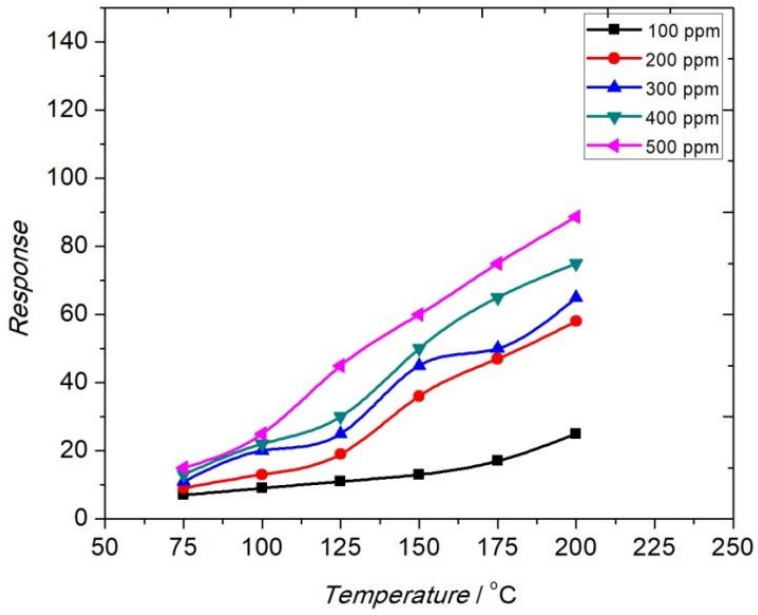

Fig.5.3. Response for 100 ppm, 200 ppm, 300 ppm, 400 ppm concentrations at 75 °C, 100 °C, 125 °C, 150 °C, 175 °C, 200 °C temperatures (Response versus Temperature).

Fig.5.4 and Fig.5.5 have shown the determined the response time of ZnO thin film for 100 ppm, 200 ppm, 300 ppm, 400 ppm, 500 ppm concentrations of methane at different operating temperatures ranging from 75 °C to 200 °C. The response time decreases with increasing concentrations at constant operating temperature. The response time decreases with increasing operating temperatures for same concentration. Resultantly, response time decreased in the combined effect of increasing of concentration and temperatures. Response time was 235 sec for 100 ppm at 75°C and 90 sec for 500 ppm at 200°C. Sensor response was quickest for 500 ppm methane at 200°C. The responses time is faster than undoped ZnO flat thin film and nano-wrinkled $Zn_{0.92}Fe_{0.08}O$ thin film for 100 - 500 ppm at ranges of 75 °C - 200 °C. In Fig. 5.4, graph A, B, C, D, E, F denoted as operating temperature at 75°C, 100°C, 125°C, 150°C, 175°C, 200°C respectively.

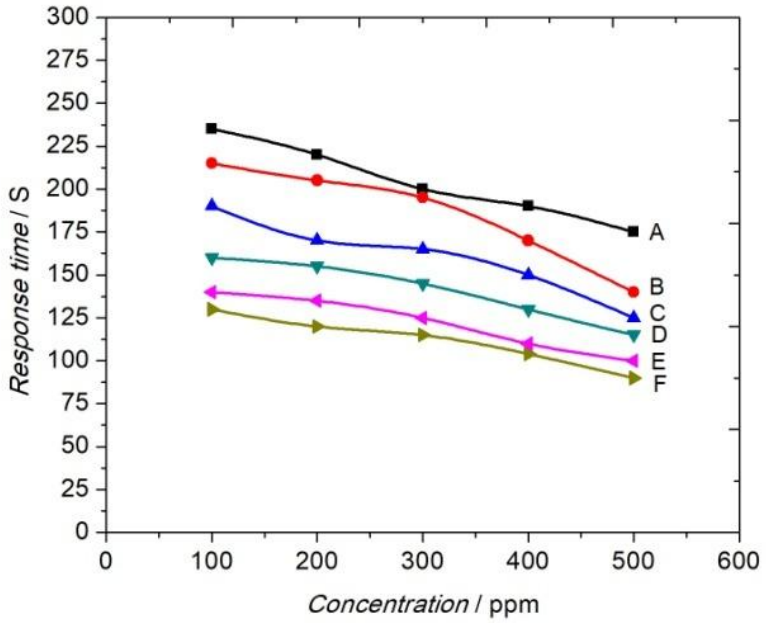

Fig.5.4. Show response time of $Zn_{0.92}Cu_{0.08}O$ thin film methane sensor for 100 to 500 ppm at operating temperatures 75 °C to 200 °C (Response time versus Concentration).

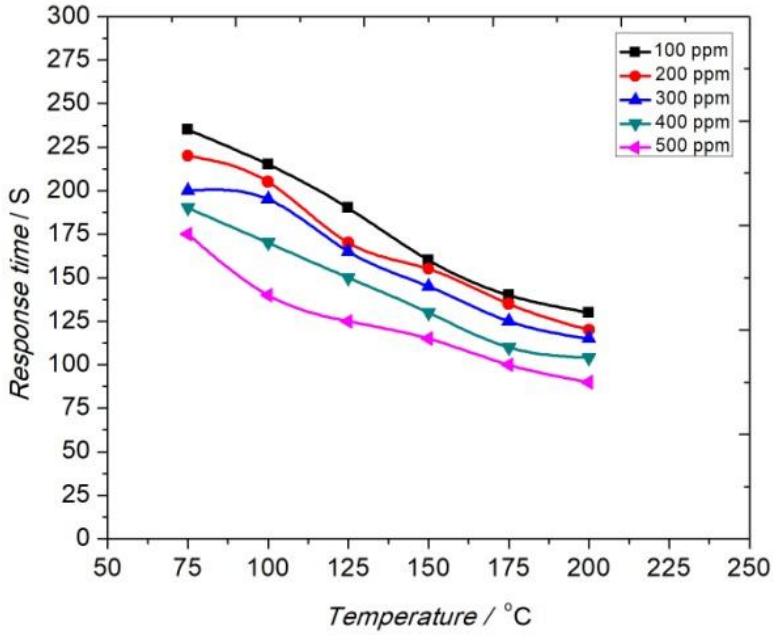

Fig.5.5. Show response time of $Zn_{0.92}Cu_{0.08}O$ thin film methane sensor for 100 to 500 ppm at operating temperatures 75 °C to 200 °C (Response time versus Temperatures).

Recovery time increased with increasing concentration at constant operating temperature, while decreased with increasing of operating temperature for same concentration. Resultantly, recovery time decreased with the combined effect of increasing of concentration and temperatures. Fig.5.6 and Fig.5.7 show the recovery time for 100 ppm, 200 ppm, 300 ppm, 400 ppm, 500 ppm methane at operating temperatures 75 °C, 100 °C, 125 °C, 150 °C, 175 °C and 200 °C. Recovery time was 170 sec for 100 ppm at 75°C and 190 sec for 500 ppm at 200 °C. This thin film based sensor is suitable up to 200 °C and response was higher than the Fe doped wrinkled based sensor. Desorption of gas molecules was started above 200 °C. In Fig.5.6, graph A, B, C, D, E, F denoted as operating temperature at 75°C, 100°C, 125°C, 150°C, 175°C, 200°C respectively.

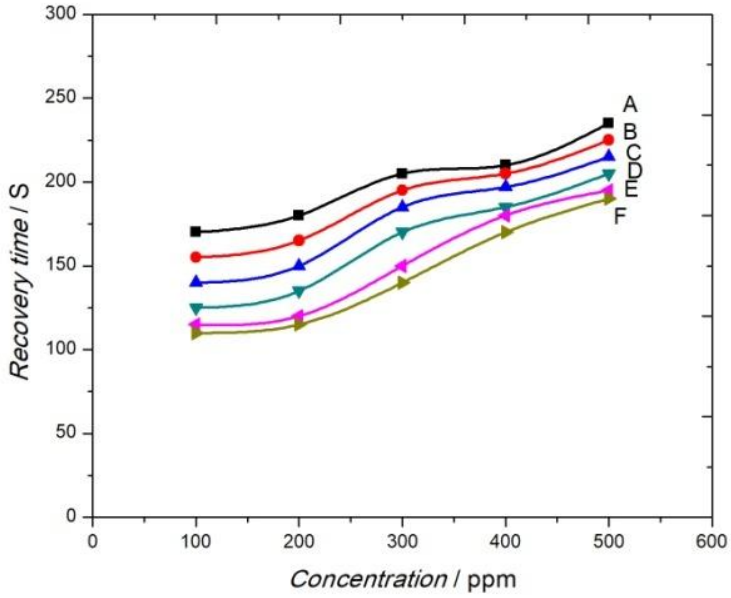

Fig.5.6. Show recovery time of $Zn_{0.92}Cu_{0.08}O$ thin film methane sensor for 100 to 500 ppm at operating temperatures 75 °C to 200 °C (Recovery time versus Concentration).

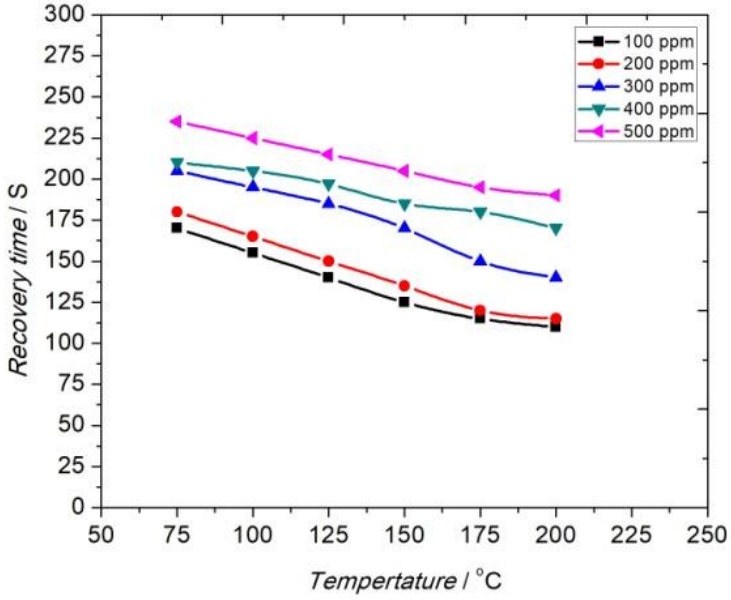

Fig.5.7. Show recovery time of $Zn_{0.92}Cu_{0.08}O$ thin film methane sensor for 100 to 500 ppm at operating temperatures 75 °C to 200 °C (Recovery time versus Temperature).

5.3 Selectivity

Cu doped nano crysatalline based thin film sensor showed is fast selectivity for 500 ppm concentration of methane at the operating temperature range of 150 °C to 200 °C. The selectivity response for H_2 and CH_4 shown in Fig.5.8. In this study, quickest response time was observed for 500 ppm of methane at 200 °C than Fe doped nano wrinkled based thin film sensor. High response was observed in the range of 75 °C to 150 ^{o}C for 500 ppm of H_2.

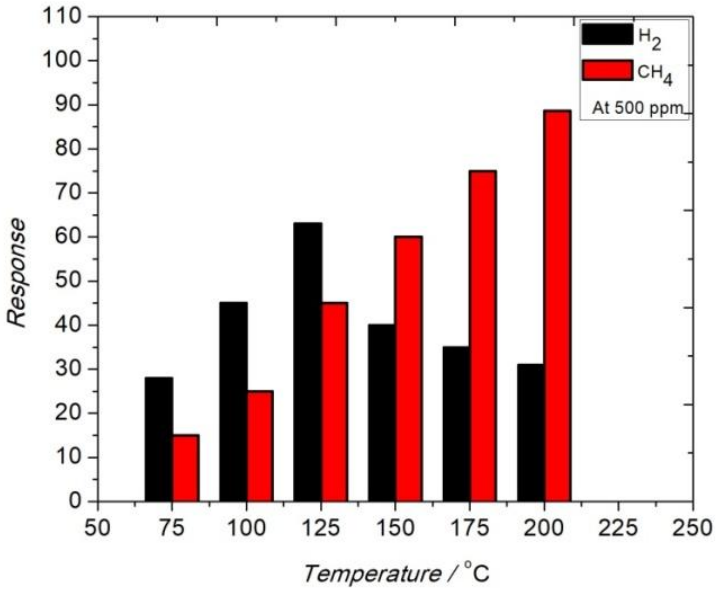

Fig.5.8. Selectivity response of $Zn_{0.92}Cu_{0.08}O$ thin film based sensor for methane and hydrogen for 500 ppm at the operating temperatures range of 75 ^{o}C to 200 ^{o}C.

5.4 Conclusion

Nano-crystallin film showed high sensitivity for 100 – 500 ppm concentration of methane at operating temperatures range of 75 °C - 200 °C. The response was highest (88.63 %) for 500 ppm at 200 °C. The selectivity was quickest with hydrogen for 500 ppm at 200 °C. This film was better than undoped zinc oxide flat thin film for methane sensing.