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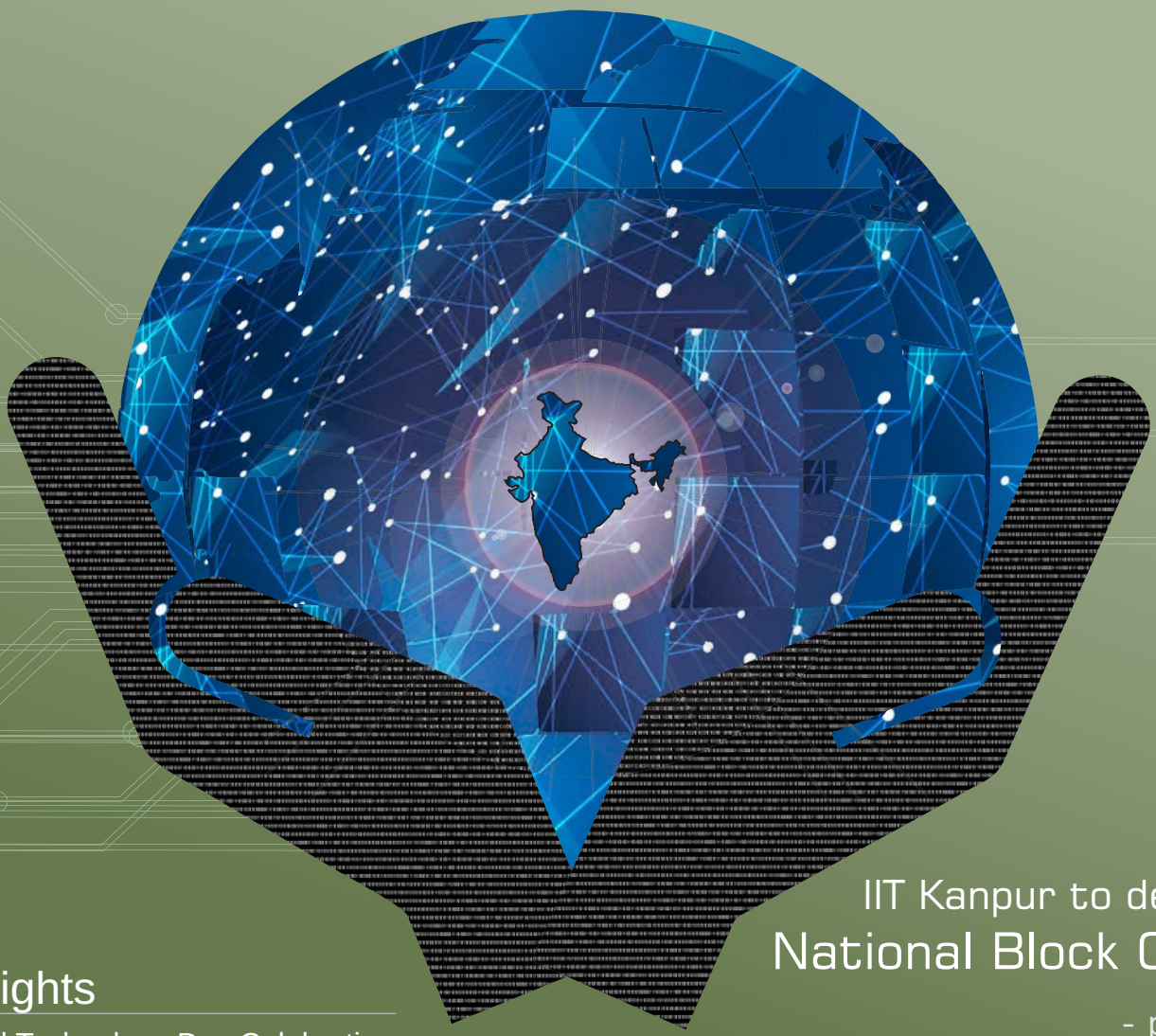
R&D Newsletter

Indian Institute of Technology Kanpur



IIT Kanpur to develop
National Block Chain
- page 3

Highlights

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National Technology Day Celebration

IIT Kanpur celebrated the National Technology Day on May 11, 2018. The event was organised by the National Centre of Flexible Electronics (NCFlexE), IIT Kanpur. NCFlexE was established in 2014 with a grant from the Ministry of Electronics and Information Technology, Govt. of India, and with support from the institute. Prof. Siddhartha Panda, Coordinator of NCFlexE, delivered the welcome address in the event describing the vision and achievement of the centre. Prof. Abhay Karandikar, Director IIT Kanpur, addressed the audience and elucidated about the technological needs of the country and the appropriateness to have a theme on an emerging technology that can shape the future. Prof. Y.N. Mohapatra delivered a popular lecture titled, "What if Electronics is Flexible". He mentioned that the emerging flexible electronics based technologies have the potential to impact all aspects of our life and this was enabled by the aspects of printability and flexibility. He described many such novel applications, demonstrated several technologies developed in the Centre including silver filled pens and conducting textiles and described several other technologies being developed such as organic solar cells, organic light emitting diodes, sensors, and thin film transistors. Over 250 school children from the city participated and gained exposure from the event.

Aerospace Engineering Department received FIST grant to Strengthen the Research Facility

The department of Aerospace Engineering received research grant Fund for Improvement of S&T infrastructure in universities & higher educational institutions (FIST) with a total support of Rs. 4.53 crores approximately, for 5 years for strengthening of the research facilities in the department. The funds are to be used for the following equipment / facilities: i) Free Piston/Expansion Tube Facility and essential instrumentation ii) Nd YAG Laser (for up-gradation of existing equipment) iii) Multi-Material Laser Sintering system, iv) Rayleigh Thermography setup v) Coherent Anti-Stokes Raman scattering (CARS) setup. This funding support from the Department of Science and Technology is being used to help initiate / expand the research capability of the department in the following areas: high enthalpy high speed flows, advanced flow diagnostics, improving mechanical integrity of aerospace materials and Unmanned Aerial Systems.

Cover Story

Development of National Blockchain and Demonstrate two Strategic Applications


PI: Prof. Manindra Agrawal (manindra@iitk.ac.in),
Co-PI: Prof. Sandeep Shukla (sandeeps@iitk.ac.in),
Department of Computer Science & Engineering

Sponsor: National Cyber Security Coordinator (NCSC).

The objective of the project is to develop **indigenous block chain platform for e-governance**. The 33.4 crores INR fund will be used over 5 years to research and develop prototype platform on which government agencies can build digital ledgers of various transactions and records which will be cryptographically secured while transparent to stake holders.

Block Chain technology is most well known in the popular press as the underlying technology for bitcoin – a much controversial cryptocurrency. However, this project will not deal with crypto currency applications at all. Instead, **the project will leverage the technology of block chain that provides a distributed digital platform that records events, records, and transactions which need to be transparent to the citizenry while being tamper proof, secure, and preserves privacy of individuals whose data resides on the platform.** In this project, IIT Kanpur will work with two government agencies to provide block chain based E-governance platform which if successful can be replicated throughout the government, and other sectors.

The project is planned in 3 phases, first a feasibility study and identification of agencies to pilot with, research and prototyping phase, and finally an incubation phase. In the incubation phase a IIT Kanpur incubated company will productive the solution and provide solution engineering to various agencies for block chain based transparent e-governance. Dr. Gulshan Rai, the National Cyber Security Coordinator has been instrumental in conceiving and funding the project. Prof. Shweta Agrawal from IIT Madras will be collaborator with Prof. Manindra Agrawal and Prof. Sandeep Shukla of IIT Kanpur in executing the project.

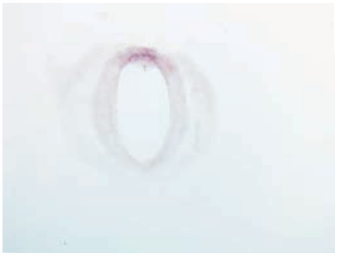
Functional Characterization of Metabolism related Genes (MRGs) with Restricted Expression in the Developing Vertebrate Nervous System


PI: Prof. Jonaki Sen (jonaki@iitk.ac.in),
Co-PI: Prof. Amitabha Bandyopadhyay (abandopa@iitk.ac.in),
Department of Biological Sciences & Bioengineering

Sponsor: Department of Biotechnology

In the developing embryo, a process known as differentiation leads to production of specialized cells a pool of undifferentiated stem/progenitor cells. Differentiated cells belonging to different tissue types possess distinct physico-chemical properties that correspond to the specific function that they perform. These differences in physico-chemical properties maybe attributed to the distinct repertoire of metabolites present within the cell belonging to a particular tissue. A special class of genes known as **Metabolism Related Genes (MRGs)** that code for metabolic enzymes, transporters etc. are responsible for the unique metabolites in each tissue type.

This proposal stems from a previous study conducted in the laboratory of Prof. Amitabha Bandyopadhyay, where a genome-wide screen showed that several MRGs are expressed in a tissue restricted manner in the developing chick embryo. This observation, gave further motivation to propose a study where it is aimed to functionally characterize and elucidate the role of a subset of such MRGs in the developing central nervous system, using chicken and mouse embryos as model systems. **The ultimate goal of the study is to determine whether any of these MRGs exhibit 'moonlighting activity" along with their metabolic function during development.** This study is likely to provide new insights into the mechanisms of vertebrate nervous system development.




PHACTR1 CNKSR2

Two MRGs showing tissue restricted expression in the cross-section of the embryonic chicken forebrain: a) PHACTR1 (Phosphatase 1 and actin regulatory subunit 1), showing specific expression in the ventral region of the chick forebrain.
b) CNKSR2 (Connector Kinase Suppressor of Ras 2), showing specific expression in the dorsal region of the forebrain, as indicated by the appearance of purple colouration at the site of its presence.

Enhanced Coal-Bed-Methane and Shale-Gas Recovery from Underground Reservoirs aided by Permeability Enhancement and CO_2 Sequestration – an Experimental Approach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Co-PI: Prof. Malay K. Das (mkdas@iitk.ac.in),
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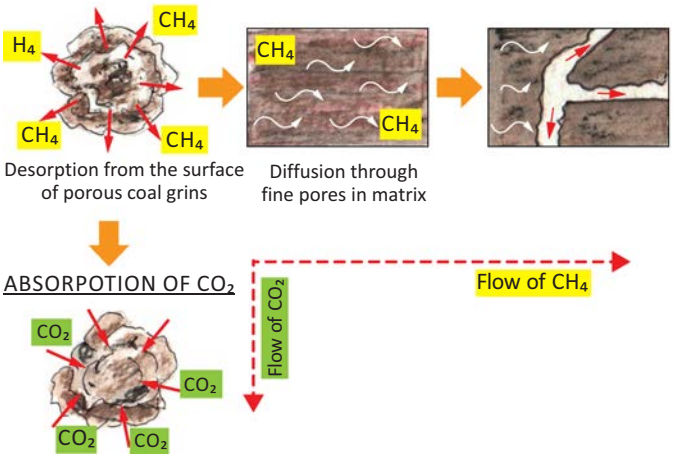
Sponsor: Oil and Natural Gas Corporation Limited (ONGC)

The project will explore and quantify the enhanced CH_4 (Unconventional Energy Resource, UER) recovery from selected Indian coal-basins, gas-rich-shale and tight-sediment reservoirs by studying the **stress induced micro-mechanisms to maximize the gas flow under complex Thermal-Hydrological-Mechanical environment coupled with CO_2 injection**. It will characterize the controlled and directional fracture generation using the intrinsic properties of coal and shale, particularly the anisotropy, natural-fractures and regional stress-field. An additional effort will be given to understand adsorption-desorption interaction of CH_4 and CO_2 to further extract CH_4 from the reservoir. Hydraulic pressure along a narrow channel (analogues to bore-hole) will be used to create the fracture network in the representative samples. Acoustic emission (AE) and pulse transmission (PT) measurements will track the fracture propagation and seismic property variations, respectively, during the fracturing. A high pressure temperature tri-axial load frame equipped with PT and AE facilities will be installed as major instrumentation, which can also be employed to characterize geothermal-reservoirs in future.



A schematic illustration suggesting the micro-mechanics and processes during CO_2 injection mediated enhanced CH_4 recovery. [Mukherjee & Misra, Earth Science Reviews, 2018]

From strategic point of view, the proposal aims to develop **sustainable research collaboration between ONGC and IIT Kanpur** in continuing effective research directions of UER exploration, Rock Physics and Geo-Mechanics.

snippets

The research work of Mr. Dipro Sarkar, a Ph.D. student under the supervision of Prof. Rajiv Sinha, Department of Earth Sciences had been highlighted in a television show on "Might Rivers" broadcasted on Animal Planet on 8th April 2018 in the USA. The British filmmaker Jermey Wade, the maker of the famous series on River Monsters, made this film. He visited IIT Kanpur in 2017 and filmed the work carried out by Dipro Sarkar.

The work involves the innovative use of remote sensing techniques particularly the UAVs for water quality mapping in the Ganga river. In this work, optical and hyperspectral remote sensing is being used from airborne cameras for mapping and characterizing the effluents into the Ganga river. This work was partially supported by the IMPRINT program.

https://drive.google.com/open?id=1iUF2Dl1tC8k_wTPtxhZup0rEXK0nQkKK

Nanohybrids for Hydrogen Storage



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Department of Chemistry

Sponsor: Science and Engineering Research Board (SERB)

Intense investigations are in progress globally towards the use of hydrogen as an alternate fuel. Hydrogen storage is an important step towards realizing this vision and solid state storage has emerged as the preferred method. Monolithic materials often suffer from more than one lacunae with regard to hydrogen storage and hybrids have taken centre stage to take this technology towards widespread applications. Microstructurally engineered Mg-based nanohybrids have shown promise via good storage capacity and fast kinetics.

Traditionally used materials store hydrogen principally in one form. The hydrogen is stored either in molecular form (MOFs or carbonaceous materials) or in hydride form ($LaNi_5$, Mg_2Ni, Mg). The materials storing hydrogen in molecular form typically do so by adsorption, which requires low temperatures. Some of the materials which store a large quantity of hydrogen (e.g. sodium alanates) do so in non-reversible fashion and require high temperatures for desorption. If the material is not naturally a catalyst for the breakdown of the hydrogen molecule into atomic form, high temperatures are required even for absorption. The current work focuses on a multi-mode hydrogen storage philosophy using nanocontainers (Figure 1).

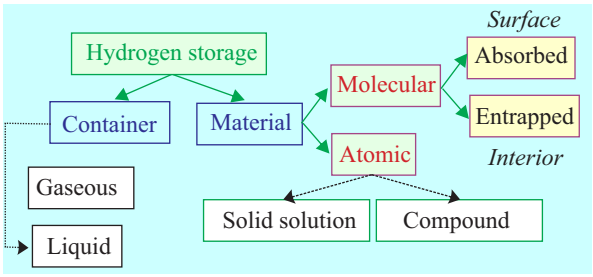


Figure 1: Multi-mode hydrogen storage philosophy to exploit storage of hydrogen in various phases

The objectives of the current investigations are to transcend traditional approaches and to devise a novel strategy for hydrogen storage in nearly all conceivable forms; i.e., (i) in a container; (ii) in atomic form as (a) solid solution, (b) as a compound; (iii) in molecular form (a) adsorbed on the surface and (b) free gaseous form. This is to be achieved using single and multilayer nano-hybrids.

The project will attempt to address the following important scientific issues:

(i) Can the catalytic layer in the hybrid play a 'double role' (dissociation at the outer surface and recombination in the inner surface)?
(ii) Can hollow hybrids be used as nano-reactors? How to understand the diffusion?
(iii) What form is the hydrogen present inside hollow hybrids (adsorbed, absorbed) and at what pressure?
(iv) In hybrids where is the nucleation of the hydride/second phase preferred?
(v) In hybrids with carbon can storage be achieved under ambient conditions?

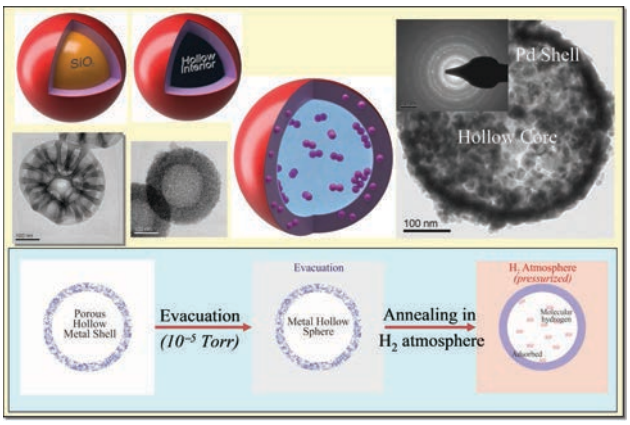


Figure. 2. Processing and structure of nanohybrids.

Hip Joint Replacement System

PI: Prof. Kantesh Balani (kbalani@iitk.ac.in),
Department of Materials Science & Engineering

Sponsor: Department of Science & Technology, DST

The project is awarded as Swarnajayanti Fellowship

Current research emphasizes on understanding basic mechanisms of strengthening, to elicit interfacial interactions, develop mechanistic models to explain toughening, assess biological aspects to obtain cytocompatibility, and in vivo evaluation of systemic biocompatibility.

Hip-joint replacement involves mainly three components:

(I) femur,
(ii) acetabulum, and
(iii) interlayer cartilage.

Materials that replace the femoral components are: (i) metal/alloys for femoral stem, (ii) a ceramic femoral head, and (iii) polymeric acetabular cup liner to serve as articular cartilage (with a metallic backing to serve as acetabulum), Fig. 1. In general, a revision surgery on young patients may be expected after 10-15 years of implantation due to its loosening, which is costlier and more painful than the first one. Herein, an attempt is made to: (i) designing polymeric liner materials with enhanced tribological life and limited aseptic loosening, and (ii) creating multi-functional porous coating on femoral stem for ensuring rapid bone growth.

The main objectives of project are:

(i)To fabricate antibacterial acetabular cup liner (UHMWPE-Al_2O_3-Ag/ZnO-based) with enhanced tribological resistance

(ii) Deposit functionally graded and multi-length scale porous coating of hydroxyapatite (HA-CeO_2-CNT-Ag/ZnO based) on femoral stem (with enhanced fracture toughness, uncompromised bioactivity and antibacterial resistance)

(iii) Ceramic processing for completely dense and antibacterial femoral head (YSZ-Al_2O_3-CNT based ceramic composites)

(UHMWPE: Ultra high molecular weight polyethylene, HA: Hydroxyapatite, CNT: carbon nanotubes, YSZ: Yttria stabilized zirconia)

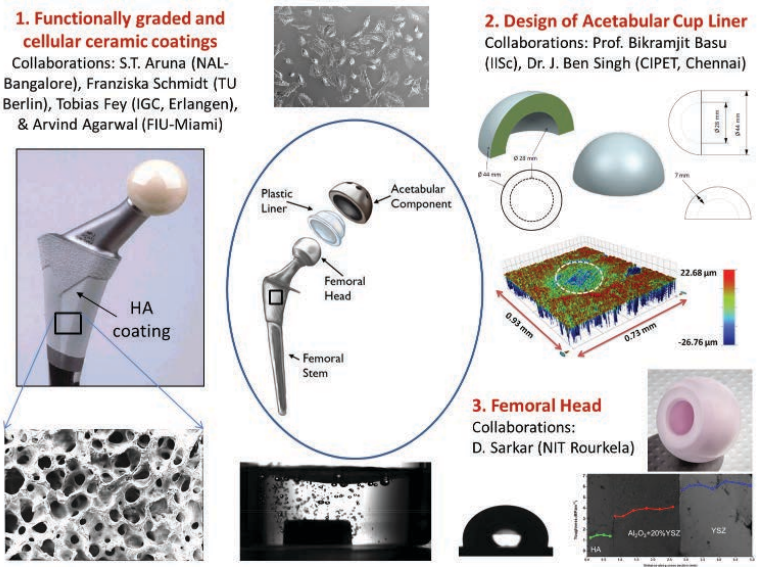


Fig. 1: Bird's eye view of the challenges associated with the design of hip-joint components (images from self-research & https://www.molteno.com/m-sphere-natural-hydroxyapatite-orbital-implants & www.exac.com). These aspects are targeted in the current research.

snippets

- A recent paper of Prof. J.N. Moorthy and his students from the Chemistry department titled "Photochromic 2D Metal-Organic Framework Nanosheets (MONs): Design, Synthesis, and Functional MON-Ormosil Composite" has been published in the journal, CHEM. The works have demonstrated that 2-dimensional metal-organic nanosheets (MONs) constructed from photochromic building blocks can be used for the desired optical properties in photochromic polymers. This research will have many applications notably in ophthalmic lenses. CHEM is a prestigious journal published by the Cell Press.

  more details about the publication:
  https://www.sciencedirect.com/science/article/pii/S2451929418301268

Indigenous 5g Test Bed Design

PI: Prof. Rohit Budhiraja (rohitbr@iitk.ac.in),
Co-PI: Prof. Adrish Banerjee (adrish@iitk.ac.in)
Department of Electrical Engineering

Sponsor: Department of Telecommunications, Ministry of Communications

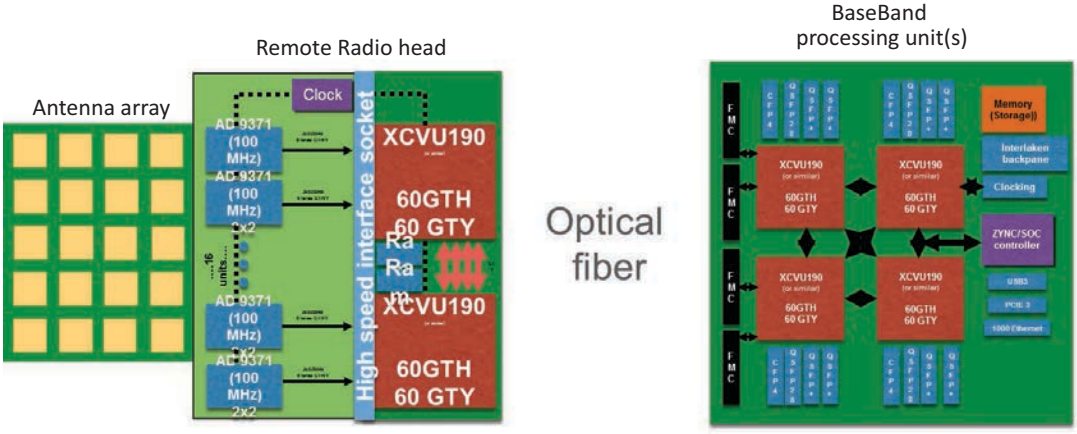
A 5G testbed is being built to enable Indian industry and academia to achieve the 5G technology development and implementation plans. This testbed will be designed and completely built in house.

The project goals are to:

- Provide an open test bed that can enable R&D teams in Indian academia and industry to validate their products, prototypes and algorithms for the 5G networks.
- Develop an end to end test bed to develop and demonstrate various 5G services and technologies, e.g, IoT, massive MIMO and millimeter wave (MMWave) communication system.
- Provide a test bed to work on new novel concepts/ideas holding potential for standardization in India and on global scale.
- Develop a test bed available for Indian telecom operators to understand the working of 5G technologies and plan their future networks.

Other than IIT Kanpur, this multi-institute project has participation from IIT Bombay, IIT Delhi, IIT Hyderabad, IIT Madras, IISc Bangalore, CEWiT and SAMEER (both from Chennai). IIT Kanpur is designing the hardware and software algorithms for the 5G massive MIMO, MMWave and full-duplex access network. As a part of this testbed, a state-of-the-art 5G testbed lab is being developed in the Electrical department, consisting of wireless test equipments such as vector signal analyzers, spectrum analyzers, logic analyzers and high-speed oscilloscopes. The lab will also have printed circuit board simulation and design softwares.

A block diagram of the massive MIMO base station (BS) consisting of 32 antennas being architected at IIT Kanpur, is shown below. A BS consists of an antenna array, a remote radio head (RRH) and a baseband processing unit (BBU). The antenna array transmits and receives the radio signals. The RRH up converts and down converts the transmit and receive signals respectively. BBU , the BS workhorse, consists of high-end FPGAs which executes both transmitter and receiver algorithms. The RRH and BBU are connected using optical fiber.



snippets

- Prof. Aditya K. Jagannatham, Department of Electrical Engineering, with his students Mr. Suraj Srivastava and Ms. Saumya Dwivedi, have been selected for the Qualcomm Innovation Fellowship (QInF) 2018-2019. The fellowship is an award for an innovative idea entitled "Sparse Signal Processing for 5G mm Wave MIMO Technology."

- In 2016, Professor RRK Sharma, Mr. Vinayak A. Drave, and Dr. Jyoti Kainth have published a conceptual paper on "Strategy and Supply Chain Structure of E-Tailers in India. After extensive Data collection and analysis the work got recognized by the Retailers association of India and published as a cover story (The changing interplay of Strategy , supply chain & Retail) in their quarterly magazine Storai (Vol 9 | Issue 3; March_April 2018).

Inauguration of Centre for Energy Regulations

IIT Kanpur establishes India's first Centre for Energy Regulation (CER). CER is an endeavour towards comprehensive and sustained institutional strengthening in the Indian power sector. It is an initiative led by the Department of Industrial Management and Engineering. Mr. PK Pujari, chairperson Central Electricity Regulatory Commission (CERC), inaugurated the centre on May 17 at a ceremony held on New Delhi. The centre's logo and web portal were unveiled at the ceremony in the presence of other dignitaries including secretary, ministry of power AK Bhalia, Chairman, Board of Governors IITK, Mr. RC Bhargava and Gavin McGillivray, Head, Department for International Development, India.

The aim of the Centre is to strengthen the Indian power sector working closely with key stakeholders particularly the Electricity Regulatory Commissions (ERCs), electric utilities and academia. The Centre and its activities are partly supported by the UK Government through a project on 'Strengthening Regulatory Research Network in the Power sector' under the "Supporting Structural Reforms in the Indian Power Sector" program.

more at:
http://cer.iitk.ac.in/

IIT Kanpur to develop VTOL Aircraft Prototypes

Researchers at IIT-Kanpur have signed a Rs 15-crore MoU with VTOL Aviation India Pvt Ltd to develop functional prototypes of which have the potential to be used as flying taxis. The Aerospace department of IITK has one of the country's leading state-of-the-art facility when it comes to research in aerospace and propulsion. It houses wind-tunnels and flight labs capable of testing aircraft. VTOL aircraft can be used for surveillance, rescue mission, combat situations, paramedics, and civil aviation. These aircraft will also be very useful for rapid medical evacuation of troops from difficult terrains. The development of such a prototype could be quite revolutionary if realised effectively, bringing in drastic changes to our transportation systems and connectivity.

Industry-Academia Collaboration

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