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**ISRO-UoP  
Space Technology Cell**

**University of Pune**



**ANNUAL REPORT  
2011-12**

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## 1. Introduction

Primary objective of the Indian Space programme is to harness the advanced research areas of space science and technology for national development and to derive the maximum benefit for the people of India. The Space Programme includes elements like applications in space communications, long distance education, earth resources survey, meteorology, geodesy, development of orbiting satellites, sounding rockets and satellite launch vehicles. ISRO intends to establish strong links with academic Institutions to carryout quality research and developmental projects which are of relevance to Space and derive useful outputs of such R&D to support its programmes. University of Pune, has excellent academic achievements and expertise for conducting advanced studies in the field of Science and Technology and ISRO, which is engaged in the execution of space projects of national importance, is interested in generating basic knowledge through advanced academic research in support of its activities. It was therefore considered of mutual advantage to formulate and to conduct Joint Research Programme (JRP), between ISRO and UoP. A Memorandum of Understanding (MoU), initiating Joint Research Programme (JRP), was signed between Chairman ISRO and Vice Chancellor University of Pune on 21 January 1998. To begin with, the Joint Research Programme focused on research areas comprising (i) Origin of life (ii) Space Radiation (iii) Wind measurements & modeling (iv) Optical coatings & sensors and (v) Rural development & developmental communication. The co-operation between the two organizations had been found beneficial and as a result, while renewing the MoU on 24 February 2006, these areas were enlarged by identifying six new disciplines. Additional areas where more emphasis could be laid on are (i) Geo-informatics (ii) Remote sensing applications (iii) Material Sciences (iv) Biodiversity (v) Instrumentation and (vi) Image processing. JRP programme is believed to enhance academic base, generate quality human resources and infrastructure at the academic Institution to support the space programme.

## 2. Management of Joint Research Programme

Under ISRO-UoP Joint Research Programme, emphasis has been on promoting research and applications in Space Science and Technology that compliments space agencies efforts and in promoting human resource development and training in Space Science and Technology. The Joint Policy Committee (JPC) governs all the activities carried out under this Programme. Presently this body consists of 9 members nominated by Vice Chancellor, University of Pune and 7 members nominated by Chairman, ISRO with Vice Chancellor, University of Pune as ex-officio Chairman.

### Composition of Joint Policy Committee (JPC)

Vice Chancellor, UoP	Chairman
Associate Director, SDSC/ISRO	Member
Director, LEOS/ISRO	Member
Deputy Director, PCM, VSSC/ISRO	Member
Director, DECU/ISRO	Member
Group Director, ESAG, NRSC/ISRO	Member
Deputy Director, LVPO, ISRO HQs	Member
Deputy Director, RESPOND, ISRO HQs	Member
Prof S Ananthkrishnan, Raja Ramanna Fellowship, UoP	Member
Shri P P Kale, Director, VLSI, UoP	Member
Director BCUD, UoP	Member
Head, Dept of Chemistry, UoP	Member
Head, Dept of Atmospheric and Space Sciences, UoP	Member
Head, Dept of Physics, UoP	Member
Director, College of Engineering, Pune	Member
Finance & Accounts Officer, UoP	Member
Shri M C Uttam, ISRO-UoP STC	Member Secretary

JPC supervises the overall management of the Interaction Programme, recommends the funds requirement for the approved and the planned programmes to ISRO HQs and suggests new areas of activities as and when necessary.

**Preliminary Evaluation Committee (PEC)**

The Joint Research Programme is co-ordinated and assisted by Preliminary Evaluation Committee (PEC). This Committee carries out preliminary evaluation of new research proposals received under ISRO-UoP Joint Research Programme in University of Pune and interacts with the Investigators for effecting any changes in their proposals. The proposals recommended by the Committee are examined by the Joint Policy Committee for final approval. PEC also reviews the progress of the ongoing projects on a regular basis. Composition of the PEC is as follows:

Dr S Ananthkrishnan (Adjunct Professor & Raja Ramanna Fellow)	Chairman
Shri PP Kale	Member
Dr PB Vidyasagar	Member
Dr (Mrs) Deepti Deobagkar	Member
Prof Madhurima Dikshit	Member
Director BCUD	Member
Finance & Accounts Officer, UoP	Member
MC Uttam	Member Secretary

### 3. Completed Research Projects

Under ISRO-UoP Joint Research Programme, a total of 125 research projects have been undertaken by the various departments of the University and its affiliated colleges. As of now, 104 of these projects are completed and final technical reports submitted by the Investigators. In order to bring the results of the study to the notice of ISRO Scientists/Engineers, brief details along with summary of findings of the completed research projects are published from time to time. Full technical reports of the completed projects are sent to various libraries of ISRO Centres. Summary of findings of the completed projects were first published in **Research Project Compendium 2006-07** giving the details of the projects completed till 2006-07. For the projects completed after this publication, the information is available in **Annual Reports 2007-08, 2008-09, 2009-10 and 2010-11** of ISRO-UoP Space Technology Cell, University of Pune. During the year 2011-12, eleven projects, listed below, have been completed and summary of findings of these projects is given in the subsequent paragraphs.

1. Doppler shift flow meters for liquid & gases (project no.58)
2. Development and analysis of MOS device with embedded nanocrystals of silicon dioxide layer for enhancement in charge transfer rate (project no.87)
3. Synthesis of ZnS thin film by modified Spray Pyrolysis method and study of its physical properties for optical sensor and solar cell applications (project no.90)
4. Autonomous navigation system for Low Earth Orbit (LEO) satellite using Global Navigation Satellite System (GNSS) (project no.93)
5. Study of temporal and spatial distribution of seaweeds for their sustainable utilization using ground based and satellite borne systems (project no.94)
6. Synthesis of undoped and Cd, Al, In, B doped nanostructures of ZnO by intermittent chemical spray pyrolysis for optoelectronic and gas sensing applications (project no.97)
7. Studies on preparation and photocatalytic applications of nanocrystalline TiO<sub>2</sub> and its nanocomposites (project no.99)
8. Development and characterization of thin film solid electrolyte cells as voltage source, temperature, pressure and gas sensor (project no.100)
9. Photographic observations of meteor showers (project no.101)
10. 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 (project no.103)
11. Study of Si quantum dots for solar cell applications (project no.114)



<b>PROJECT NO</b>	58
<b>TITLE</b>	Doppler shift flow meters for liquid and gases
<b>INVESTIGATORS</b>	Prof S A Gangal, Dept of Electronic Sciences & Mrs Pooja More, Dept of Instrumentation Science, UoP
<b>DURATION</b>	2 years (Started on: April 2005)
<b>BUDGET (₹)</b>	4,69,086

### **SUMMARY OF FINDINGS**

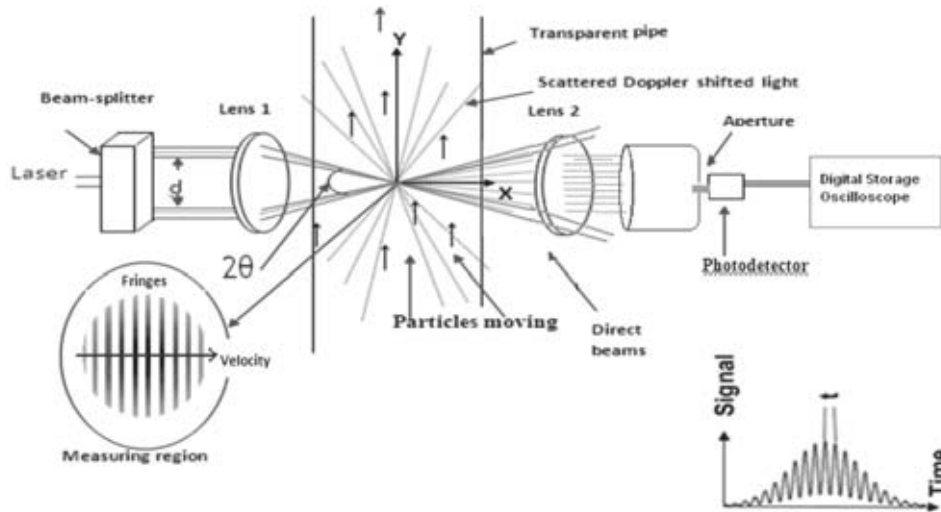
The title of the project indicates the development of flow meter for liquid but it actually deals with the measurement of two different parameters of a liquid, one is liquid level and second is liquid flow velocity. Development of the liquid level measurement equipment was partially done in the previous project. The same is taken to completion during this project period.

#### **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**

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 ( $\text{SiH}_4$ ), Hydrogen ( $\text{H}_2$ ), and oxygen ( $\text{O}_2$ ).  $\text{SiO}_2$  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.



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

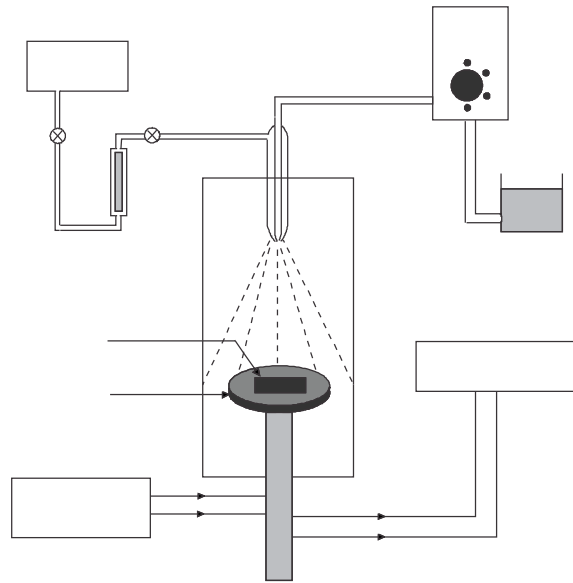
**DURATION** 3 years (Started on: July 2007)

**BUDGET (₹)** 7,00,000

**SUMMARY OF FINDINGS**

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 1 cm 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

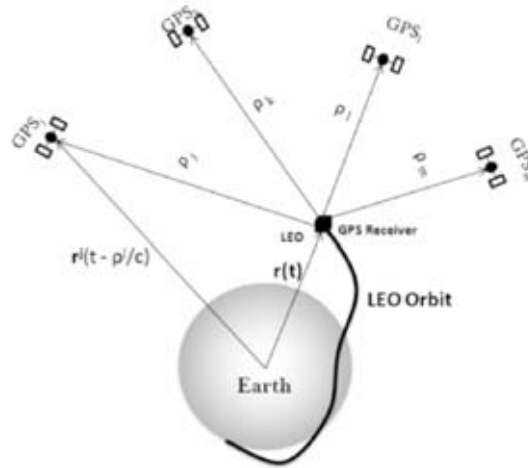
(111) of cubic structure. Observed direct band gap energy and grain size of ZnS material is  $E_g=3.634$  eV and  $D=185\text{\AA}$  respectively for Zn:S ratio of 1:6. EDS spectrum shows that the atomic weight percent of trace element, Chlorine decreases and that of Sulphur increases with increasing 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.



Schematic diagram of Modified Spray Pyrolysis (MSP) system

<b>PROJECT NO</b>	93
<b>TITLE</b>	Autonomous navigation system for Low Earth Orbit (LEO) satellite using Global Navigation Satellite System (GNSS)
<b>INVESTIGATORS</b>	Prof S A Gangal (PI) and Dr Suwarna Datar (Co-PI), Dept of Electronics Science, UoP
<b>DURATION</b>	2 years (Started on: August 2007)
<b>BUDGET (₹)</b>	8,82,400
<b>SUMMARY OF FINDINGS</b>	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  $\rho_j, \rho_k, \rho_l, \rho_m$  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  $r(t)$  of the LEO's centre of mass.



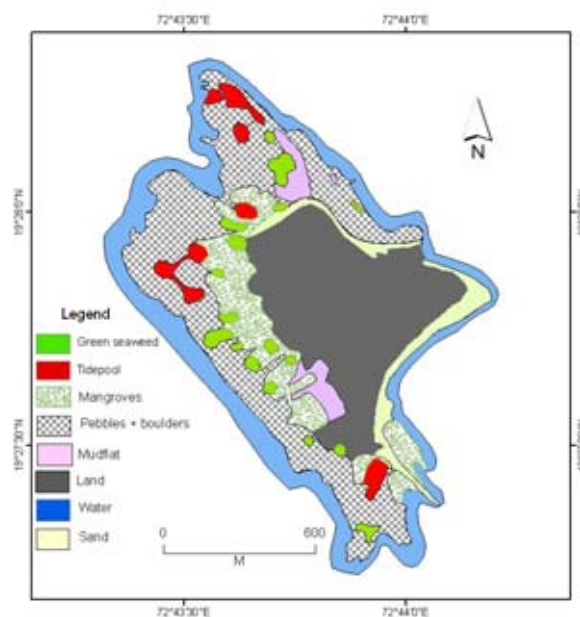
Concept of Autonomous Orbit determination

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.

<b>PROJECT NO</b>	94
<b>TITLE</b>	Study of temporal and spatial distribution of seaweeds for their sustainable utilization using ground based and satellite borne systems
<b>INVESTIGATORS</b>	Prof. B.B. Chaugule (PI), Dept of Botany, UoP & Dr. D.B. Jadhav (Co-PI), IITM, Pune
<b>DURATION</b>	3 years (Started on: January 2008)
<b>BUDGET (₹)</b>	7,00,000

### SUMMARY OF FINDINGS

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 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.



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

<b>PROJECT NO</b>	97
<b>TITLE</b>	Synthesis of undoped and Cd, Al, In, B doped nanostructures of ZnO by intermittent chemical spray pyrolysis for optoelectronic and gas sensing applications
<b>INVESTIGATORS</b>	Dr. C. M. Mahajan, Associate Professor (Physics), Department of Engineering Sciences and Humanities, Vishwakarma Institute of Technology, Pune
<b>DURATION</b>	3 years (Started on: June 2008)
<b>BUDGET (₹)</b>	11,85,000

**SUMMARY OF FINDINGS**

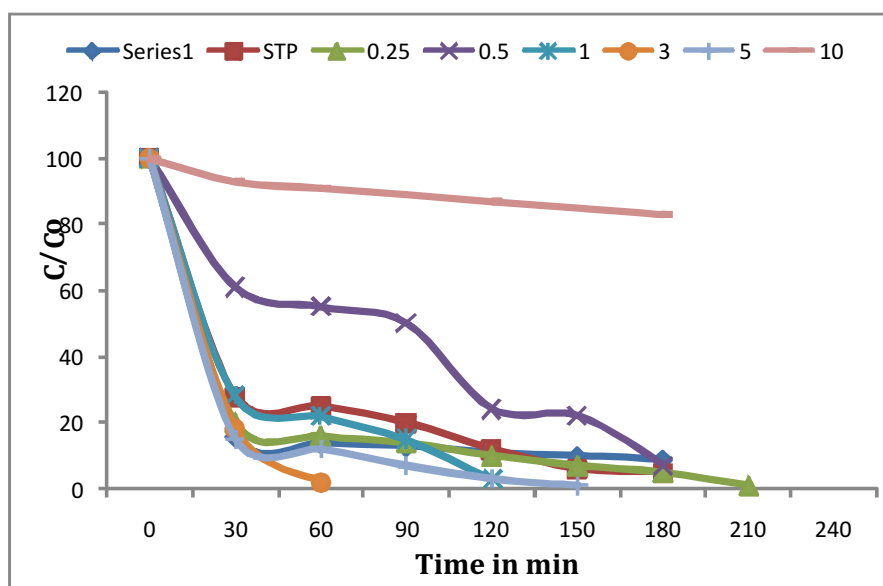
Zinc oxide (ZnO) is wide band gap ( $E_g = 3.2$  eV), n type transparent conducting oxide (TCO) with high chemical and mechanical stability. ZnO films are increasingly preferred in optoelectronics, thin film solar cell (TFSC) and gas sensor devices. Aim of the present study was to deposit device quality 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 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 ( $\Phi_{TC}$ ) 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. ZnO films show either very poor or no sensitivity for LPG below  $100^\circ\text{C}$  but exhibited best sensitivity at  $200^\circ\text{C}$  temperature for 2340 ppm LPG.

<b>PROJECT NO</b>	99
<b>TITLE</b>	Studies on preparation and photocatalytic applications of nanocrystalline TiO <sub>2</sub> and its nanocomposites
<b>INVESTIGATORS</b>	Dr (Mrs) S.S.Joshi, Dept of Chemistry, UoP
<b>DURATION</b>	3 years (Started on: June 2008)
<b>BUDGET (₹)</b>	11,66,275

### SUMMARY OF FINDINGS

TiO<sub>2</sub> 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 TiO<sub>2</sub> and to investigate its potential for use as a visible light activated photocatalyst. Properties of pure ZnFe<sub>2</sub>O<sub>4</sub>, pure and modified TiO<sub>2</sub> synthesized by different methodologies have been determined. Crystal structure, particle size, particle interaction, optical characteristics and photoactivity of TiO<sub>2</sub>-ZnFe<sub>2</sub>O<sub>4</sub> nanocomposites have been studied. Characterization of TiO<sub>2</sub>, ZnFe<sub>2</sub>O<sub>4</sub> 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. ZnFe<sub>2</sub>O<sub>4</sub> alone is found to be not an effective photocatalyst but its composite with TiO<sub>2</sub> in nanosize has shown enhanced efficiency in photodegradation of organic compounds. Addition of low percentage of ZnFe<sub>2</sub>O<sub>4</sub> in TiO<sub>2</sub> shows more effective degradation..



Visible Light MB Degradation Rates for TiO<sub>2</sub>-(X%)ZnFe<sub>2</sub>O<sub>4</sub> at various percentages of Zinc Ferrite



<b>PROJECT NO</b>	100
<b>TITLE</b>	Development and characterization of thin film solid electrolyte cells as voltage source, temperature, pressure and gas sensor
<b>INVESTIGATORS</b>	Dr SB Iyyer, B.P.H.E Society's Ahmednagar College, Ahmednagar
<b>DURATION</b>	3 years (Started on: August 2008)
<b>BUDGET (₹)</b>	10,10,000

#### **SUMMARY OF FINDINGS**

Aim is to deposit thin films of CdS, both sandwich and planer structured cells (Al-CdS-Ag) and study the following:

- Measurement of open circuit voltage and finding shelf life
- Discharge characteristics for various loads at various temperatures (to study polarization effect)
- I-V characteristics at various temperatures to separate out ionic and electronic conductivities of solid electrolyte and to find activation energy
- Variation of cell voltage with temperature (temperature sensor)
- Variation of cell voltage with ambient pressure
- 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 whereas 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 M $\Omega$ , 5 M $\Omega$  and 1M $\Omega$ ) 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/ $^{\circ}$ C. 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, planer 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 O<sub>2</sub> 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 O<sub>2</sub> 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.

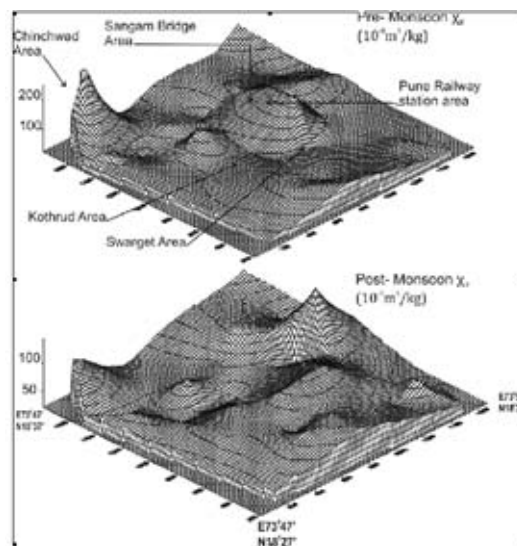


Faint trail of Geminides captured at dawn – top left-  
note the trail of an Airplane has also been captured – bottom centre

<b>PROJECT NO</b>	103
<b>TITLE</b>	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
<b>INVESTIGATORS</b>	Dr SJ Sangode, Department of Geology, University of Pune Dr D M Chate, IITM, Pune & Dr D C Meshram, Department of Geology, University of Pune
<b>DURATION</b>	3 years (Started on: August 2008)
<b>BUDGET (₹)</b>	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 ( $<0.06 \mu\text{m}$ ). 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.

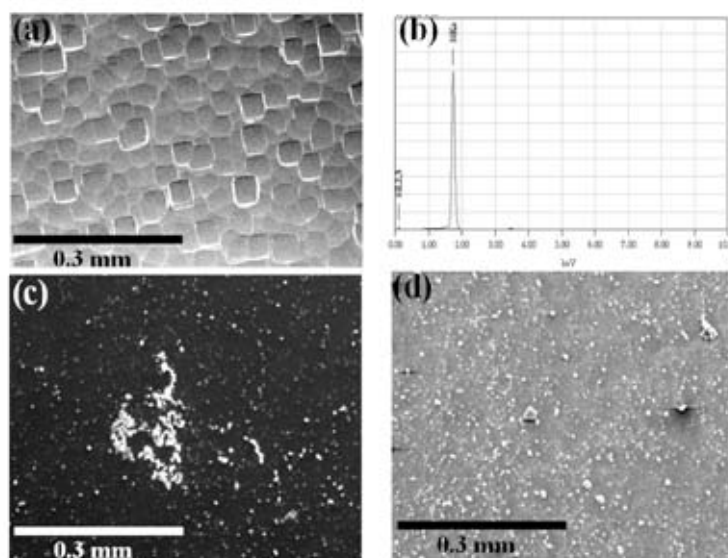


Pre and post monsoon variation in the susceptibility of top soils in the PMR region

<b>PROJECT NO</b>	114
<b>TITLE</b>	Study of Si quantum dots for solar cell applications
<b>INVESTIGATORS</b>	Prof. Shailaja Mahamuni, Dept of Physics, UoP Prof S V Ghaisas, department of Electronic Sciences, UoP
<b>DURATION</b>	1 year (Started on: June 2010)
<b>BUDGET (₹)</b>	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

#### 4. Research Projects in Progress

Presently there are 21 ongoing projects. Progress of these projects is monitored through periodical progress reports and reviews by the Preliminary Evaluation Committee (PEC). Investigators are invited to make detailed presentation highlighting the technical milestones in their studies. Midcourse correction is made wherever necessary. In the year 2011-12, PEC chaired by Prof S Ananthakrishnan conducted two review meetings to assess the progress of the ongoing projects. Current status in respect of these projects is given below:

S.No. Project title, name of Investigator, Project cost & Duration	Current status of the study
<p>1. Application of remotely sensed data for the evaluation of impervious surface growth and its effect on surface runoff in two rapidly urbanizing watersheds of Western Maharashtra, India (Project no.104) Dr (Ms) Anargha Dhorde</p> <p>Budget: Rs 9.66 lakhs Duration: 3 years (Started on: May 2010)</p>	<p>Soil Conservation Services Curve Number method has been selected for estimation of runoff. This method computes direct runoff through an empirical equation that requires rainfall, soil, land cover and the curve number (CN), which represents the runoff potential of the land cover soil complex (SCS, 1972). Base layers like soil map, HSG map, landuse/land cover map have been prepared. Currently Bhima-Bhama basin is taken for the runoff analysis. Layers like LULC, sub-basins, soil-HSG map, rainfall map have been prepared and examined for the runoff conditions for different seasons.</p>
<p>2. Modeling spatial patterns in fresh water reservoirs with special reference to plankton, mollusks and fishes using physicochemical characteristics of water and remote sensing techniques (Project no.105) Dr Pandit Sangeeta V</p> <p>Budget: Rs 13.68 lakhs Duration: 3 years (Started on: April 2010)</p>	<p>Human activity was studied by observing parameters such as industrial discharge, domestic discharge due to washing, bathing and recreational activity near the site. Sites were fixed using the GPS and samples will be collected from these sites. Water quality stations will be fixed after final collection and analysis of the samples. Physico chemical parameters are studied using different probes and also by titration method. Analysis of the remote sensing image of the area acquired from LANDSAT 7 and also from IRS satellites is progressing.</p>
<p>3. Chemical deposition of layered transition metal chalcogenides to study their tribological properties. (Project no.106) Dr SD Sartale</p> <p>Budget: Rs 7 lakhs Duration: 2 years (Started on: April 2010)</p>	<p>Aim is to deposit Layered Transition Metal Chalcogenide thin film with type-II structure using SILAR (Successive Ionic Layer Adsorption and Reaction) technique and to study their tribological properties. Sodium molybdate is mixed with excess sodium sulfide and hydrochloric acid is added till the pH becomes 8.</p> $\text{Na}_2\text{MoO}_4 + 4\text{Na}_2\text{S} + 4\text{HCl} \rightarrow \text{Na}_2\text{MoS}_4 + 4\text{NaOH} + 4\text{NaCl}$ <p>Band gap of molybdenum sulfide is in the range of 1.7 eV to 1.9 eV. With increase in concentration of sulfur, the band gap moves towards molybdenum sulfide. SEM images confirm the uniformity of film. Sulfurization of the film is needed to convert molybdenum oxide into molybdenum sulfide.</p>

4. Synthesis and applications of composites of  $\text{TiO}_2$  with Carbon nanotubes and metal chalcogenides (Project no.107)  
Dr Pragati R. Thakur
- Budget: Rs 14.52 lakhs  
Duration: 3 years  
(Started on: April 2010)
- $\text{TiO}_2$  and  $\text{TiO}_2$ -MWCNT nanocomposite were prepared by hydrothermal method using titanium tetraisopropoxide as the precursor and characterized. X-ray powder diffraction confirms the formation of  $\text{TiO}_2$ -MWCNT composite. Raman spectra show the interface integration of  $\text{TiO}_2$  and MWCNT. SEM of  $\text{TiO}_2$  shows similar particle size and shape and TEM image reveals a composite microstructure made of  $\text{TiO}_2$  nanoparticle agglomerates and embedded on MWCNTs. Photocatalytic activity was monitored.  $\text{TiO}_2$ -MWCNT nanocomposite shows a much higher photocatalytic activity in UV irradiation compared to the prepared  $\text{TiO}_2$  nanoparticles.
5. Chemical deposition of  $\text{CuInSe}_2$ , CdS and ZnO thin films for solar cell applications (Project no.108)  
Dr. Habib M. Pathan
- Budget: Rs 9 lakhs  
Duration: 2 years (Started on: April 2010)
- Optimization studies for depositing and making  $\text{CuInSe}_2$  and CdS a p-n junction are completed. ZnO is deposited for the buffer layer by zinc acetate as ZnO thin films showed large grains.  $\text{CuInSe}_2$  is deposited by two electrode deposition in acid bath by  $\text{CuSO}_4$ ,  $\text{In}_2(\text{SO}_4)_3$  and  $\text{SeO}_2$  solution. Deposition potential is 2.0 V for 20 ml each of (0.001M)  $\text{CuSO}_4$ , (0.004 M)  $\text{In}_2(\text{SO}_4)_3$  and (0.008M)  $\text{SeO}_2$  on different substrates like stainless steel, FTO and Mo. Films are deposited with  $\sim 1 \mu\text{m}$  thickness. Surface morphology and optical characterization have been completed for these films.
6. Use of a Geographical Information System to study tuberculosis epidemiology and the factors affecting case detection in a rural population in Pune district, Maharashtra (Project no.109)  
Dr Anita Kar
- Budget: Rs 9.61 lakhs  
Duration: 2 years (Started on: April 2010)
- Aim of the study is to identify and determine the epidemiology of the circulating *Mycobacterium tuberculosis* genotypes in real-time in Chakan, a rapidly developing industrial area in Pune district. In the first part of the study, mapping of all health care services in the area was undertaken in order to set up a reporting system. Subsequently, each health care provider was contacted and asked to report cases of tuberculosis presenting at his/her clinic. Sputum samples from each suspect was collected by the practitioner and transported for culture. For genotyping, DNA was isolated from individual cultures and species confirmation was done using MPB64 typing. For the purpose of genotyping, 12 MIRU-VNTRs (Mycobacterial interspersed repetitive units, variable number tandem repeats) were identified and polymerase chain reaction (PCR) amplification was conducted. Genotyping has to be completed for 7 more VNTRs for all 51 samples. The data then needs to be mapped to test whether it is possible to determine the dynamics of transmission of tuberculosis.

7. A comparative study of telecommunication technology: Its impact and relevance on Urban, Rural and Tribal community of Maharashtra. (Project no.110)  
Dr Prakash B. Gambhir
- Budget: Rs 4.40 lakhs  
Duration: 2 and half years  
(Started on: April 2010)
- 75% of the primary data has been collected. Data has been scrutinized. Data collection from tribal areas has been difficult and time consuming. The project is in its final stage.
8. Study of invertebrate biodiversity of Sawanga Lake region, Dist Amravati, Maharashtra (Project no.111)  
Dr Varsha Wankhade
- Budget: Rs 13.18 lakhs  
Duration: 3 years (Started on: April 2010)
- Parameters like turbidity, conductivity, pH, dissolved O<sub>2</sub>, total alkalinity, total hardness, chloride, nitrate, iron, fluorides, phosphorus, ammonia and TDS for lake water have been studied. Most of the parameters are in normal range. Level of ammonia is marginally higher. Lake area is divided into five stations for water analysis. There is no significant difference in the physicochemical parameters at the five stations except west station. West zone has high turbidity. This can be due to high human interference at this station. Total dissolved solids are also found to be higher here. Soil parameters are in normal range and soil of the lake is good for growth of fauna and flora.
9. Impact of radiations on the food quality and shelf life of food for space mission (Project no.112)  
Prof. Madhurima Dikshit
- Budget: Rs 14.91 lakhs  
Duration: 3 years  
(Started on: May 2010)
- As per the decided protocol initially mung beans were selected for the present study. This was followed by the processing (sprouting,  $\gamma$ - radiation and packaging). Phytochemical content, polyphenolics, flavonoids & flavanols, antioxidant activity (ferric reducing antioxidant potential), radical scavenging activity (2, 2-diphenyl-1-picrylhydrazyl), ABTS (2, 2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) and Spectrophotometric determination of antioxidant vitamins (A, E and C) have been completed. Cooked products like steamed and fried mung beans were studied using above parameters. Physical parameters have shown good stability (increased shelf life - 6 months) for both raw and cooked processed products.
- 10 Study of the direct radiative forcing of atmospheric aerosols over different environments (Project no.113)  
Dr G. R. Aher
- Budget: Rs 13.64 lakhs  
Duration: 3 years  
(Started on: May 2010)
- Eppley make Precision Spectral Pyranometer is operated from morning to evening along with MICROTOPS-II Sun-photometer and WXT Weather Sensor on clear sky, cloudless days to measure global solar flux in the spectral range 280-2800nm, AOD and meteorological parameters (viz., temperature, relative humidity, wind speed and wind direction, and pressure). The observing season normally starts from

November and continues upto May. Data on about 130 clear sky observing days have been obtained.

11. Studies on structural, optical and electrical properties of transparent conducting thin film(TCO)  
(Project no.115)  
Dr Arle Ramdas Nivrutti
- Budget: Rs 3.30 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Literature survey has been completed. Deposition system is assembled. Process parameters optimized and ZnO thin film samples have been prepared. Electrical & optical characterization work is initiated.
12. Novel electrochemical approach to prepare CuInGaSe<sub>2</sub> based solar cells using non-aqueous bath  
(Project no.116)  
Dr N B Chaure
- Budget: Rs 12.68 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Thin films are deposited from aqueous and non-aqueous bath using a conventional three electrode cell. Deposition potential has been optimized using cyclic voltammetry experiments with respect to Ag/AgCl reference electrode. The films are characterized. CIS layers from non-aqueous bath are highly crystalline compared to the layer deposited in aqueous bath. Particle size also increases. Test results indicate their suitability for the development of high efficiency solar cells. Work on ZnO and ZnS (Cd free window layer for development of solar cell) has been initiated and uniform and compact thin films made. Two papers have been presented in conferences.
13. Design and development of an odor tracking system  
(Project no.117)  
Dr Mrs DC Gharpure/Dr AD Shaligram.
- Budget: Rs 10.60 lakhs  
Duration: 2 years (Started on: August 2011)
- Literature survey is in progress. Characterization of Gas Sensors and generation of Odor data base is being done with the help of Lab VIEW based Data acquisition system. Designing and development for direction detector is progressing. For preliminary experimentation and testing, some components have been purchased. Gas characterization system has been designed and implemented.
14. Study of interferometric data and its applications for subsidence monitoring  
(Project no.118)  
Mrs Chaitali Abhijit Laulkar/Dr Vijaya Chamundeeswari
- Budget: Rs 6.56 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Studied GMTSAR software at SAC, ISRO and trying to implement enhancement of the software. Kutch has been finalized as Study area. Visited SAC /ISRO and discussed with Dr Rajawat, Dr. S.K.Pathan & Mr. Hiren Bhatt the proposed methodology.



15. Identification of critical areas of conservation concern using RS-GIS technique from northern Western Ghats of India  
(Project no.119)  
Dr Ankur Patwardhan  
  
Budget: Rs 10.87 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Present study aims at prioritizing areas of high conservation value based on composite knowledge of multiple taxa diversity. The focus taxa of the study include woody plants, birds and butterflies. To evaluate diversity at local level, the study area is divided into grids of  $2.5^{\circ} \times 2.5^{\circ}$  (~25 km<sup>2</sup>). Base maps have been prepared using Google Earth Plus (beta) and SOI toposheets. Each grid is mapped to quantitate area under human habitation and/or impact (agriculture, industry etc.). Stratified random sampling approach has been adopted for survey. Focal taxa have been surveyed to understand grid level species richness, abundance, density so as to arrive at various thematic maps. Out of total 116 grids, 40 grids have been surveyed and mapped.
16. Development of high performance polycarbonate/graphite nanocomposites with low percolation for EMI shielding application (Project no.120)  
Dr Rajendra Kumar Goyal/  
Dr (Mrs) R C Aiyer  
  
Budget: Rs 10.30 lakhs  
Duration: 2 years  
(Started on: August 2011 )
- Literature survey has been completed. Polycarbonate matrix nanocomposites containing 0, 0.1, 0.2, 0.3, 1, 2 and 3 wt% nano-graphite powder (total 7 compositions) have been prepared by solution method followed by hot pressing. Sample size is  $\Phi$  25 mm  $\times$  2 mm thickness. Density and electrical conductivity of above samples have been determined. The percolation threshold is between 1 and 2 wt% nano-graphite.
17. Synthesis and characterization of Copper Chromite for propellant (Project no.121)  
Dr SL Bonde / Dr(Mrs) RP Bhadane.  
  
Budget: Rs 8.00 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Literature survey for the synthesis of copper chromite by various methods has been carried out. Installation of the vertical tube furnace is in progress. After installation of the equipment, preliminary trials have been planned for the synthesis of copper chromite catalyst.
18. Preparation of ternary oxides like lead zirconium titanate (PZT) with and without dopants and barium titanate - polymer composites for microwave dielectric application (12-15 GHz)  
(Project no.122)  
Dr. Manisha Y. Khaladkar / Dr.(Mrs.) Rohini P.Mudhalwadkar.  
  
Budget: Rs 10.00 lakhs  
Duration: 2 years  
(Started on: August 2011)
- BaCO<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, ZnO, MgO – material received. Synthesis and process parameters optimization for BMT and BZT are in progress. DTA of above prepared material by solid state method is done from ambient to 1000 °C. XRD of the BMT is done for materials heated at various temperatures ranging from 950 °C to 1300 °C and time varying from 2 to 39 hours. XRD images at various temperatures showed reported hexagonal phase (JCPDS No 8-212).

19. Biodegradation of Ammonium Perchlorate by phytoremediation approaches (Project no.123)  
Dr Rekha Gupta/Dr Vinay Kumar
- Budget: Rs 10.52 lakhs  
Duration: 3 years  
(Started on: August 2011)
- Biodegradation of perchlorate takes place sequentially via chlorate ( $\text{ClO}_3^-$ ), chlorite ( $\text{ClO}_2^-$ ) to innocuous chloride ( $\text{Cl}^-$ ) under specific conditions. Several plant species absorb and accumulate perchlorate from soil and irrigation water. Salt cedar, tobacco, black willow, sweetgum, eastern cottonwood are able to absorb and accumulate perchlorate from soil and water. Screening of plants growing under different environmental conditions in presence of Perchlorate has been carried out. Study involves random selection of plants growing in different sites and estimating the amount of perchlorate quantitatively. Plants growing in perchlorate contaminated areas are being identified.
20. Enhancing rural development through improved communication: case study western India (Project no.124)  
Prof Sanjeev Sonawane / Smt Geeta Kamble
- Budget: Rs 10.12 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Communication modes play vital role in rural development. There are defined policy and schemes for rural communication. Present study in its initial phase aims to identify the policy, schemes and to carry out analysis of the mode of communication, special functions and outcome with reference to rural development elements. This study further identifies and analyses Technology Transfer Policy of ISRO programmes such as Satcom, Hamsat, Gramsat, Edusat and VRC, Telemedicine etc in addition to different media such as Newspaper, Radio, Television Network, Telecom, Internet and ICT support in Rural development.
21. Measurement of plasma temperature and identification of species during re-entry of Space Shuttle, using plasma emission spectroscopy (Project no.125)  
Dr V L Mathe / Prof Mrs S V Bhoraskar, / Dr Indrani Banarjee
- Budget: Rs 12.164 lakhs  
Duration: 2 years  
(Started on: August 2011)
- Electron Cyclotron Resonance (ECR) plasma reactor is a microwave (2.45 GHz) assisted cold plasma. ECR plasma can produce plasma densities of the order of  $10^{10}$  to  $10^{13} \text{ cm}^{-3}$ . This plasma density is equivalent to density at around 90 km from the earth surface. Such plasma is generated in ECR plasma reactor and species present in such plasma are investigated by emission spectra from the gaseous plasma consisting of air, nitrogen, oxygen, hydrogen and argon. Wavelength of emitted radiation is compared with the NIST atomic data base which is used for identification of the species.

## 5. New Research Projects for the Year 2011-12

Invitation for new research proposals was sent to various departments/affiliated colleges of University of Pune in the month of September-October 2011 for submission of research proposals under ISRO-UoP Joint Research Programme. In response to our invitation, 58 proposals from various Departments of the University and its affiliated colleges were received. These were evaluated by Preliminary Evaluation Committee (PEC) chaired by Prof S Ananthakrishnan and 21 were shortlisted based on the criteria evolved by the Committee. Investigators of these 21 proposals were invited to give technical presentation to PEC on 14 December 2011. Modifications in objectives, methodology, schedule etc wherever needed, were suggested and Investigators were advised to incorporate the same and resubmit the proposal. Three proposals were referred to ISRO scientists to get comments in regard to the relevance of these works with reference to ISRO programme. After a careful evaluation, PEC recommended 16 proposals for further processing and approval by Joint Policy Committee (JPC). Investigators of these proposals were invited for making detailed presentation to JPC on 23 February 2012. JPC considered the recommendation of PEC and the views of ISRO experts and observed that the proposal titled '*Electrowetting based adoptive sensors for measurement of vibration and surface charge density*' is relevant to ISRO programme but requires considerably higher funding, if the end results of the studies are to be brought to a practical application and hence recommended it to be directly referred to ISRO for their consideration. Committee after due deliberation, approved ten research proposals, as listed below, for taking up in the coming financial year 2012-13

1. Splitting of carbon dioxide into oxygen and carbon moiety using biomimetics of biological catalysts involved in photosynthesis
2. Preparation of  $\text{Co}_3\text{O}_4$  films by using electrochemical and spray pyrolysis deposition methods for gas sensing applications
3. Development of transition metal oxide nanoparticle films for solar radiation protection and solar cells
4. Real time human detection using covariance matrix as human descriptor
5. Sensor-less XY planar flexural scanning mechanism for precision application
6. Metallic surface plasmon phenomenon as a biosensor for the identification of biomolecules
7. Hazardous gas leakage detection and monitoring system using wireless network
8. Impact of Geo-hazards on human settlement
9. Digital elevation model (DEM) fusion
10. Development of conducting polyaniline-ZnO nano particle composite paint coating for corrosion protection.

## 6. Major Events in the STC Calendar

### • Preliminary Evaluation Committee (PEC) Meetings

1. Eighth meeting of Preliminary Evaluation Committee (PEC) took place on 8 April 2011 to review the progress of ongoing projects. Investigators were invited to make detailed presentation on the status of their projects. Committee noted considerable delay in completion of Project no.58 titled *Doppler shift flow meters for liquid & gases*. The project started in 2005 but got delayed due to change of Principal Investigator as the original PI Mrs Pooja More had resigned from the University. Prof SA Gangal took the charge of Principal Investigator with a view to resume the proposed studies and complete the project by August 2011. Prof Gangal made a technical presentation on the work carried out so far and the details of pending task. In view of the considerable delay in completing this project, Investigator was requested to complete the studies before August 2011. Committee also noted the delay in completion of the following four projects and expressed its concern.



Project status presentation during 8<sup>th</sup> PEC Meeting

- i. Development and analysis of MOS device with embedded nanocrystals of silicon dioxide layer for enhancement in charge transfer rate (Project no.87)  
*Prof SV Ghaisas*
- ii. Synthesis of ZnS thin film by modified spray pyrolysis method and study of its physical properties for optical sensor and solar cell applications (Project no.90)  
*Prof R V Zavare and Mr S A Arote*
- iii. Autonomous navigation system for Low Earth Orbit (LEO) satellite using Global Navigation Satellite System (GNSS) (Project no.93)  
*Prof S A Gangal (PI) and Dr Suwarna Datar*
- iv. Study of temporal and spatial distribution of seaweeds for their sustainable utilization using ground based and satellite borne systems (Project no.94)  
*Dr BB Chaugule and Dr DB Jadhav*

PEC advised the investigators of the above projects to ensure completion of the project & submission of the Final Report without seeking further extension.

2. Next meeting to review the progress of the ongoing projects was held on 5 November 2011. Committee noted that after its last Meeting held on 8<sup>th</sup> April 2011, four Projects have been completed and Final Technical Reports submitted. In the case of two reports, some changes were suggested and investigators requested to resubmit the report after incorporating these changes. With a view to complete the experimental part and submission of the final report, extension to

project titled **Development and characterization of thin film solid electrolyte cells as voltage source, temperature, pressure and gas sensor** (project no. 100) by *Dr S B Iyyer* and Project titled **Synthesis of undoped and Cd, Al, In, B doped nanostructures of ZnO by intermittent chemical spray pyrolysis for optoelectronic and gas sensing applications** (project no.97) by *Dr CM Mahajan* has been given by 3 and 6 months respectively. Remaining ongoing projects are progressing satisfactorily. After completion of presentation and discussions, PEC Members opined that this type of review is very useful and should be held at least once in six months.

9<sup>th</sup> PEC Meeting in progress

3. Tenth meeting of PEC was held on 18 November 2011 for evaluation of 58 new research proposals. After a scrutiny of the proposals, 21 were shortlisted based on the following criteria:

- Relevance of proposed research work in the identified areas and ISRO activities / programme
- Novelty/innovation in the proposed research work
- Past performance of the Investigators in regard to their completed/on-going projects under this scheme

10<sup>th</sup> PEC Meeting in progress

4. PEC held its Eleventh meeting on 14 December 2011 when prospective investigators of the shortlisted proposals were invited for technical presentation. Committee sought views from ISRO scientists on following three proposals to ascertain their relevance with respect to ISRO programme.

- i. Proposal titled **Electrowetting-Based adoptive lenses and sensors for measurement of vibration and surface charge density** by *Dr Arun Banpurkar* aims at developing sensors for measurement of vibrations and surface charge density. Proposal is to be referred to ISAC, VSSC/ISRO.
- ii. Proposal titled **Online e-governance assistance as a communication media for rural development – case study of farmers of Maharashtra** by *Dr Rupa Hiremat* is to be modified and referred to Director DECU/ISRO.

- iii. Proposal titled **Investigate the immune system related changes after space flight and combat them by the use of time tested Indian medicinal plants on ground based studies in analogue settings** by *Mr Rajesh Sharma* is to be referred to Human Space Flight Programme (HSP), VSSC/ISRO.

Five proposals were found to have no relevance to ISRO programme and also lacked innovative idea and hence not recommended. Remaining sixteen proposals were then recommended to JPC for further processing.



Scrutiny of new research proposals

- **Joint Policy Committee (JPC) Meeting**

XIV JPC Meeting under the chairmanship of Dr Sanjay Chahande, Vice-Chancellor of University of Pune was held on 23 & 24 February 2012. Committee noted the long delay in construction of the building for Space Technology Cell at University of Pune. Concerned University Officials were requested to expedite the work. Members reviewed the status of ongoing projects and suggested that PEC may monitor the progress periodically and may recommend short closing of the project if it is not progressing satisfactorily.

Committee then considered the recommendation of PEC on new proposals and invited Investigators of 16 proposals for presentation.

Committee approved 10 proposals for funding from ISRO under ISRO-UoP Joint Research Programme. Considering the funds requirement of ongoing projects, new proposals as well as for the Office of ISRO-UoP STC, Committee approved a budget proposal of ₹ 159.30 lakhs.



Presentation during XIV JPC Meeting

- **ISRO-UoPSTC Website**

ISRO-UoP Space Technology Cell website has been developed and information on completed projects, ongoing projects, summary of findings of completed projects etc has been uploaded. Scientists/Engineers from ISRO or faculty from University of Pune can visit this site from [www.unipune.ac.in/isro](http://www.unipune.ac.in/isro) and get acquainted with the research activities under ISRO-UoP Joint Research Programme at University of Pune. Relevant information related to this Programme will be uploaded regularly.

## 7. ISRO Proposal Format

Faculty Members of University of Pune and its affiliated colleges are required to follow the ISRO format as given in <http://www.isro.gov.in/scripts/srrespond.aspx> and reproduced below for making research proposals and seeking financial grant from ISRO. Requirement is that Principal Investigator(s) should be full-time employee(s) of the concerned institution and proposal is to be forwarded through Head of the academic institution. Research proposals from individuals not affiliated to any recognized institution of the University are not considered. Institutions proposing a project for support are expected to commit the use of the existing infrastructure available with them. ISRO provides financial grants to support fellowship, materials, consumables, internal travel, testing charges, data etc. Funds for purchase of essential minor equipments which are not available in the institution and would be useful for future projects are also provided. There is no provision for any kind of payment to the Principal Investigator (or other staff) belonging to the Institution. The allocated funds cannot be used for travel abroad for any reasons. Generally invitation for making research proposals is sent in the month of September-October and processing of the proposals is completed in 4-5 months time. For any information/clarification, Faculty Members may contact the ISRO-UoP Space Technology Cell or visit our website [www.unipune.ac.in/isro](http://www.unipune.ac.in/isro) to get the necessary information.

### Application for grant of funds

1. Application Institution
2. Title of the Research Proposal
3. Name of the Principal Investigator
4. Name(s) of other investigator(s) with the name(s) of their Institution
5. Proposed duration of Research Project
6. Amount of grant requested (in ₹)

	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	Total
Staff			
Equipment and Supplies			
Others			

### Total

7.
  - a) Bio-data of all the Investigators (Format-A).
  - b) Brief description of the Research Proposal with details of budget (Format-B).
  - c) Declaration (Format-C).
8. I/We have carefully read the terms and conditions for ISRO Research Grants and agree to abide by them. It is certified that if the research proposal is approved for financial support by ISRO, all basic facilities including administrative support available at our Institution and needed to execute the project will be extended to the Principal Investigator and other Investigators.

	Name	Institution	Designation
Principal Investigator			
Co-Investigator(s)			
Head of the Department/Area			
Head of the Institution			

**Format A****Bio-data of the Investigator(s)\***

1. Name
2. Date of Birth (dd/mm/yyyy)
3. Designation
4. Degrees conferred (begin with Bachelor's degree)

<b>Degree</b>	<b>Institution conferring the degree</b>	<b>Field(s)</b>	<b>Year</b>
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5. Research/training experience (in chronological order)

<b>Duration</b>	<b>Institution</b>	<b>Name of work done</b>
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6. Major scientific fields of Interest
7. List of publications
8. Email id and Telephone number of PI
9. Email id of the Head of the academic institution

\* Bio-data for all the investigators should be given, each on a separate sheet.



## Format B

### Proposal Preparation Format

1. *Title of the research proposal*

2. *Summary of the proposed research*

A simple concise statement about investigation, its conduct and anticipated results in no more than 200 words

3. *Objectives*

A brief definition of the objectives and their scientific, technical and techno-economic importance

4. *Major scientific fields of interest*

A brief history and basis for the proposal and a demonstration of the need for such an investigation preferably with reference to the possible application of the results to ISRO's activities. A reference should also be made to the latest work being carried out in the field and the present state-of-art of the subject.

5. *Approach*

A clear description of the concepts to be used in the investigation should be given. Details of the method and procedures for carrying out the investigation with necessary instrumentation and expected time schedules should be included. All supporting studies necessary for the investigation should be identified. Necessary information of any collaborative arrangement, if existing with other investigators for such studies, should be furnished. The Principal Investigator is expected to have worked out his collaborative arrangement himself. For the development of balloon, rocket and satellite-borne payloads it will be necessary to provide relevant details of their design. ISRO should also be informed whether the Institution has adequate facilities for such payload development or will be dependent on ISRO or some other Institution for this purpose.

6. *Data reduction and analysis*

A brief description of the data reduction and analysis plan should be included. If any assistance is required from ISRO for data reduction purposes, it should be indicated clearly.

7. *Available Institutional facilities*

Facilities such as equipments, test instruments etc available at the parent Institution for the proposed investigation should be listed.

## 8. Fund Requirement

Detailed year wise break-up for the Project budget should be given as follows

	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	Total
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### 8.1 Salaries:

8.1.1 Research Fellows/  
Project Assistant

8.1.2 Supporting Technical Staff

8.1.3 Other staff, if any

**Total:**

(Note: please specify designation and rate of salary per month for each category)

### 8.2 Equipment

	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	Total
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**Total:**

(Note: Please specify various individual items of equipment and indicate foreign exchange requirement, if any)

### 8.3 Consumables and Supplies

	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	Total
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**Total:**

(Note: Please specify the items and indicate foreign exchange requirement, if any.)

### 8.4 Travel

	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	Total
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**Total:**

### 8.5 Other project costs, if any (give details)

	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	Total
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**a. Grand Total**

9. Whether the same or similar proposal has been submitted to other funding agencies of Government of India. If yes, please provide details of the Institution & status of the proposal.

## Format C

### Declaration

I/We hereby agree to abide by the rules and regulations of ISRO research grants and accept to be governed by all the terms and conditions laid down for this purpose.

I/We certify that I/We have not received any grant-in-aid for the same purpose from any other department of the central government/state government/public sector enterprise during the period to which the grant relates.

**Name**

**Designation**

**Signature**

Principal Investigator

Head of the Department/Area

Head of the Institution

**Seal of the Head of the Institution**

## 8. Suggested Topics for Research Proposals

In order to ensure that the research work carried out under JRP scheme is meaningful and relevant to ISRO programme, detailed discussions were held with ISRO Scientists/Engineers to identify the research topics where academic institutions like University of Pune, can make meaningful contribution. As a result of this effort, following list of research topics has been prepared which can act as guideline for the prospective Investigators from Pune University in making research proposals under ISRO-UoP Joint Research Programme.

<b>Research area</b>	<b>Outline of suggested research proposal</b>
<i>Space radiation</i>	<ol style="list-style-type: none"> <li>1. Equilibrium as well as non-equilibrium air radiation modeling for estimation of radiative heating in re-entry from interplanetary mission when entry velocity is greater than 15 km/s</li> </ol>
<i>Wind measurements &amp; modeling</i>	<ol style="list-style-type: none"> <li>1. Dynamic modeling for real time weather forecast</li> <li>2. Assimilation of satellite data in numerical weather and ocean prediction models improving the initial condition in models</li> <li>3. Global and regional numerical dynamic models for ocean state forecast</li> <li>4. Diagnostic study using satellite data to understand atmospheric and oceanic process near ocean surface</li> <li>5. Empirical and dynamic modeling and assimilation techniques for predicting movement and intensity of a cyclone</li> <li>6. Algorithms/models for generating 5-daily and 10-daily snow cover products, snow melt run-off, features of glaciers to understand Himalayan cryosphere</li> <li>7. Modeling marine lithosphere using satellite altimetry over marine regions</li> <li>8. Studies related to:             <ul style="list-style-type: none"> <li>• Aerosols and their impact on climate</li> <li>• ARFI : Aerosol Radiative Forcing over India (National Network with 40 Universities and Institutions)</li> <li>• IGBP : ISRO Geosphere Biosphere Programme</li> <li>• Physics and dynamics of atmospheric boundary layer (0-1km)</li> <li>• Cloud studies using satellite data</li> <li>• Atmospheric dynamics – winds, waves and structure</li> <li>• Ionospheric (100-1000km) modeling characteristics, features, dynamics, electron content</li> <li>• GAGAN – Aircraft navigation</li> <li>• Planetary atmosphere</li> <li>• Studies of inner and outer planets</li> <li>• Temperature and humidity profile from atmospheric sounders</li> <li>• Wind vectors from satellite observations</li> <li>• Rainfall estimates from infrared and microwave radiometers</li> </ul> </li> </ol>

- Land parameters from microwave radiometers
- Application of atmospheric parameters in monsoon related activities
- Retrieval of ocean surface wind vector from first principle
- Retrieval of ocean wave spectra and ocean winds from Synthetic Aperture Radar
- Retrieval of coastal Bathymetry using SAR
- Simulation of altimeter signals from ocean surface and retrieval of basic ocean parameters
- Simulation of coastal wave and circulation through Numerical Model
- Merging open ocean and coastal models for waves and circulations
- Sensitivity studies on forecast winds, waves, mixed layer depth for their application in physical and biological oceanography
- Propagation studies for ionospheric correction making use of satcom technology

*Optical coatings  
& sensors*

1. Piezoelectric films on Zn-cut  $\text{Al}_2\text{O}_3$ , NCD substrates for Surface Acoustic Wave (SAW) devices with low propagation loss, high performance and high frequency characteristics
2. Langasite single crystal (LGS) for high performance, low loss narrow band SAW filters
3. Nanostructured magnetostrictive thin films for SAW device applications
4. Ferroelectric thin films for electronically tunable filters used in wireless communication system
5. Investigating compaction, focusing, alignment techniques and swath improvement in Hyper spectral system
6. Mathematical modeling and optical domain processing in multipurpose large area array detectors
7. Sensor/detectors related studies:
  - Developing complete sensor system for  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{SO}_2$  and other Greenhouse gases
  - Testing, calibration and evaluation of sensors
  - Life/failure mechanism in photo detectors using InGaAs, InSb and Si-PIN technologies and modeling to estimate life of such detectors
  - Atmospheric modeling for radiometric correction

*Rural development &  
developmental  
communication*

1. Socio-economic research/evaluation of satellite-based societal applications
2. Demonstration projects for new applications of space and related technologies for end-users of socio-technical system

3. Study of social, economic and cultural impact of new technologies and production of software as models/examples
4. Content generation in terms of multi-media programs and evaluation study at national and regional levels for Edusat utilization
5. Interactive programs for applications like Training, Education, e-Governance, Disaster Management, Tele-conferencing, Urban/Rural Development under Gramsat programme
6. ISRO's Village Resource Centres into multi-service centres and integration with existing VRCs
7. Innovative applications for education, health and rural welfare using satcom technology

### *Geo-informatics*

1. Algorithms and techniques for processing terrestrial imagery acquired in stereo/mono
2. Study of planetary geodesy for optimization in calculating surface measurements (coordinates, distances, areas) on spheres or spheroids
3. Methods to analyze multisensor satellite data and to detect guides for mineral exploration
4. Three dimensional models of urban area using GIS techniques
5. Continuous simulation model using high resolution satellite data embedded with GIS technique to represent the entire hydrological system on computer
6. Multi facet model for assessing the impact of a geo-hazard on human settlement and simulating the damage scenario
7. Spatial decision support system (SDSS) for flood management, using Geoinformatics (mathematical and statistical modeling techniques)

### *Remote sensing applications*

1. Investigation in geocorrection models namely (a) Model based on ephemeris platform and sensor information (b) Model relating ground control points or features and (c) Hybrid model
2. Sensor calibration on ground based test sites
3. Signal processing and Tracker algorithms for altimeter sensor, correlation algorithm for synthetic aperture radiometer and performance analysis, feature extraction algorithm for microwave data
4. Partitioning land surface temperature into components using angular thermal remote sensing
5. Quantifying variability of green-house gases (GHG) using space borne sensors
6. Estimating aerosols over land and ocean using multiangular and polarization measurements
7. Agro-ecosystem models to study long term sustainability
8. Developing land data assimilation system to optimally merge

- remote sensing observations with hydrological model
9. Earthquake precursors using satellite data such as land surface temperature and gravity anomalies
  10. Modeling the dynamics of change of land use/cover for future projection
  11. Modeling hydrological cycle of natural wetlands in relation to change in land use/cover
  12. Differential SAR interferometry and its applications for geohazards monitoring
  13. Agriculture resources related studies:
    - Classification of hyperspectral remote sensing data to discriminate between crop condition, variety and stage
    - Inversion of radiative transfer model for estimation of crop parameters from hyperspectral data
  14. Marine resources related studies:
    - Calibration and validation
    - Mixed layer physics
    - Algal-bloom specific algorithm for chlorophyll retrieval from ocean color data
    - Identification of phytoplankton functional type (PFT) and time series measurements on inherent optical properties to develop bio optical algorithm
    - Assessment of fate of carbon during algal bloom
    - Impact of climate change on ocean productivity
  15. Environment related studies:
    - Eco-casting of environmental parameters
    - Quantitative modeling of wind erosion
    - Decertification vulnerability analysis
    - Quantitative estimation of gas emission from biomass burning
    - Urban hazard model
    - Microwave scattering and emissivity models from natural surfaces
    - Retrieval and modeling of atmospheric pollutants
    - Hyper spectral data evaluation for forest condition assessment
    - Early warning/forecasting models for land slides
    - Forewarning and damage assessment for natural disasters
    - Development of indices for urban transportation geometry
    - Development of semi automated procedures for urban structural planning
    - Evaluating impact of watershed treatment
    - Web based solution for multi resolution image fusion
    - Methodology to derive digital terrain model
    - Development of web based services
    - Development of data mining tools
  16. Disasters related studies:

- Early warning for cyclone prediction of track and probable landfall point
- Areas likely to be inundated and estimation of population affected in case of floods
- Short range and medium range forecast for local severe weather conditions
- Earth-quake precursors with satellite based observations and ground experiments
- System study on services for rural centers, fishing community etc

### *Material Sciences*

1. Making H<sub>2</sub>O<sub>2</sub> of 98% purity, stabilizers for its safe storage and catalyst for its decomposition
2. Synthesizing cubane and substituted cubanes in industrial scale
3. Aqueous solution of Hydroxylammonium nitrate (HAN) (minimum concentration of 60%) and catalyst to initiate decomposition at lower temperatures
4. Indigenize lubricants FLUOR-06 and FLUOR-60 for use in liquid rocket engines
5. Development of silicone polymers for thermal paints on satellite components
6. Code/software for prediction of mechanical & ballistic properties of composite solid propellants
7. Catalytic splitting of carbon dioxide into carbon monoxide and oxygen
8. Graphite fiber reinforced aluminum for material housings in components like DC-DC converters
9. Electric propulsion systems related studies:
  - 18 mN & 75 mN stationary plasma thruster (SPT)
  - Pulsed plasma thruster
  - Power processing & control systems for SPT
  - Xenon flow controllers
10. Studies related to fuel cells:
  - Simulation & analysis of humidification methods in microgravity environment
  - Techniques for using product heat and water for humidification
  - Techniques for separation of liquid water from exhaust hydrogen and oxygen gases
  - Influence of membrane thickness, temperature, saturation level on water balance of proton exchange membrane (PEM)
  - Modeling bipolar plate flow field geometry
11. Studies related to Human Space Flight Programme:
  - System supporting LiOH particles on porous ceramic material to absorb carbon dioxide produced by human metabolism
  - Block copolymer based on polyethylene oxide (PEO) soft



- segment and polyether-ester block amide (PEBA) hard segment to make liquid cooling & ventilation garment (LCVG) for space suit
  - High pressure Oxygen compatible materials
  - Fluid circuit for thermal control system inside crew module
  - Suit circuit system
  - Dynamic modeling and analysis of human body exposed to vibration environment during space flight
12. Studies related to mechanical and materials:
- Modeling guided wave propagation in (i) circumferential direction of tubes (ii) sheets with defects
  - Experimental analysis and evaluation of formability limit diagram for Inconel-718
  - Thermal analysis of resistance spot welds
  - Analysis of weld bead instability in the overlap zone of keyhole electron beam welds
  - Thermal analysis of partial penetration and full penetration seam welds by laser
  - Testing/screening of metallic materials at high temperatures and in high oxygen environment
13. Studies related to composites:
- Structural health monitoring of composite structures using optical fibres with Bragg Grating sensors
  - Miniature specimen test techniques
14. Studies related to Aeronautics/Aerodynamics/Aerothermal areas:
- Thermal response of sandwich honeycomb panels under transient heating condition
  - Heat flux distribution in the vicinity of protrusions on the cone cylinder body under varying mach number and Reynolds number
15. Studies related to rocket motors:
- Carbon – carbon liner with transpiration cooling
  - Vacuum plasma sprayed CuCrNb liner
  - Thermal barrier coating for improving life cycle
  - Thermal protection system for liquid He storage vessel and feed lines
  - Nickel electroplating on Copper
  - Seals and bearings for turbo pump
  - Kerosene refinement - using catalysts
  - Nano particles and nano fluids for augmentation of heat transfer in thrust chamber
  - Pulse mode combustion studies
  - Hydrostatic bearings
  - Micro-gravity slosh analysis
16. Studies related to design and manufacturing:
- Assessment of EB weld of Titanium, spot welding of Aluminum inter-stages through acoustic emission

- Strain measurement using bi-refrigerant coatings
- 3d strain mapping using stereovision and digital image correlation
- Digital holographic microscope for mems characterization, deflection and shape measurement
- Experimental investigation of delamination fracture toughness of sandwich panels
- Sandwich structures with negative Poisson's Ratio
- Finite element software for inflatable structures
- Development of 3-d contact element with friction
- Health monitoring of structures using vibration data
- Control algorithm for multi-axial vibration testing
- Vibration isolation system for payloads
- Visco-elastic structural analysis of solid propellant grains
- Fracture studies in textile composites

#### *Biodiversity*

1. Modeling sediment transport in coastal and marine environment using satellite retrieved parameters. Study involves identifying source to sink path ways, impact on habitats, mapping shoreline changes, coastal erosion, predicting shoreline changes and quantifying coastal vulnerability to predicted sea level rise.
2. Ecosystem models to assess the condition of marine ecosystems like coral reef, sea grass bed etc.

#### *Instrumentation / Electronics*

1. Fiber optic sensor based measuring system with multiplexing capability for simultaneous measurement of strain, temperature, pressure and displacement
2. Portable and compact equipment based on computerized digital optics and capable of whole field strain measurement from photoelastic coating fringe data
3. Development of an algorithm and integrated computer based optical system capable of non-contact whole field strain mapping with minimum resolution of 50 micro strains using the principles of stereovision and Digital Image Correlation (DIC)
4. Sensor system and data acquisition/analysis for measurement of strain on space structural components at temperatures higher than 800 °C
5. Characterize performance and reliability of micro and nano electro mechanical systems like sensors, actuators and controls under static and dynamic conditions
6. Non-linear stability analysis for MMIC design
7. Extending exact synthesis method to non-linear microwave circuit designs like mixer, modulator, frequency multiplier to get the best results
8. Design of an input filter with low mass and volume by inductor and capacitor values enhancement techniques

9. Design of an input filter by hybrid of Equivalent and EM technique combining accuracy of EM solver and the speed of Equivalent
10. Studies related to acoustic emission:
  - In-flight health monitoring of launch vehicle structures using acoustic emission
  - Automated AE monitoring with Neural Network for the real time integrity evaluation
  - Differentiating genuine AE signals from external noise in the real time AE monitoring
11. Studies related to piezoelectric material:
  - Application of piezoelectric material in precision position control of mirrors used in optical structures of satellites
  - Characterize piezo stack actuators and Macro Fiber Composite (MFC)
12. Transducers and sensors related studies:
  - MEMS based transducers and sensors
  - Cryo temperature sensor

### *Image processing*

1. A generic model based on Rational Polynomial Coefficient (RPC) is a common approach in satellite data processing in encapsulating the interior and exterior orientation of image acquisition, geometric correction and derivation of digital elevation models (DEM). Investigation related to various orders of polynomials, functional representations, bundle adjustment of a block of images using such representations, DEM generation for a block of imagery and extension of this methodology to planetary data processing, need to be carried out.
2. Currently satellite images have resolution ranging from 25 m to 0.8 m and likely to improve to 0.25 m. Study needs to be carried out for generating images with better than 0.25 m resolution using available multi-resolution images. This involves development of concepts like super resolution, image registration, sub-pixel processing and multi-resolution.
3. With the availability of high resolution stereo imagery, there is a need to develop new techniques for a dense set of match point pairs from such data to derive the DEM. In view of large volume of data involved, optimization aspect is to be investigated. New algorithms should remove the short comings of cross-correlation techniques using FFTs.
4. Urban DEM poses a different challenge due to singular nature of the underlying DEM surface which needs to be detected. It should cater to identification of buildings and steep landscapes and determination of their heights through space intersection by

other means. Special techniques based on morphological features and AI paradigms to be developed for solving this problem. Generation of relative DEM also needs to be investigated.

5. Developing robust techniques using image cues for interpolating from DEMs and considering constraints such as break points, break lines and exclusion masks
6. Combining DEMs from various sources into a single DEM considering slope, aspect and other terrain properties for better DEMs
7. Antenna related studies:
  - Antenna design for very large apertures
  - Development of feed elements
  - Milli-Meter (MM) wave reflector antenna and feeds
  - Thinned array antenna
8. Data processing related studies:
  - Hyperspectral data processing for theme specific application leading to optimization of spectral bands
  - Automatic registration of images of different sensor, resolution and acquisition modes
  - Automated feature extraction using multiple data sets from multiple sources
  - Multi-source data fusion and integration
  - Automatic 2D/3D feature extraction, object recognition from high resolution data.
  - Automatic DSM/DTM generation from different data sources (satellite, Aerial, Lidar) in different terrains (urban, forest, coastal)
  - Advanced quantitative, physical based retrieval of biophysical and biochemical parameters