


UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110 002.

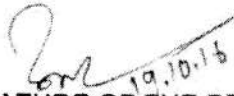
Annual/Final Report of the work done on the Major/Minor Research Project.
(Report to be submitted within 6 weeks after completion of each year)

1. Project report No. 1st/2nd/3rd/Final : Final
2. UGC Reference No: 37 - 564/2009 (SR) Dated: 23-12-2009
3. Period of report: From 01-02-2010 to Till Date
4. Title of research project: Fabrication and characterization of nano gas sensor
5. (a) Name of the Principal Investigator Dr. B. Mondal
(b) Deptt. and University/College where work has progressed: Department of Electronics and Communication Engineering, Tezpur University, Assam.
6. Effective date of starting of the project: 01-02-2010
7. Grant approved and expenditure incurred during the period of the report:
 - a. Total amount approved: Rs. 1,30,000.00 (Released One Lakh only)
 - b. Total expenditure: Rs. 90,489.00
 - c. Report of the work done: (Please attach a separate sheet)
 - i. Brief objective of the project: Separate Sheet attached
 - ii. Work done so far and results achieved and publications, if any, resulting from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication)
 - iii. Has the progress been according to original plan of work and towards achieving the objective. if not, state reasons
 - iv. Please indicate the difficulties, if any, experienced in implementing the project No
 - v. If project has not been completed, please indicate the approximate time by which it is likely to be completed. A summary of the work done for the period (Annual basis) may please be sent to the Commission on a separate sheet
Completed

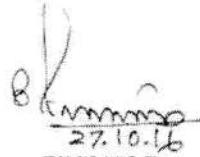

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vi. If the project has been completed, please enclose a summary of the findings of the study. Two bound copies of the final report of work done may also be sent to the Commission

vii. Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as (a) Manpower trained (b) Ph. D. awarded (c) Publication of results (d) other impact, if any N. A.



**SIGNATURE OF THE PRINCIPAL
INVESTIGATOR**



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OFFICER**
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Tezpur University*



REGISTRAR
*Registrar
Tezpur University*

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Report of the work done (Column 7 c. of Annexure-III)

i. Brief objective of the product:

Hydrocarbon like methane hazardous for mining or other underground activities and it is necessary to be detected below 5% level, which is the lowest explosive limit for methane. Hence, there is a great demand for methane sensor with very high sensitivity. The proposed aims at the development of nano structured ZnO using physical-chemical method its characterization and to study the sensing properties of the developed sample to methane (CH₄) and optimization of the sensing capacity of the same and modeling.

Metal Oxides are widely studied for sensing various toxic and inflammable gases. But the operating temperature of the material are very high, likely 300 °C or more, this restricts their use as a sensor for detection of inflammable gases. Nanocrystalline and porous materials with controlled composition are of increasing interest in gas sensing because of their large surface to volume ratio which enhances the reaction probability between the adsorbed oxygen and hydrocarbons and other reducing gases. ZnO is a promising material for gas sensor because of their chemical sensitivity to different adsorbed gases, high chemical stability, amenability to doping, non-toxicity, and low cost. Seeing the demand of methane sensor the proposed work concentrated on the study and development of nano-structured metal oxides and its characterization for sensing methane.

ii) Work done so far:

In this work methane (CH₄) gas sensing activity of zinc oxide (ZnO) nano-structure is studied. The sensing nanomaterial is synthesized on Si substrate through thermal annealing process. The structural and morphological aspects of the nanomaterial were analyzed by electron microscopy, x-ray diffraction and energy dispersive spectroscopy. The sensor response was studied for different concentration of methane gas (0.1% to 1%) at different operating temperatures ranging from 70°C to 200°C. The study reveals that the optimum operating temperature of the sensing film lies between 150°C and 200°C with a maximum sensitivity as high as 75%, indicating potential application of ZnO nanorods as sensing material for gas sensor.

Fabrication of Nanostructured Zinc Oxide:

The sensing nanomaterial is synthesized on Si substrate through thermal annealing process. Polyvinyl alcohol (PVA) was chosen as the supporting matrix for embedding ZnO nano-structures. Zinc acetate dihydrate [Zn(CH₃COO)₂.2H₂O] were added into aqueous solution of



PVA with continuous stirring followed by dropwise addition of NaOH solution under continuous stirring at 80°C for 1 h. The resulting precursor was spin casted onto the cleaned <100> oriented Si/SiO₂ substrate followed by annealing at 550 °C for ½ hour in a muffle furnace.

Results and discussion

The structural and morphological aspects of the nanomaterial were analyzed by electron microscopy, x-ray diffraction and energy dispersive spectroscopy. Figure 1 shows the scanning electron microscopy image of the ZnO nanostructured system grown on Si/SiO₂. The SEM micrograph shows the formation of nanostructures having a mean diameter of 150-200nm and length of about 1-3 μm. The fabricated ZnO nanorods are also characterized by X-ray diffraction (XRD) and Energy-dispersive X-ray spectroscopy (EDS or EDX) which confirms the growth of randomly oriented hexagonal wurtzite structured nanorods of Zinc Oxide

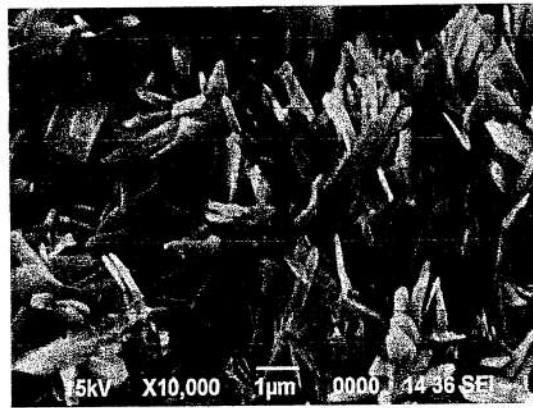


Figure 1: SEM image of the fabricated ZnO nanostructures

The experimental arrangement for studying the sensing nature of the developed sample is accomplished and the preliminary studies for calibrating the experimental set up like temperature uniformity within the sensing chamber etc. are performed. The experimental set-up is shown in figure below.



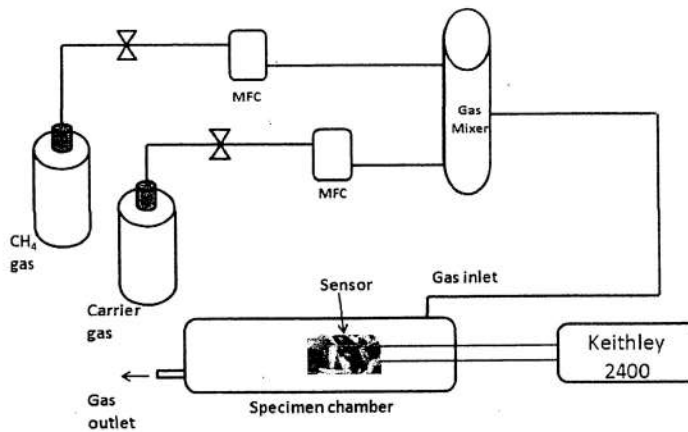


Figure 2: Schematic of the sensor setup.

Figure 3 shows the response of the fabricated sensor different concentration of methane at varied operating temperature .In general, the response has an increasing trend with increasing gas concentration.

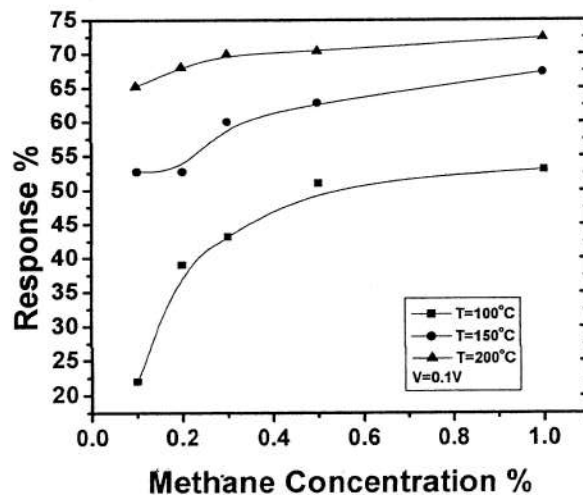


Figure 3: Response vs. sensing gas concentration for different temperatures

Conclusion: In this work Zinc Oxide based methane gas sensor fabricated by thermal annealing process. The structural and morphological aspects of the nanomaterial analyzed by electron microscopy, x-ray diffraction and energy dispersive spectroscopy shows the formation of hexagonal nanostructured ZnO with an average diameter of 150-200 nm and 1-3 μm long. Methane sensing characteristics of the nanostructured based sensor has been investigated at different operating temperature range between 70°C and 200°C.

Publication:

Handwritten signature and initials.

1. J.Dutta, S. Sarkar, B. Mondal, "Design Fabrication of Experimental Set up and methane gas sensing Behavior using Nanostructured ZnO Systems", Int. Journal of Nanotechnology and Applications, vol5, No 4(2011) pp501-506.

iii. The progress of the work is in accordance of the original work and towards achieving the objective.

iv. Please indicate the difficulties, if any, experienced in implementing the project _____ : NA

v. If project has not been completed, please indicate the approximate time by which it is likely to be completed. :

~~Another three month extension for the completion of sensing characteristics like response and recovery time, improved sensitivity etc is requested.~~

vi. If the project has been completed, please enclose a summary of the findings of the study. Two bound copies of the final report of work done may also be sent to the Commission

vii. Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as (a) Manpower trained (b) Ph. D. awarded (c) Publication of results (d) other impact, if any _____



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Annexure - IV

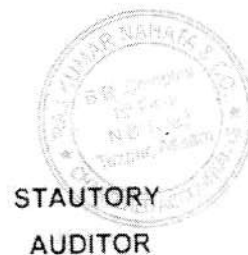
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Utilization certificate

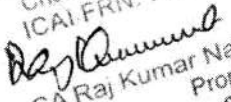
Certified that the grant of Rs. 1,00,000.00 (Rupees One Lakh only) received from the University Grants Commission under the scheme of support for Minor Research Project entitled Fabrication and characterization of nano gas sensor vide UGC letter No. F. 37 - 564/2009 (SR) dated 23-12-2009 and interest of Rs. 6099.00 (Rupees six thousand ninety nine only) earned. An amount of Rs. 90,489.00 (Rupees Ninety thousand four hundred eighty nine only) has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission. The unspent balance of Rs. 15,610.00 [Balance: Rs. 9511.00 & Interest: Rs.6099.00] is returned to UGC, Govt. of India, vide RTGS-no NEFT UTR No - SBIN516313600450 Dated 08/11/16


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For RAJ KUMAR NAHATA & CO.
Chartered Accountants
ICAI FRN. : 325770E

CA Raj Kumar Nahata
Proprietor
Mem No. : 097462

Annexure - V

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110 002


STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR/MINOR
RESEARCH PROJECT

1. Name of Principal Investigator: Dr. B. Mondal
2. Deptt. of University/College: Department of Electronics and Comm. Engg. Tezpur University
3. UGC approval No. and Date: 37 - 564/2009 (SR) dated 23-12-2009
4. Title of the Research Project: Fabrication and characterization of nano gas sensor
5. Effective date of starting the project: 01-02-2010
6. a. Period of Expenditure: From 01-02-2010 to till date
b. Details of Expenditure _____

S.No.	Item	Amount Approved Rs.	Expenditure Incurred Rs.
i	Books & Journals	--	--
ii	Equipment	70,000.00	62,520.00
iii	Contingency	10,000.00	9,122.00
iv	Field Work/Travel		
v	Hiring Services		
vi	Chemicals & Glassware	20,000.00	18,847.00
vii	Overhead		
viii	Any other items (Please specify)		
Total:		1,00,000.00	90,489.00

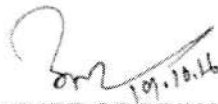
c. Staff

Date of Appointment N. A.

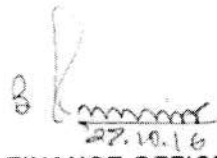

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1. It is certified that the appointment(s) have been made in accordance with the terms and conditions laid down by the Commission
2. It as a result of check or audit objective, some irregularly is noticed, later date, action will be taken to refund, adjust or regularize the objected amounts.
3. Payment @ revised rates shall be made with arrears on the availability of additional funds.
4. It is certified that the grant of Rs. 1,00,000.00 (Rupees one lakh only) received from the University Grants Commission under the scheme of support for Minor Research Project entitled Fabrication and characterization of nano.....gas sensor vide UGC letter No. F. 37 - 564/2009 (SR) dated 23-12-2009 and interest of Rs. 6099.00 earned. An amount of Rs. 90,489.00 has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission. The unspent balance of Rs. 15,610.00 [Balance amount: Rs. 9155.00 + Interest: Rs. 6099.00] returned to UGC, Govt. of India vide RTGS no. NEFT UTR No. SBIN516313600450 Dated 08/11/16.



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