

Summary of Findings of Research Projects under ISRO-UoP Programme

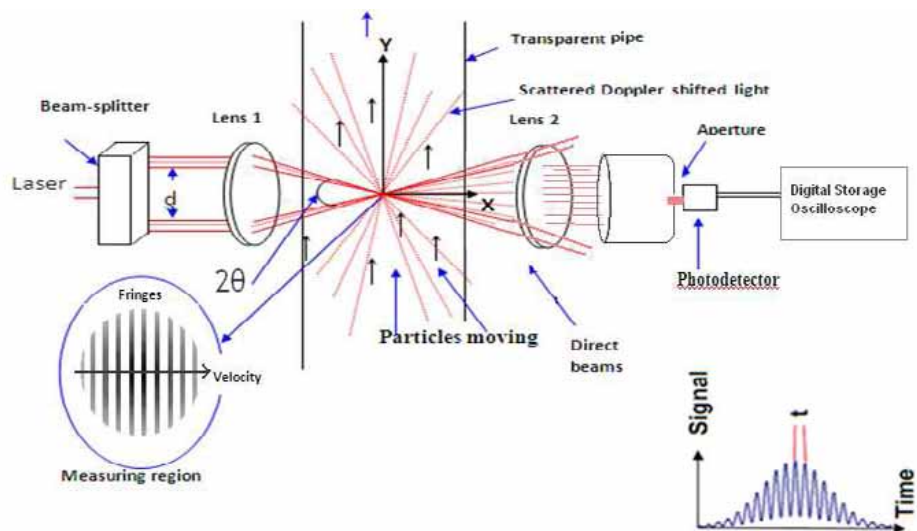
PROJECT NO	58
TITLE	Doppler shift flow meters for liquid and gases
INVESTIGATORS	Prof S A Gangal, Dept of Electronic Sciences & Mrs Pooja More, Dept of Instrumentation Science, UoP
DURATION	2 years (Started on: April 2005)
BUDGET (₹)	4,69,086
SUMMARY OF FINDINGS	<p>The title of the project indicates the development of flow meter for liquid but it actually deals with the measurement of two different parameters of a liquid, one is liquid level and second is liquid flow velocity. Development of the liquid level measurement equipment was partially done in the previous project. The same is taken to completion during this project period.</p>

Liquid Level Measurement

Water (liquid) level is the elevation of the free surface of a stream, lake or reservoir relative to a specified datum. A practical low cost dynamic and non-contact level measurement instrument is developed which provides high speed and high accuracy solution for distance and level measurement. It uses Time of Flight (TOF) principle of ultrasonic pulse, which is today's state of art technology. MA Series Transmitter (MA40S2S) and Receiver (MA40S2R) operating at nominal frequency of 40 KHz are used in this work. Transmitter and receiver circuits were designed and fabricated in-house using CMOS IC chips to reduce the cost of the system. These circuits were tested for their performance. Microcontroller Model No. 89V51RD2BN (Philips-NXP) is used for controlling the system. Software is developed for controlling the transmitter and receiver and for converting the measured time of flight in terms of level/distance in mm. The output is calibrated in mm and displayed on LCD display. The system has been used for distance in air and water level measurement.

Liquid Flow Velocity Measurement

Flow measurement is the quantification of bulk fluid movement. The Laser Doppler Velocity (LDV) measurement, the technique selected for execution for the present project, is of non-contact type and highly accurate technique. Following diagram shows the schematic of the basic components of a complete LDV system to measure flow in transparent pipe or one component of fluid velocity. The transmitting optics includes a beam splitter to split the original laser beam into two parallel beams and a lens to focus and cross the two beams at the center of the tube to form the interference pattern. In receiving optics the slit is used to mask the main beams and just to pass the scattered light through the slit. This scattered light is focused on the photo detector. Output of photo detector is given to DSO to get the Doppler Frequency Shift and by that the velocity of flow. LDV laboratory setup for getting the expected Doppler signal (Doppler burst) at the output to characterize the flow is successfully implemented. Feasibility is shown for the linear flow velocity measurement of water in the range from 0.536(cm/sec) to 5.738(cm/sec). Particle size of the scatters used is of the order of micrometer. Large number of experiments needs to be done using different diameters of tube, different sizes of scatters and taking the readings on data logger before claiming the accuracy of measurements.



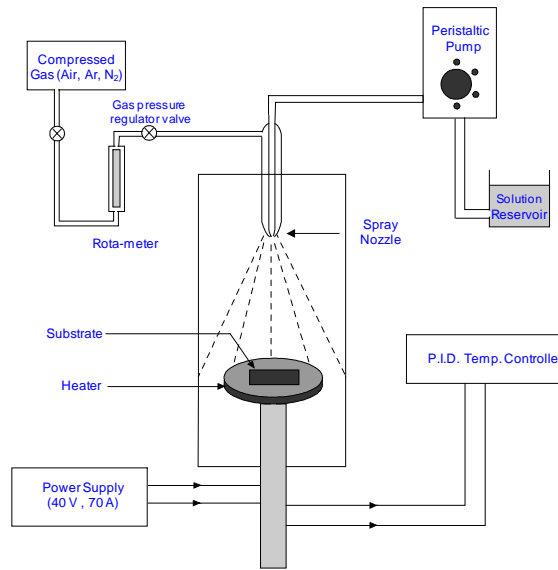
Schematic of principle of LDV

PROJECT NO	87
TITLE	Development and analysis of MOS device with embedded nanocrystals of silicon dioxide layer for enhancement in charge transfer rate
INVESTIGATORS	Prof SV Ghaisas, Dept of Electronic Sciences, UoP
DURATION	3 years (Started on: July 2007)
BUDGET (₹)	8,82,600
SUMMARY OF FINDINGS	<p>Starting from the deposition of a-Si:H by plasma-CVD method, the main goal of the present work is the optimization of the deposition parameters for nc-Si:H material. The development of MOS structure which will embed the Si nanocrystal in place of usual polysilicon has gained lot of attention. This technique is viewed as one of the future production techniques in evolving MOS structures using Nanotechnology. It is important that incorporation of nanocrystal should not involve major modification in the process lines during manufacturing stage. The present project aimed at establishing the incorporation of nanocrystal in MOS through compatible process. Thus the operations involving simple MOS structure, Plasma cleaning, tunnel oxide deposition, nanocrystals embedment, insulating oxide deposition etc are carried out in single chamber employing Radio frequency PECVD method. The basic deposition gases are silane (SiH₄), Hydrogen (H₂), and oxygen (O₂). SiO₂ films and Si quantum dots have been successfully synthesized by PECVD methods. Its capacitance – voltage measurements were investigated. The work is published in international journal.</p>



PE-CVD system used in the present study

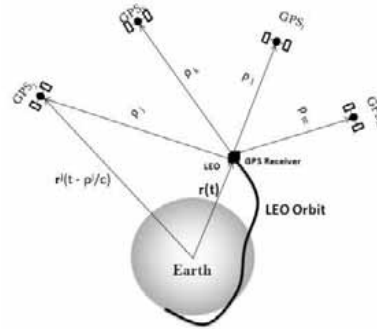
PROJECT NO	90
TITLE	Synthesis of ZnS thin film by modified Spray Pyrolysis method and study of its physical properties for optical sensor and solar cell applications
INVESTIGATORS	Prof R. V. Zavare (PI) and Mr S. A. Arote (Co-PI), Sangamner College, Sangamner - 422605
DURATION	3 years (Started on: July 2007)
BUDGET (₹)	7,00,000
SUMMARY OF FINDINGS	<p>Zinc sulphide (ZnS) has wide applications in the field of displays, sensors and photovoltaic devices. The study aimed at improving the conventional spray pyrolysis technique and optimizing the procedure for fabrication of quality nanostructure thin films. Improved system incorporates water cooled stainless steel chamber and has good controls over film processing parameters such as spray medium flow rate, liquid flow rate and substrate temperature. The films are deposited with spray medium (air) flow rate 10 lpm and liquid flow rate 40 ml/hr (peristaltic pump setting) on a glass substrate of size 2.25cm x 1cm x 1.5 mm. A stock solution 0.05 M/L is used for ZnS film deposition. Films are deposited for different Zn:S (precursor) ratio i.e. 1:1, 1:2, 1:3, 1:4, 1:5 and 1:6 at 450 °C. The average thickness of films is found to be 280nm. The films are adherent, dense, smooth and polycrystalline with preferred orientation (111) of cubic structure. Observed direct band gap energy and grain size of ZnS material is $E_g=3.634$ eV and $D=185\text{\AA}$ respectively for Zn:S ratio, 1:6. EDS spectrum shows that the atomic weight percent of trace element, Chlorine decreases and that of Sulphur increases with increasing precursor (Zn:S) ratio i.e 1:1 to 1:6. Atomic weight percent of trace element, Oxygen is negligible compared to that of Zinc and Sulphur. It is thus confirmed that there is no 'ZnO' formation during film deposition. The range of proper substrate temperature for ZnS film formation is 450 to 470 °C. Film thickness decreases with increasing substrate temperature.</p>



Schematic diagram of Modified Spray Pyrolysis (MSP) system

PROJECT NO	93
TITLE	Autonomous Navigation system for Low Earth Orbit (LEO) Satellite Using Global Navigation Satellite System (GNSS)
INVESTIGATORS	Prof S A Gangal, (PI) and Dr Suvarna Datar, (Co-PI), Dept of Electronics Science, UoP
DURATION	2 years (Started on: August 2007)
BUDGET (₹)	8,82,400
SUMMARY OF FINDINGS	Orbit determination technique of a spacecraft involves measurements of range and range rate based on ground tracking. To make the satellite orbit control system autonomous and to reduce the need for ground intervention, there should be continuous and accurate space borne knowledge of the satellite orbit. From this information, position and velocity vector of an orbiting LEO spacecraft can be determined as a function of time. The measurement principle in its simplest form is illustrated by the following figure, where P_j, P_k, P_l, P_m are the pseudoranges of the respective GPS satellites and $r(t)$ is the geocentric distance of LEO. Each GPS satellite sends its own positional information in the form of navigation data. The code measurements of at least four

GPS satellite observed at observation time t by the space borne GPS navigation sensor are used to determine geocentric position vector $\mathbf{r}(t)$ of the LEO's centre of mass.

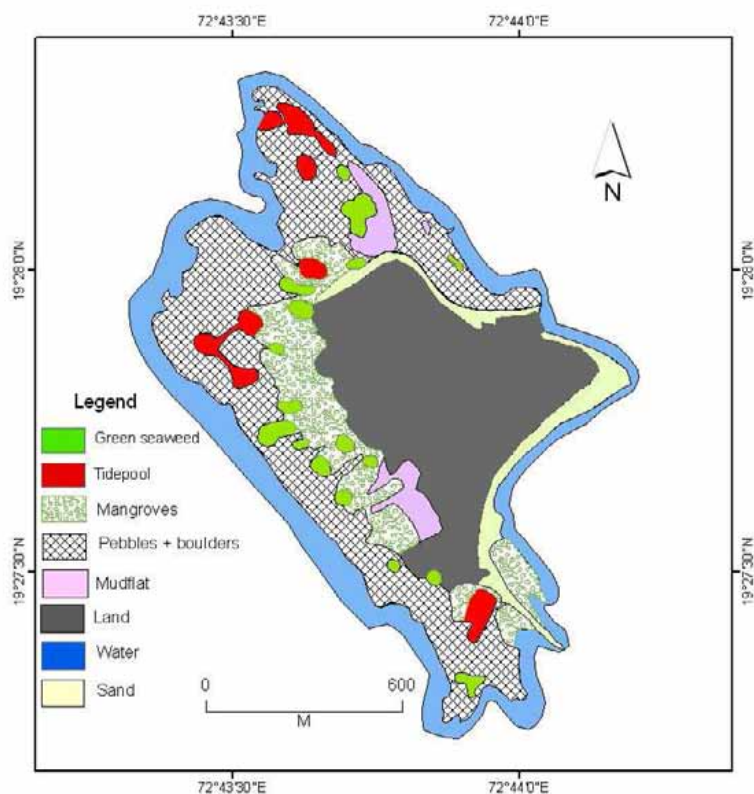


Concept of Autonomous Orbit determination

A simple but fairly accurate algorithm has been developed to determine the LEO satellite in its real time and with low computational burden. This is done by using raw navigation solution provided by GPS receiver. The satellite dynamic orbit model equation is used. A fixed step-size Runge-Kutta 4th order numerical integration method is selected for orbit propagation. Least square differential correction and Extended Kalman Filter (EKF) are used to generate the optimal state estimates of the satellite orbit. The discrete-time measurements include position and velocity vector obtained from Oceansat2 GPS navigation sensor. Software to generate reference trajectory is developed in MATLAB. The zonal perturbations j_2 , j_3 and j_4 are considered for simulations. From this study it is observed that j_2 is the main zonal parameter which affects the state vector significantly. Other parameters like j_3 and j_4 are effects for long term integration. Least squares differential correction algorithm is used to determine the orbit of a spacecraft from position and velocity measurements. Subroutine for the same is developed in MATLAB environment. It is found that the least square algorithm converges after seven iterations. The subroutine for orbit estimation is also developed in MATLAB environment using Extended Kalman Filter (EKF). It is found that in the case of EKF, the algorithm converges after three iterations. Hence, EKF algorithm satisfies the requirement of low computation load for autonomous orbit determination. It may be mentioned here that to start the EKF orbit determination algorithm, it is required to set the initial estimate. This is determined first by least square algorithm and then it is used in EKF orbit determination algorithm. EKF algorithm is found to be

fast and accurate compared to least square algorithm because of its recursive nature and this makes it suitable for implementation in autonomous orbit determination.

PROJECT NO	94
TITLE	Study of temporal and spatial distribution of seaweeds for their sustainable utilization using ground based and satellite borne systems
INVESTIGATORS	Prof. B.B. Chaugule, (PI), Dept of Botany, UoP and Dr. D.B. Jadhav, (Co-PI), IITM, Pune
DURATION	3 years (Started on: January 2008)
BUDGET (₹)	7,00,000
SUMMARY OF FINDINGS	<p>From India 1153 species of seaweed, spread over 271 genera, have been reported, out of which over 30 genera are commercially important. Efforts were made on mapping of seaweeds along the Indian coast using medium and merged high-resolution Indian satellite data. However, such attempts were restricted to seaweeds associated with corals. This is first ever-detailed study of the seaweeds using remote sensing techniques from India. This report details the spatial and temporal distribution and near accurate biomass of intertidal seaweed, using ground based seaweed survey methods and medium (LISS III) and high-resolution (L4MX) multispectral bands obtained from Indian satellite ((IRS P6) sensors. The study was carried out by selecting four sites along the coast of Maharashtra and Gujarat states. Ground information about seaweed diversity was collected through periodical visits to the study area starting from April 2008 to December 2010 and real time satellite images of the study area were procured from National Remote Sensing Centre (NRSC), Hyderabad. ERDAS IMAGINE 9.1 and ENVI 4.2 software were used for image processing and data analysis. Image classification technique appeared to be suitable for visualizing nature and extent of substratum and type of seaweed diversity in an intertidal region. Empirical equations have been proposed to estimate seaweed biomass at a given location.</p>



Map of Arnala Island (Maharashtra, India) based on IRP P6 L4MX data and showing diversity of substrata and vegetation.

PROJECT NO	97
TITLE	Synthesis of Undoped and Cd, Al, In, B doped nanostructures of ZnO by Intermittent Chemical Spray Pyrolysis for Optoelectronic and Gas Sensing Applications.
INVESTIGATORS	Dr. C. M. Mahajan, Associate Professor (Physics), Department of Engineering Sciences and Humanities, Vishwakarma Institute of Technology, Pune – 37.
DURATION	3 years (Started on: June 2008)
BUDGET (₹)	11,85,000

SUMMARY OF FINDINGS

Zinc oxide (ZnO) is wide bandgap ($E_g = 3.2$ eV), n type Transparent Conducting Oxide (TCO) with high chemical and mechanical stability. ZnO films are increasingly preferred in optoelectronics, Thin Film Solar Cell (TFSC) and gas sensor devices. Aim of the present study was to deposit device quality ZnO and Cd, Al, In and B doped nanostructured ZnO thin films for TCO and LPG sensor applications using chemical spray pyrolysis technique. During course of study, process parameters such as substrate temperature, solution flow rate, air flow rate, dopant concentration etc have been optimized. Analysis of structural, optical and electrical properties of ZnO films, in relation to deposition conditions, is discussed in the report. The films were then characterized for structural properties (crystal structure, orientation, surface morphology). XRD studies show that under optimized conditions all ZnO films are polycrystalline with most preferred orientation along [002] direction. SEM and AFM analysis shows formation of vertically aligned nanorods of undoped, Al, In and B doped films whereas pyramid like nanoflakes of Cd doped ZnO films. The shift in the absorption edge as a function of carrier concentration is explained on the basis of the Burstein-Moss model. Increase in conductivity by order of magnitude has been observed when ZnO films are doped with Cd, Al, In and B, mainly due to increase in carrier concentration and carrier mobility. The sheet resistance (R_s) and figure of merit (Φ_{TC}) were the optimized parameters to test the transparent conducting ability of ZnO films. The $R_s \setminus \Phi_{TC}$ values for ZnO:In, ZnO:Al, ZnO:B and ZnO:Cd films are $3.24 \Omega/\text{cm}^2 \setminus 16.6 \times 10^{-2} \Omega^{-1}$, $8.14 \Omega/\text{cm}^2 \setminus 6.53 \times 10^{-2} \Omega^{-1}$, $7.68 \Omega/\text{cm}^2 \setminus 6.03 \times 10^{-2} \Omega^{-1}$ and $23.5 \Omega/\text{cm}^2 \setminus 2.15 \times 10^{-2} \Omega^{-1}$ respectively. The results obtained in the present study show that ZnO:In, ZnO:Al and ZnO:B thin films have comparable electrical and optical properties and are potential contenders to ITO and FTO films.

Fully automatic and computerized Gas Sensor Unit was used to investigate the LPG sensing properties of deposited films. The change in electrical resistance of the deposited ZnO films for varying concentrations of LPG was measured. All ZnO films show either very poor or no sensitivity for LPG below 100°C even for high LPG concentrations (~ 4680 ppm). All ZnO based film exhibited best sensitivity at 200°C temperature for 2340 ppm LPG with maximum for ZnO:Al (31%) and for ZnO:In ($\sim 23\%$), ZnO:B (18%), ZnO:Cd (17%) and of undoped ZnO was (15%).

PROJECT NO 99

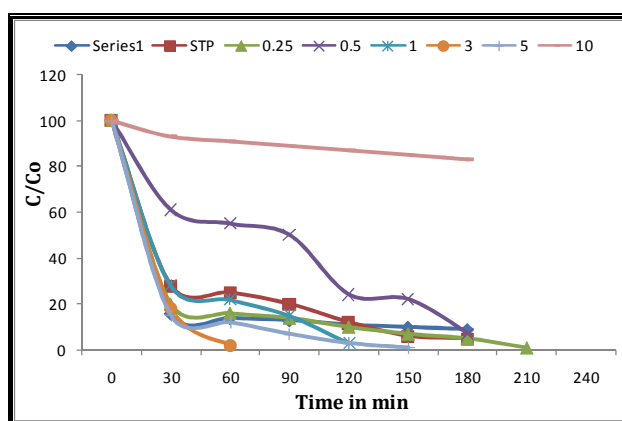
TITLE Studies on preparation and photocatalytic applications of nanocrystalline TiO₂ and its nanocomposites

INVESTIGATORS Dr (Mrs) S.S.Joshi, Dept of Chemistry, UoP

DURATION 3 years (Started on: June 2008)

BUDGET (₹) 11,66,275

SUMMARY OF FINDINGS TiO₂ is considered as a promising agent for photocatalytic destruction of organic pollutants because it is stable, inexpensive and nontoxic. But it is active only in the UV range. Zinc ferrite is useful solar energy material for photoelectric conversion. In the present study an attempt has been made to couple Zinc ferrite with TiO₂ and to investigate its potential for use as a visible light activated photocatalyst. Properties of pure ZnFe₂O₄, pure and modified TiO₂ synthesized by different methodologies have been determined. Crystal structure, particle size, particle interaction, optical characteristics and photoactivity of TiO₂-ZnFe₂O₄ nanocomposites are studied in detail. Characterization of TiO₂, ZnFe₂O₄ and alloys has been done using UV-DRS, XRD, FTIR, SEM, UV-Vis spectroscopy and photodegradation procedures. The photoactivity has been studied through methylene blue degradation experiments. ZnFe₂O₄ alone is not found to be an effective photocatalyst but its composite with TiO₂ in nanosize has shown enhanced efficiency in photodegradation of organic compounds. Addition of low percentage of ZnFe₂O₄ in TiO₂ shows more effective degradation.



Visible Light MB Degradation Rates for TiO₂-(X%)ZnFe₂O₄ at various percentages of Zinc Ferrite

PROJECT NO	100
TITLE	Development and characterization of thin film solid electrolyte cells as voltage source, temperature, pressure and gas sensor
INVESTIGATORS	Dr SB Iyyer, B.P.H.E Society's Ahmednagar College, Ahmednagar
DURATION	3 years (Started on: August 2008)
BUDGET (₹)	10,10,000
SUMMARY OF FINDINGS	Aim of the study is to deposit thin films of CdS, both sandwich and planer structured cells (Al-CdS-Ag) and carry out the following observations.

- a. Measurement of open circuit voltage and finding shelf life
- b. Discharge characteristics for various loads at various temperatures (to study polarization effect)
- c. I-V characteristics at various temperatures to separate out ionic and electronic conductivities of solid electrolyte and to find activation energy
- d. Variation of cell voltage with temperature for temperature sensor study
- e. Variation of cell voltage with ambient pressure
- f. Variation of cell voltage with gas (gas sensor)

It is found that when thin films of CdS are sandwiched between the two electrodes Silver (Ag) and Aluminum (Al), the cell generates a voltage in the range 400-800 mV with short circuit current of 100 nA. The internal resistance for the sandwich structure is found to be of the order of 10^6 ohm where as internal resistance for planner cells is of the order of 10^9 ohm. The cell has shelf life of about 2-3 months. This short life may be due to the electronic conductivity of CdS. Hence it is believed that even in open circuit, the cell reaction continues, reducing the life of the cell. The discharge characteristics for three different loads ($10\text{ M}\Omega$, $5\text{ M}\Omega$ and $1\text{M}\Omega$) were studied for 1 hour.

The short circuit current was initially of the order of 100 nA and falls to 10 nA with in 2-3 minutes and there after remains constant. It was observed that cell regains its voltage on the removal of the load after 2-3

hrs. The cell voltage increases with temperature almost linearly with coefficient of 6-8 mV/⁰C. This leads to the possibility of using the configuration as temperature sensor. Thin film of Al/CdS/Al sandwich structure shows capacitance value in the range of 15 to 30 nf. The structure shows variation of capacitance with temperature. Hence such structure finds application as capacitive type temperature transducer. To observe the effect of incident light on the cell voltage, planner cells were used. It was observed that the cell voltage decreases with increase in intensity of light. Hence it can be used as light sensor. Similar experiments were carried out for Ag/PbS/Al cell structure. The cell voltage decreases under vacuum conditions. The results suggest that some air constituents play a role in voltage generation. On further investigation, it was observed that in the presence of O₂ gas, there is enhancement in cell voltage. These studies indicate the possibility of Al-CdS-Ag sandwich structure, finding applications as voltage source, active temperature-pressure transducer and O₂ gas sensor.

PROJECT NO	101
TITLE	Photographic observations of Meteor showers
INVESTIGATORS	Dr (Mrs) RV Dabhade, FC College, Pune
DURATION	2 years (Started on: July 2008)
BUDGET (₹)	5,00,000
SUMMARY OF FINDINGS	Objective of the project is to record major meteor showers using photographic technique. Canon 10-22 USM wide angle lens was used for observations. Meteor photographs of both faint and fireball events have been successfully obtained. As only meteor image was captured and no chopper was used, the velocity determination could not be done. Observations of Geminides were made in December 2010. Computed average population index comes to 1.7 which corresponds to the fact that an appreciable number of bright meteors with a number of fire balls are found throughout the shower. Apart from ZHR, masses of Geminides and Lenoids have been calculated. Geminide activity as a function of

magnitude has also been studied.



Faint trail of Geminides captured at dawn – top left- note the trail of an Airplane has also been captured – bottom centre

PROJECT NO 103

TITLE Developing an environmental magnetic model for assessment of the Anthropogenic Particulate loading in the urban environments : A case study from the Pune Metropolitan region, Maharashtra

INVESTIGATORS Dr Dr SJ Sangode, Department of Geology, University of Pune
Dr Dr D M Chate, IITM, Pune
Dr Dr D C Meshram, Department of Geology, University of Pune

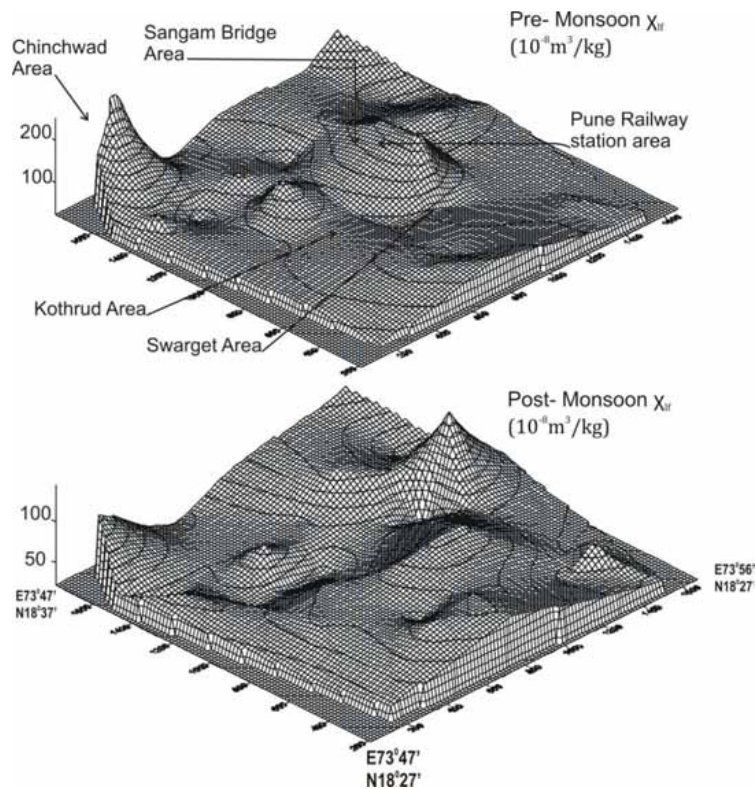
DURATION 3 years (Started on: August 2008)

BUDGET (₹) 14,49,306

SUMMARY OF FINDINGS

The study finds that the most effective redistribution and concentration of particulate matters over top soils in urban areas in India occur during the monsoon season. This redistribution is greatly controlled by the ground morphological factors (slope being the most important) for rainwater circulation seconded by wind circulation. The polluting sources i.e. industry, traffic and railway/bus stations show higher concentration during the pre-monsoon and the scenario is changed by redistribution of anthropogenically loaded soils during post monsoon.

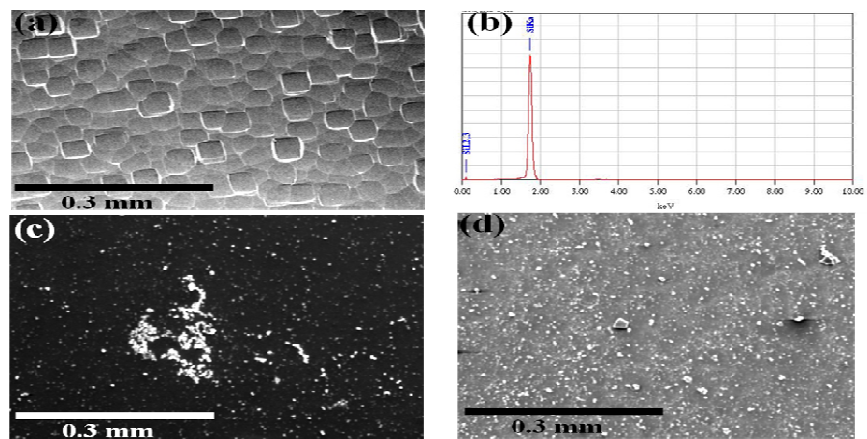
The study carried out in the Pune Metropolitan Region (PMR) demonstrates the utility of the rock magnetism as rapid method to map the anthropogenic loading, its redistribution and seasonal dumping. The bedrock and soil composition in the PMR is mainly of ferrimagnetic nature and their concentration and grain size in the top soils is governed by the anthropogenic loading and its redistribution. Surface water run-off during monsoon precipitation controlled by relief is the chief mechanism of the redistribution of the top soils and sediments loaded with anthropogenic particulate matters. Prevailing winds during summer and monsoon seasons appears to be another efficient agent for large scale dispersal of the finer ferrimagnetic particles (<0.06 μm). We attempted to find the areas of seasonal dumping and are further studying the sediment archives to depict the historical inputs to these sites to study the residence effect of heavy metal loading.



Pre- and post monsoon variation in the susceptibility of top soils in the PMR region

PROPOSAL NO	114
TITLE	Study of Si quantum dots for solar cell applications
INVESTIGATORS	Prof. Shailaja Mahamuni, Dept of Physics, UoP Prof S V Ghaisas, department of Electronic Sciences, UoP
DURATION	1 year (Started on: June 2010)
BUDGET (₹)	3,93,200
SUMMARY OF FINDINGS	The project aims at (a) development of preparation methods for Si nanoparticles (NPs) with distinct optical behavior and (b) to explore use of Si NPs in solar cell applications. Films of Si NPs were spin cast on silicon solar cells (procured from the market) at room temperature. The analysis showed 9.4 % increase in Si solar cell efficiency due to the

surface passivation effect offered by Si NPs. In this work, Si NPs are prepared by pulverizing electrochemically formed porous Si layer and passivated with hydrogen and 1-heptene molecules. Investigations to understand the underlying phenomena indicate the reduction in surface recombination. Reflectivity of O-capped Si nanoparticle film is observed to change as a function of temperature. Water adsorption on Si NPs passivated with oxygen is found to be responsible for such a distinct optical behavior. The optical absorption of Si NPs below $1\ \mu\text{m}$ is observable. Temperature dependent change in surface opacity of Si NPs film is observed within a range of 30 to $100\ ^\circ\text{C}$. The change in surface opacity due to water adsorption and desorption with temperature is repeatable.



SEM images of (a) bare Si solar cell, (b) EDAX of bare Si solar cell. SEM image of (c) H-Si and (d) Hep-Si NPs coated over the solar cell. SEM images are taken on the same scale of 0.3 mm