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From the Editor's Desk

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Visualise one such smart classroom filled with 'engaged' students using the wondrous power of technology. The idea behind technology enhanced classrooms is to foster better opportunities for teaching and learning. Do these classrooms serve their purpose? Some educators question the excessive use of technology in schools.

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Internet helps us to move ahead in life. The opponents worry. They worry that the internet shifts our cognitive functions from searching for information inside the mind towards searching outside the mind. They say the way calculators have reduced the role of pure computation and simple arithmetic, internet is reducing the role of our thought process. They say Internet has freed us from the burden of commuting to attain literacy, but has also fragmented our thinking process.

Information overload, some believe, has begun to affect our reflection and introspection. They feel, over information is coming in the way of our ability to take risks. Overburdened with so much real-time information, where is the time for introspection and innovation, they ask.

We live in a world where information is cheap, but meaning is expensive, writes George Dyson. In such a world, should we allow submergence of human intelligence by computational intelligence?

ACADEMY ACTIVITIES

11th National Frontiers of Engineering Symposium (NatFOE-11)

The Eleventh National Frontiers of Engineering Symposium (NatFoE-11) was held from June 30-July 1, 2017 at IIT Bombay. Prof. DV Khakhar, Director, IIT Bombay had hosted the NatFOE-11 Symposium at IIT Bombay. The aim of the Symposium was to promote cross-disciplinary exchange of ideas and transfer of new techniques in order to build and sustain the innovation paradigm. The overall purpose of the symposium was to achieve synergy among Aerospace, Energy and Biomedical Engineering disciplines at different scientific scales through discussions in the following four thematic areas:

- Alternate and Advanced Fuels
- Manufacturing and heat transfer for Aerospace applications
- Technology for improving Childcare and Mothercare
- Technology for tackling fog and pollutants.

56 leading researchers, technologists and policy-makers from various institutes and R&D labs, industries & start-ups came together to share their contributions and discuss the way forward with respect to these themes. Special attention was given to cover policy related aspects relevant to these topics. The Symposium featured several very stimulating talks and close interactions, with interesting interactive sessions held all day long. Plenary talks by Prof. Baldev Raj, FNAE, Director, NIAS, Bangalore on Energy and Prof. Devang Khakhar, FNAE, Director, IIT Bombay on Need for R&D in India were very well received by the audience. Each of these talks were followed by a particularly thought provoking question-answer session. The keynote talks were delivered by distinguished personalities such as Dr. B.N. Suresh, President INAE, Mr. S.A. Bhardwaj, FNAE Chairman, AERB, Dr. Mallini Shankar, Director General, Shipping, Dr. Ajit Sapre, FNAE, Group President–R&T, Reliance Industries Limited and Dr. Rakesh Kumar, Director, CSIR-NEERI, Nagpur. Various fine points were brought out in these talks due to the vast personal experience of the speakers in their respective fields.

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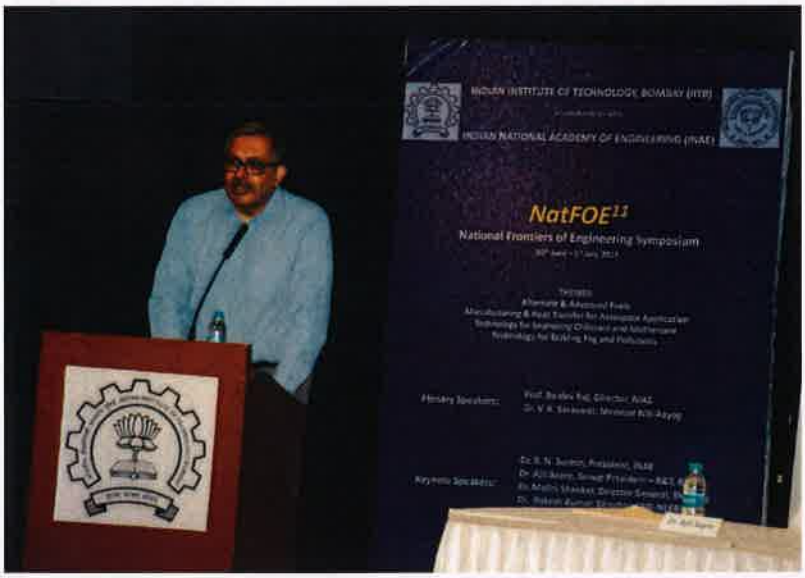


Prof DV Khakhar, Director, IIT Bombay Delivering the Welcome Address

Dr BN Suresh, President, INAE Delivering the Keynote Address

In addition, 10 distinguished scholars gave invited talks. The remaining invitees gave a brief presentation about their work. There were also two overview talks and a panel discussion, coordinated by Prof. M.D. Atrey, IIT Bombay. The topic of the panel discussion was "Creating Eco-system and Mentoring Start-ups" and comprised two sets of panel members – those who have helped create eco-system and those who have utilized the eco-system to successfully create their start-ups. The response of the audience to the panel discussion was particularly heartening, even when it was almost the last event in the schedule.

A large number of INAE Fellows and Faculty Members from IIT Bombay also attended the Symposium and contributed by chairing the various sessions. Prof. Atul Sharma & Prof. Upendra V. Bhandarkar of IIT Bombay will be releasing the proceedings of the Symposium shortly. The cross-disciplinary nature of the Symposium allowed a wider perspective to the participants, and exposed them to some of the pressing societal issues and ongoing research work in various parts of the country.

INAE-NIRDPR Workshop on "Frugal Innovations"

INAE jointly with National Institute of Rural Development and Panchayati Raj (NIRDPR) and Vijnana Bharathi organized a Workshop on "Frugal Innovations" on July 7-8, 2017 at NIRDPR, Hyderabad. The Workshop focused on ways and means to encourage frugal innovation to happen in the country and to create much needed eco system between Government, industry, entrepreneurs and the youth. The subject Workshop was planned in continuation of the engagement of INAE with the youth in the country wherein participation of young entrepreneurs involved in Frugal Innovation and the experts in the area spread over various sessions was envisaged. The Chief Guest Shri M Venkaiah Naidu, Hon'ble Union Minister for Urban Development, Housing and Poverty Alleviation and Information and Broadcasting, Govt. of India on July 7, 2017 delivered the Inaugural Address on July 7th, 2017. Dr WR Reddy, Director General, NIRDPR delivered the Presidential Address in the Opening Session which also featured an Address by Guest of Honour, Shri Konda Vishveshwar Reddy, Hon'ble MP, Lok Sabha, Telangana. The workshop was conducted in four Technical Sessions on "Frugal Innovation"; "Frugal Innovation-Success Stories"; "Voice of Student Innovators" and "Marketing Business Models and Outreach". The highlight of the Workshop was the participation of about 200 students from all over the country, who were selected through competitions on innovations. Their work was also exhibited in the Workshop. The structure of the Workshop was organized in such a manner, that it addressed all these vital areas and the experienced experts in these areas delivered the lectures. There was a special student's session

and 10 students who were selected through a rigorous screening, based on their work just a day prior to the workshop were given an opportunity to present their work. An intense interaction with all stakeholders was also held. The workshop concluded with a Valedictory and Panel Discussion on "Way Forward to Reach Out" that was Chaired by Dr VK Saraswat, Member Niti Aayog, Govt. of India. During this session, presentations were made by the Sessions Chairs of the four Technical Sessions and a Prize Distribution Ceremony was held for the students. After the workshop, a visit was organized to showcase Live Demonstration of different rural technologies including DRDO Life Sciences at Rural Technology Park.

The Chief Guest, Shri M Venkaiah Naidu, Hon'ble Union Minister for Urban Development, Housing and Poverty Alleviation and Information and Broadcasting,

Dr. Abdul Kalam Technology Innovation National Fellowship

INAE and DST have taken an initiative to institute "Abdul Kalam Technology Innovation National Fellowships" to outstanding engineers to recognize, encourage and support translational research by individuals to achieve excellence in engineering, innovation and technology development. All areas of engineering, innovation and technology will be covered by this fellowship. A Maximum of 10 Fellowships will be awarded per year. Efforts are ongoing to finalize the guidelines and launch the Fellowship by Aug 15, 2017

Annals of INAE

The soft copy of the Annals of the INAE Volume XIV, April 2017 containing the text of the lectures delivered by Life Time Contribution Awardees; newly elected Fellows of the Academy and INAE Young Engineer Awardees 2016 has been uploaded on INAE website under the Publications sub-head. The same can be downloaded from the link given below

http://inae.in/ebook/inae-annals-2017/

INAE on Facebook and Twitter

INAE has created a Facebook and twitter Account to post the news of recent INAE activities in the Social Media. The same can be viewed at the link below.

(a) Facebook -link https://www.facebook.com/pages/Indian-National-Academy-of-Engineering/714509531987607?ref=hl

(b) Twitter handle link https://twitter.com/inaehq1

All INAE Fellows are requested to visit and follow the above to increase the visibility of INAE in Social media.

Important Meetings held during July 2017

- **Selection Committee for shortlisting of projects/theses for Innovative Student Projects Award 2017 on July 19, 2017** for presentations before the Selection Committee.

- **Steering Committee Meeting on on Research Schemes/Proposals on July 20, 2017** wherein the main agenda included Presentations by shortlisted nominees for INAE Innovator Entrepreneur Award for selection of the Awardee

International Conferences/Seminars being organized by IITs/other Institutions
To view a list of International Conferences/Seminars being held in the month of August 2017 click here

Honours and Awards

1.	Dr Baldev Raj, Immediate Past President -INAE and Director, National Institute of Advanced Studies, Bangalore and formerly Distinguished Scientist and Director, IGCAR Kalpakkam and Formerly President-Research, PSG Institutions, Coimbatore was conferred the Jawaharlal Nehru Birth Centenary Award by Indian Science Congress Association, (ISCA), Bangalore Chapter. The award honours key individual for significant and lifetime contribution to the development of Science and Technology for the country and was announced during 104th Indian Science Congress held at SV University, Tirupati on January 3, 2017. Dr Baldev Raj was also conferred the SASTRA-CNR Rao Award for Excellence in Chemistry & Materials Sciences, at SASTRA University, Thanjavur on February 28, 2017. He also received the Prof. T R Anantharaman Memorial Award on Metallurgy Day at the Department of Metallurgical Engineering, IIT-Banaras Hindu University, Varanasi. He was also conferred the Lifetime Achievement Award, Indian Science Monitor & Indo Asian Foundation for Archaeological Research by Hon'ble Chief Justice M.N. Venkatachaliah.

News of Fellows

1.	Dr Baldev Raj, FNAE, Immediate Past President -INAE and Director, National Institute of Advanced Studies, Bangalore and Formerly Distinguished Scientist and Director, IGCAR Kalpakkam and Formerly President-Research, PSG Institutions, Coimbatore was conferred the Degree of Doctor of Science (Honoris Causa) for the outstanding contribution in the field of Science and Technology by Indian Institute of Engineering Science and Technology (IIEST); An Institute created by Act of Parliament, Shibpur, March 4, 2017. Hon'ble Prime Minister of India & President Council of Scientific & Industrial Research (CSIR) has appointed Dr Baldev Raj as the Chancellor & Chairperson of the Board of Governors of the Academy of Scientific and Innovative Research (ACSIR), CSIR, New Delhi, 2017. Dr Baldev Raj was appointed Chairman of the Eminent Apex Committee of Council of Scientific & Industrial Research (CSIR) to recommend transformations and improvements for meeting and enhancing the objectives of CSIR, 2017. Department of Science and Technology (DST) has appointed Dr Baldev Raj as Chairman of BRICS- Science &Technology Enterprise Partnership (BRICS-STEP) Working Group for the periods of 4 years, 2017. Dr Baldev Raj is Chairman, BRICS Experts Panel Committee on International Collaborations relating to Advanced Materials, Nanotechnology, Photonics, Astronomy and Astrophysics, 2017. Dr Baldev Raj is also

	Chairman, Selection Committee for Selection of Indian Team for participation in 2nd BRICS Young Scientists Conclave to be hosted by China, Ministry of S&T, DST, Delhi. Dr Baldev Raj is Member of Confederation of Indian Industry (CII) National Committee on Higher Education (2014-18). He is Expert Member, Committee, NITI Aayog for framing S&T Vision for India. Dr Baldev Raj is Member, "Emerging scenario for Nano-Electronics" under Chairmanship of Dr R Chidambaram, PSA to GoI to take into view, the opinion of experts and stakeholders for the next phase of R&D efforts, including the maintenance of the excellence already achieved, industry interaction and develop a road-map in this important field, 2017. Dr Baldev Raj is also Member of the Over Arching Committee for the R&D project on the development of the Advanced Ultra Supercritical technology (AUSC) for thermal power plant, Ministry of Heavy Industries and Public Enterprises, Department of Heavy Industry, Government of India, 11 April 2017. He is also Member, Board of Governors, TransDisciplinary University, Bengaluru, May 2017 and Member of Indian Ministerial Delegation of the 7th BRICS STI Senior Official Meetings and 5th BRICS STI Ministerial Meeting at Hangzhou China, DST GoI, India, May 2017. Dr Baldev Raj is Chairman, Council of Scientific and Industrial Research CSIR- Recruitment & Assessment Board (RAB) Advisory Group, New Delhi (2017-2019), 7 June 2017. Dr Baldev Raj is Member, Committee of Life Time Achievement Award and Outstanding Achievement Award of ISRO Awards Scheme, ISRO, June 2, 2017 and also Chairman, Committee for Reviewing the outcome of the Centre for Knowledge Management of Nanoscience & Technology (CKMNT) Phase –I, International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), Hyderabad, 21 June 2017.
2	Prof. K. Bhanu Sankara Rao Ministry of Steel Chair Professor at MGIT Hyderabad has been elected as Fellow of Telangana Academy of Sciences.

International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS 2017) on August 1-2, 2017 at Chennai
https://conferencealerts.com/show-event?id=185773

2nd Springer International Conference on Intelligent Computing and Communication – ICICC 2017 on August 2-4, 2017 at Pune
https://conferencealerts.com/show-event?id=181295

International Conference on Recent Trends in Electrical Sciences & Medical Engineering on August 8-10, 2017 at Manipal
https://conferencealerts.com/show-event?id=182379

4th International Conference on Nanoscience and Nanotechnology on August 9-11, 2017 at Chennai
https://conferencealerts.com/show-event?id=184393

2nd International Conference on Telecommunication and Networks on August 10-11, 2017 at Noida
https://conferencealerts.com/show-event?id=181110

The IEEE International Conference on Innovations in Control, Communication and Information Systems (ICICCI-2017) on August 12-13, 2017 at Greater Noida
https://conferencealerts.com/show-event?id=182718

5th International Conference on Innovations in Computer Science & Engineering on August 18-19, 2017 at Hyderabad
https://conferencealerts.com/show-event?id=184123

International Conference on Recent Advances in Computer Science E-Learning Information & Communication Technology on August 19, 2017 at New Delhi
https://conferencealerts.com/show-event?id=188704

High Efficient Converters: A Backbone of Efficient Renewable Energy Systems in an Indian Electricity Network

Hiralal M. Suryawanshi

Continuously growing population and industrial revolution in India demands affordable, reliable, uninterrupted and quality power supply. Thermal power generation has major share of current electricity demand in India, which leads to emission of carbon pollutants and causes global warming. In order to overcome the energy crises and avoid hazardous effects of global warming, hybrid DC/AC micro-grids equipped with renewable energy sources such as solar photovoltaic, wind energy systems, fuel cells, micro-hydro power generation units, etc. are gaining more popularity. These sources are low voltage sources; therefore, design of high efficient, high step-up, soft-switched converters plays a prominent role in efficient utilization and conversion of available energy; particularly, DC-DC converters for DC micro-grids and DC-AC converters for AC micro-grids. High-speed wide band-gap (WBG) semiconductor devices, such as silicon carbide (SiC) and gallium nitride (GaN) both, having ability to withstand higher voltages with reduced switching and conduction losses are used to further increase the converter efficiency. Use of high-speed semiconductor devices allows converter to operate at high switching frequency, which reduces size of the magnetic components, hence increases power density of the converters and overall power conversion efficiency with reduced size and cost. This letter aims to focus the researcher's concentration towards the necessity and practical implementation of renewable energy based hybrid DC/AC micro-grid systems. Necessity of high efficient converters using high-

speed wide band-gap (WBG) semiconductor switches for further efficiency improvement is narrated in subsequent sections. An improvement in the converter efficiency compared to conventional converter efficiency is demonstrated graphically.

I. Necessity of DC micro-grid

At the beginning, invention of electricity distribution was started with DC power distribution electricity grids in 18th century. Due to lack of technology and availability of resources for energy transformation, instead of developing DC power grids, researchers have concentrated on generation, transmission and distribution of AC power networks in 19th century. In last century, most of the residential lighting loads and industrial motor loads demand AC power only. Hence, installation of AC power grids became necessity for energy utilization. In addition, it is very easy to step-up and step-down AC voltage levels in order to transmit generated power over a long distance for efficient utilization. These advantages made AC power network a main choice.

Today's continuously growing population and industrialization in India demands affordable, reliable, uninterrupted and quality power supply. Fossil fuel based thermal AC power generation has major share of current electricity demand in India. Due to scarcity and the soaring prices of fossil fuels, installation of new thermal AC power plants is becoming expensive day by day. In addition, fossil fuel based thermal power generation leads to emission of carbon pollutants and causes global warming. These generating stations are remotely located, hence increases the long distance transmission losses so decreases the overall power conversion efficiency. In order to overcome the energy crises and avoid hazardous effects of global warming, locally distributed DC micro-grids equipped with renewable energy sources such as solar photovoltaic, wind energy systems, fuel cells, mini-hydro power generation units, etc. are gaining more popularity.

From last few decades, inventions of new solid-state devices and advancements in the power electronics technology have evolved an advanced DC-DC converters and different types of residential and industrial DC power loads. Today's most of the residential and industrial loads demand DC power supply such as: Electric vehicles, international space station (ISS), spacecrafts, modern aircrafts, telecommunications, off-grid buildings loads, LED lighting loads, charging phones, laptops, LCD TVs, modern variable speed industrial drives, electronics loads, heating, ventilation and energy efficient air conditioning equipments, etc. Air conditioning equipments have variable speed DC motor drives. Incorporation of high efficient DC micro-grid with appropriate voltage levels is the only economical solution for such loads where conversion of AC to DC is not necessary that leads to tremendous amount of conversion losses. Therefore, it is more economical and efficient way to power such loads directly from a local DC micro-grid. Fig. 1 shows typical structure of an efficient DC micro-grid incorporated with renewable energy sources, energy storage systems and high efficient power electronics converters. As it is very difficult to replace strong AC grid entirely with DC micro-grid, interconnection of DC/AC grid is feasible and economical solution. Therefore, in order to overcome global energy crises and the effects of global warming, incorporation of hybrid DC/AC micro-grid systems should be India's future contribution to globalization.

II. Necessity of high efficient converters design and development

Keeping in mind today's energy scenario and electricity consumers demand, it is necessary to build a power supply system with low energy conversion losses, high conversion efficiency and pollution free. With these goals, researchers should focus towards development of renewable energy systems based hybrid DC/AC micro-grids.

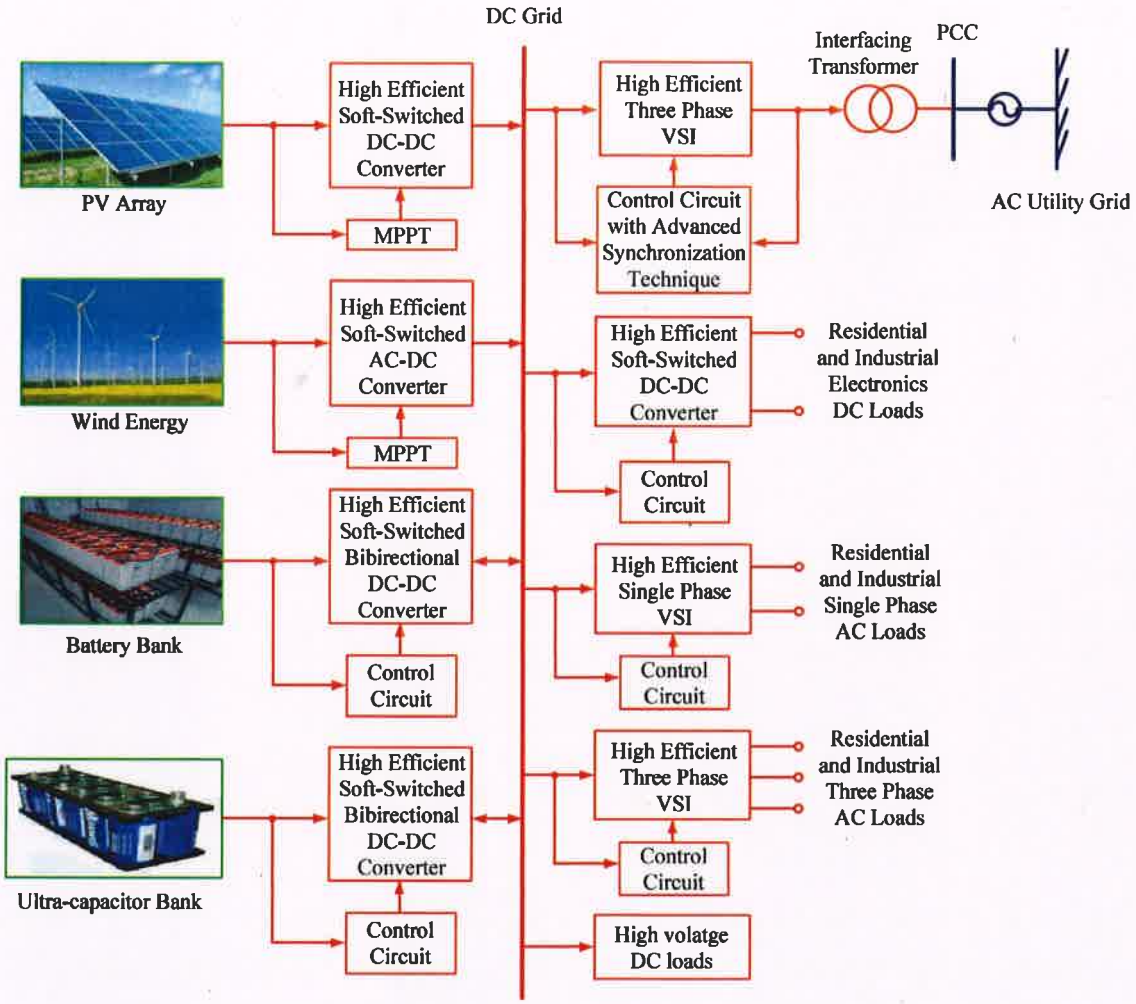


Fig. 1 Typical structure of an efficient DC micro-grid incorporated with high efficient converters.

Due to easily available solar energy, solar photovoltaic panels based locally distributed DC micro-grids are gaining more popularity. The only drawback of solar photovoltaic generation unit is its energy conversion efficiency is very less. Maximum efficiency of the solar PV cell is 16%. Due to this reason, solar PV systems installed for residential and industrial applications are preferred to operate at low output voltage (generally less than 50V). This voltage is not sufficient to drive most of the loads and cannot be integrated to the utility grid. In order to boost this voltage to utility voltage level, conventional boost converters are used. However, conventional boost

converters have limitation of high voltage gain as its efficiency decreases due to high conduction losses, large voltage stress on the switches and diode's reverse recovery losses.

To avoid these problems, in the past few decades, extensive research has made revolutionary changes to conventional boost converters. Various researchers have proposed different types of high step-up DC-DC converters, which incorporate different features such as high frequency transformers, coupled inductors, interleaved coupled inductors, active and passive clamp circuits, etc. Isolated converters can also be used to achieve high voltage gain, but non-isolated converters are preferably used because of their higher efficiency, lower cost and higher power density. Among the various non-isolated high step-up DC-DC converters, the coupled inductor boost converters are considered as best solution for high-step-up applications, because it has facility to increase the voltage conversion gain by simply changing the turn's ratio. The main drawback of these converters is that the leakage energy in the coupled inductor increases voltage spike on the switches, which is further reduced by using lossless active and passive clamp circuits.

The integrated boost converter is also used as high step-up converter, in which boost converter is acting as a passive clamp circuit but experiences high voltage stress on the output diodes. In order to reduce this voltage stress and improve the voltage gain, voltage multipliers are introduced at the secondary side of the coupled inductor. In this type of converters, the leakage inductance of the coupled inductor reduces the reverse recovery losses of the diodes and hence increases converter efficiency. However, these converters are all hard-switched converters, which have limited conversion efficiency up to 80%. Hence, overall solar PV based generation system conversion efficiency is very less as indicated in Table I.

TABLE I: Overall system conversion efficiency with hard switching converters.

Sr. No.	Renewable Energy System Component	Efficiency
1	DC-DC Converter	Less than 80%
2	DC-AC Converter	Less than 80%
3	Magnetic components: Transformers, Inductors, Switching devices, Gate driver circuits, Digital signal processor, Power supply	Less than 95%
4	Solar Cell	Less than 16%
Overall system efficiency (1 to 3) = 0.8*0.8*0.95		Less than 60.8%
Overall system efficiency including solar cell (1 to 4)= 0.8*0.8*0.95*0.16		**Less than 9.73%**

A. Why not hard switching converters?

1) Switching frequency of the hard switching converters can be increased to reduce the size of the converter reactive components like inductors, capacitors, high frequency transformers etc.
2) However, such high switching frequency operation significantly affects power conversion efficiency because of increased switching power losses caused due to the overlap of switch voltage and switch current during a switching transition.

Efficiency of all these high gain hard-switched converters is further improved by reducing the switching losses. This is achieved by incorporating soft switching techniques such as zero voltage switching (ZVS) and zero current switching (ZCS). In integrated boost converter, ZVS of the main switch depends only on the stored energy of the leakage inductance. In non-isolated, soft switched integrated boost converter, a resonant voltage quadrupler cell is integrated at the secondary terminals of the coupled inductor to obtain high voltage gain. In addition, ZVS turn on of main MOSFET and the ZCS turn off of all the diodes reduces the high frequency switching

losses and reverse recovery losses. Hence improves overall power density and converter efficiency as shown in Table II.

TABLE II: Overall system conversion efficiency with soft switching converters.

Sr. No.	Renewable Energy System Component	Efficiency
1	DC-DC Converter	Greater than 95%
2	DC-AC Converter	Greater than 95%
3	Magnetic components: Transformers, Inductors, Switching devices, Gate driver circuits, Digital signal processor, Power supply	Less than 95%
4	Solar Cell	Less than 16%
Overall system efficiency (1 to 3) = 0.95*0.95*0.95		Greater than 85.74%
Overall system efficiency including solar cell (1 to 4) = 0.95*0.95*0.95*0.16		**Greater than 45.6%**
% Rise in the overall system efficiency (1 to 3)		**41.02%**
% Rise in the overall system efficiency including solar cell (1 to 4)		**368.65%**

B. Why soft switching converters?

1) The soft-switching techniques like zero-voltage switching (ZVS) and zero-current switching (ZCS) will reduce switching power losses.
2) Soft switching converters are operated at high switching frequencies hence reduction in size of reactive components.
3) Switching converters have higher conversion efficiency and power density.
4) Soft switching feature is favorable to reduce noise and electromagnetic interference (EMI) effects.
5) Reduced stresses on the switching devices due to ZVS & ZCS.

6) Can be operated in variable frequency control, variable duty ratio control or combined variable frequency and duty ratio control.
7) Reduces filter size.
8) Hence, improves overall system efficiency.

All these aforementioned converters are developed by using silicon based power semiconductor switching devices. Silicon material properties have some limitations such as, low band-gap energy, low operating switching frequency and low thermal conductivity. In addition, the on-state resistance of silicon switches is also high. These limitations do not allow the converter to operate at high switching frequency because it increases losses and the size of magnetic components required. This affects the converter efficiency and power density.

However, new invention of wide band-gap semiconductor devices such as silicon carbide (SiC) and gallium nitride (GaN) have wider band-gaps, higher thermal conductivity and high breakdown electric field. Such devices are able to block higher voltages, operate at higher switching frequencies than silicon devices. In addition, the on state resistance of these switches is also low. Therefore, converters developed using such switches are operated at high switching frequencies. Hence, it drastically reduces the size and cost of the magnetic components required. In addition, the switching and conduction losses are very less. As these switches are able to block higher voltages, such converters can be used for high power application. Hence, using such devices, it is possible to achieve highest conversion efficiency and highest power density. As it is very difficult to improve efficiency of the solar cell, it became mandatory to develop high efficient soft switched converters using high-speed wide band-gap (WBG) semiconductor switches, such as silicon carbide (SiC) and gallium nitride (GaN) in order to improve overall system efficiency. These advantages make such high power, high step-up, high efficient soft-switched converters as

perfect solution to integrate low voltage renewable energy resources with the DC micro-grid. The graph shows comparison of efficiencies of the hard-switched and soft-switched converters having conventional devices and soft-switched converters having WBG devices with respect to power output.

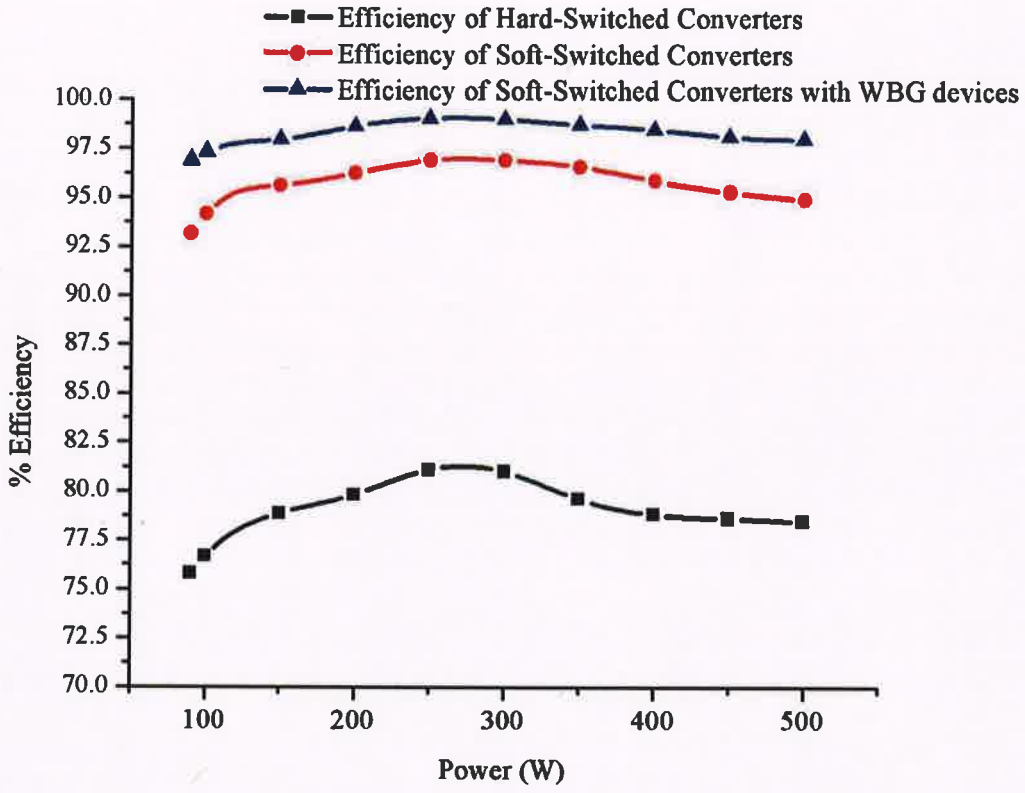


Fig. 2 Comparison of efficiencies of the hard-switched and soft-switched converters having conventional devices and soft-switched converters having WBG devices.

III. Conclusion

Keeping in mind today's electricity demand and the hazardous effects of global warming, development of high efficient hybrid DC/AC micro-grids equipped with renewable energy sources should be the ultimate goal of all researchers. In order to reduce the installation cost of renewable

energy sources; high step-up, high efficient, soft-switched converters plays an important role in efficient conversion and utilization of available energy. High-speed wide band-gap (WBG) semiconductor devices, such as silicon carbide (SiC) and gallium nitride (GaN) both increases power density of the converters and overall power conversion efficiency with reduced size and cost. Because of excellent properties of WBG devices, high step-up, high efficient soft-switched converters developed using such devices is the good solution for integration of low voltage renewable energy resources to the hybrid DC/AC micro-grid.

A DREAM COMES TRUE

T.K. Bera

I was born in a middle class large family in a remote village in the District of Bankura, West Bengal in 1954. My initial schooling was in the village primary school followed by high school in Bengali medium where English, Hindi and Sanskrit were taught from sixth standard onwards. My father was a school teacher in the High school and also had the added responsibility of managing the village post office apart from looking after the agricultural fields and running his charitable Homeopathic Dispensary. He was a simple, honest, hardworking person with the single motto of bringing up his children to the best of their abilities, sacrificing his own luxury and comfort. My mother was a homemaker with lot of love and care. Both of them taught us dignity of labour, honesty and dedication right from our childhood days.

I was an average student but passed out the Higher Secondary Examination in first class which was rare distinction for a village level school. I joined Garbeta Government College for BSc Honors course in Chemistry. Due to the turmoil of Naxalite agitation in West Bengal in the early 70's and frequent stoppage of classes in the college, my father suggested me to go outside Bengal for my studies. Thus I landed up in Varanasi to join the Institute of Technology, BHU for a 5 years B.Tech. course in Ceramic Technology discipline.

The first year was agonizing due to frequent ragging, not knowing to speak proper Hindi and waiting for the money order to come every month to get my pocket expenditure. However, I survived the ordeal and grabbed a merit-cum means scholarship and also managed to change my branch from Ceramic to Chemical Technology due to good score in the common curriculum for all engineering disciplines in the first two years. Thereafter the journey for the next three years in the Chemical Technology Department was smooth and memorable due to some wonderful professors whose teachings and guidance made me what I am today. I still fondly recall Prof.

Gopal Tripathi for Fluid Mechanics, Prof. NS Garg for Thermodynamics, Prof. Umashankar for Mass and Material Balance, Prof. Tewari for Reaction Kinetics.

After passing out B.Tech with Honors in Chemical Engineering in 1976, the option was to go for higher education or for a job. I opted for the former to give financial support to my family. Luckily quite a few job offers came in the way, namely, RIL, ONGC, RCF, INDAL and BARC. I opted for the last one on the advice of my father since it was a Central Government job and offers an opportunity to do work in a research oriented field in the frontier area of Science and Technology. I joined the 20th batch of BARC training and went through the one year rigorous training course in Nuclear Science and Technology with specialization in Nuclear Chemical Engineering. Thereafter I was selected as a Scientific Officer 'C' and joined the New Activity Section of Chemical Engineering and Technology group in BARC, Trombay campus in the year 1977.

It was a small multidisciplinary group under the dynamic leadership of Shri B. Bhattacharjee that my journey in the Department of Atomic Energy began. The group was assigned with the task of developing a process for enrichment of Uranium (increasing the concentration of 235 U from natural 0.7% to higher value say 3.5% 235 U for Light Water Reactors or > 20% for Nuclear Explosive Devices) wherein very little information was available in the published literature, a task that was considered near impossible for a country like India. The world enrichment at that stage was controlled by US, USSR, CHINA, FRANCE and UK through capital intensive gaseous diffusion process and the gas centrifuge process was in the initial stages of deployment in USSR, GERMANY, UK and Netherlands. Because of the potential of Enriched Uranium being used as a Nuclear Bomb (after Hiroshima & Nagasaki during 2nd world war) and to control the world enrichment market, the technology as well as all equipment and machinery connected with it were in the secret domain and embargo regime.

Under these circumstances, the quest for development of a suitable process for enrichment of uranium began in BARC, Trombay campus in the mid 70's. Initially it was scouring through scanty literature and patents that were available on the subject. After initial attempts on developing porous membranes and compressors for gaseous diffusion process, the focus was shifted to gaseous nozzle process, an aerodynamic process under development in Germany since it was a stationary wall device, easier to fabricate and experiment. However, development of critical components like Rotor, End caps, Drive motor, Bearings etc., for high speed gas centrifuge rotor continued in parallel since the gas centrifuge process offers higher separation factor and

consumes relatively little power. We were faced with numerous challenges right from the initial days. Vacuum technology was not taught in our engineering curriculum, but was an essential part of any of the enrichment process. Therefore we started learning about vacuum pumps, vacuum gauges and leak detectors. To design a vacuum system, we had to learn about suitable materials technology, type of joints and seals as well as welding technologies. A lot of effort went towards developing local vendors willing to manufacture and supply these components and systems. After initial learning of isotope separation technology through the separation nozzle setup using SF6 gas mixture, the focus got shifted entirely towards High Speed gas centrifuge process due to some promising initial results.

The initial breakthrough came in the form of a High Speed Rotor System with special bearing arrangement driven by a motor generator set. Gas entry and outlet scoops was arranged from the top through a hole in the end cap where there concentric tubes were inserted. Although the machine had a very short life, experiments on "U" isotope separation began with full earnest with in-house produced hex gas. With little or no experience in handling supersonic stratified gas dynamic inside a high speed rotor, the results were disastrous. But the tenacity to continue in spite of repeated failures and dogged determination to face the obstacles on the way soon got converted into a dream. In a short span of time we got an improved version of the High Speed Machine with pivot jewel non-contact bearing at the bottom and hysteresis induction motor drive as well as a molecular pump on the top. After struggling day and night for almost 3 to 4 years, the isotopic analysis of the product and waste streams showed that the high speed machine is truly capable of separating the 'U" isotopes. Soon various design of aerodynamic scoops as well as temperature control at the top and bottom yielded better results. The challenge was to multiply the effect and get some significant quantity of product. This too was realized soon from a five machine square cascade operating in a recycle mode.

I was pleasantly surprised when a few of us got an invite from the then Chairman, AEC Dr. Raja Ramanna to join for a celebration dinner at the famous Taj Mahal Hotel at Gateway of India, Mumbai. It was a memorable event for a young engineer like me at that time but at the same time another dream was thrown into our mind; to build a gas centrifuge demonstration facility with few thousand machines sometime soon in the near future to qualify the technology as well as to produce some enriched uranium for various strategic applications of DAE.

During mid-80's the initial project work was initiated including identification of the site. We were still groping in the dark since the mechanism of separation inside the gas centrifuge was only partly understood and building a demonstration cascade of thousands of such machines working in a uninterrupted manner was a distant Dream. However, once again we started working, making P&I diagram, layout, equipment design, writing specification in a feverish manner.

Many a times, the entire work as thrown into the dustbin to rework with a more feasible idea. It's a difficult ball game to work on a R&D project with so many unknowns and so much of uncertainty. Additionally the difficulty in most of the multi- disciplinary engineering R&D project is that laboratory scale result are not enough, the concept must be proven at a scale where most of the engineering challenges are seen.

The Project site with an area of about 100 acres, was a barren piece of rocky land with hardly any green patches. We started visiting the project site from 1983-84, once the ground breaking started. Our first guest house cum office was an old bungalow type house belonging to the ancestors of Dr. Raja Ramanna. From 1985-86 recruitment of technical staff by holding interviews in the guest house started. We, a team about 10-15 engineers, were deputed to the project site to expedite the construction work and commission the project. In the initial years till the commissioning of the first cascade hall of the demonstration facility in 1990, the Project was under the administrative control of Indian Rare Earth limited, a PSU under DAE under the leadership of Shri R.K. Garg, CMD, IRE. We had to face a hostile neighborhood for almost a decade till we could convenience them about the zero discharge concept of effluent discharge to the environment from the project. Subsequently many of our outreach programmes and social welfare activities won their hearts.

By 1989-90, within five years from the inception of the project, the first cascade hall of High Speed Rotors was commissioned. However teething problems started arising one after another. The cascade could not be filled with hex gas since there was over pressure build up towards the enricher end and as a result machines were slipping away from synchronous speed. Occasionally machines will suddenly crash due to stress corrosion leading to leakage from vulnerable joints. The learning curve for cascade operation was very tedious and nerve breaking. By the time the teething problems were solved, the cascade life came to an end due to loss of a large number of rotors. But the lesson learnt out of this exercise revealed a lot knowledge about gas centrifuge

cascade operation which no published literature on the subject provides and gave us the confidence to go ahead.

The process of building capacity by adding more and more cascade of high speed machines continued over the next two decades under the dynamic leadership of Shri B. Bhattacharjee inspite of strict embargo regimes, which was tackled with intense Indigenous development efforts since early 90's. In house R&D gave us more and more advanced version of machines with higher and higher output and they were also inducted on the way in a phased manner. Indigenous development efforts paid good dividends particularly development of Special Vacuum Pumps and Gauges, Ultra Low Pressure Drop Mass Flow Meters, Hermetically Sealed Compressors, Helium Mass Spectrometer, Leak Detectors, Special Bearings, Molecular pumps etc. The production of indigenous enriched uranium opened up many frontiers of application which were not considered feasible earlier due to conditionality that comes with imported material.

A two-pronged expansion strategy was worked out during the silver jubilee celebrations of the project in 2009 under the guidance of Dr. Anil Kakodkar as Chairman, AEC and Dr. S. Banerjee as Director, BARC. An expansion of the existing Rare Materials Project during the XI and XII plan to take care of immediate needs of DAE and a long term commercial project plan at a new location to cater the fuel needs of Nuclear Power sector like AHWR/ &IPWR and even imported PWR's.

The expansion project executed under the leadership of Dr. Banerjee is in the final stages of completion where commissioning activities have started. For the other long term objective a suitable land with an area of about 1800 acres has been acquired and first phase of project activities for building up the new facility has started after obtaining the Environmental clearance from MoEF.

I have superannuated from service during March 2014 with a sense of pride and fulfillment of a life time dream of taking up a technical challenge and bringing it to a successful stage from where it can flourish further and serve the needs of the nation. We feel proud that this project is based entirely on 100% indigenous technology, a truly made in India product. Over the years I have built a team of competent and dedicated scientists and engineers, who I am sure, will carry the torch forward and bring more laurels for DAE and the country as a whole.

I would consider myself lucky for being able to fulfill my deferred ambition of completing my higher education - PhD in Engineering Science from Homi Bhabha National Institute during February 2014 and also to continue serving the department as a Raja Ramanna Fellow after superannuation.

I shall fail in my duty if I do not acknowledge the support and mentorship that I received all through my career in DAE in achieving my dream from my colleagues and Gurus. I also thank my family for supporting me in all my endeavours, particularly my wife Smt. Debi and sons Gaurav and Saurav. Lastly, I acknowledge the support given by DAE in offering me the Raja Ramanna Fellowship to continue my intellectual pursuit that enabled me to write this article. Last but not the least, I thankfully acknowledge the contributions in drafting and typing the article by my erstwhile colleagues namely Shri R. Ravindra Kumar, Smt. MS. Pushpa and Shri B Pradeep.

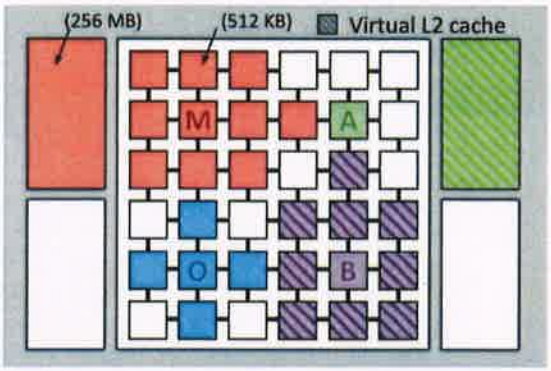
Civil Engineering

1. Concrete from Wood

A new type of concrete has been created that largely consists of wood. The building material offers the construction industry new possibilities and is based in large part on renewable resources. Houses can be made of wood, as they were in the past -- or of concrete, as they are today. To build for tomorrow, the two building methods are being combined: these hybrid structures, which contain both wood and concrete elements, are becoming increasingly popular in contemporary architecture. Swiss researchers have now developed an even more radical approach to combining wood and concrete: they are fabricating a load-bearing concrete which itself consists largely of wood. In many blends, the volume fraction of the wood is over 50 percent. Cement-bonded wood products have been around for more than a hundred years. Yet previously they were used only for non-load-bearing purposes, such as insulation. Daia Zwicky, head of the Institute for Building and Environmental Technologies at the School of Engineering and Architecture of Fribourg together with his team, experimented with the content and granularity of the wood as well as diverse additives and subsequently subjected the various blends to rigorous tests. The main difference from classical concrete is that the gravel and sand content is replaced with finely ground wood. In other words, sawdust rather than small stones is mixed in with the cement. Thanks to the high wood content, the new building materials show good flame retardance and act as thermal insulation. "They weigh at most half of what normal concrete weighs -- the lightest of them even float!" says Zwicky. Moreover, as the materials are based largely on renewable resources, after dismantling they can be reused as a source of heat and electricity. The wood content can be burnt in waste incineration, although for everyday use it conforms to fire protection standards. Initial 1:1 stress tests show that the new wood-based concrete is also suitable for slab and wall elements and can provide a load-bearing function in construction. The process is also suited to prefabricated units. In this context, in particular, the Fribourg group would like to deepen their expertise through a broader range of tests. The researchers want to find out which wood-concrete composite is best for which applications, and how it can be produced efficiently. "It will take several years before we see the first buildings in which lightweight concrete containing wood plays an integral role in the construction," says Zwicky. "The level of knowledge required for widespread application is still too limited."

Source https://www.sciencedaily.com/releases/2017/07/170705112735.htm

2. Ad Hoc 'Cache Hierarchies' Make Chips Much More Efficient



For decades, computer chips have increased efficiency by using "caches," small, local memory banks that store frequently used data and cut down on time- and energy-consuming communication with off-chip memory. Today's chips generally have three or even four different levels of cache, each of which is more capacious but slower than the last. The sizes of the caches represent a compromise between the needs of different kinds of programs, but it's rare that they're exactly suited to any one program. Researchers at MIT's Computer Science and Artificial Intelligence Laboratory have designed a system that reallocates cache access on the fly, to create new "cache hierarchies" tailored to the needs of particular programs. The researchers tested their system on a simulation of a chip with 36 cores, or processing units. They found that, compared to its best-performing predecessors, the system increased processing speed by 20 to 30 percent while reducing energy consumption by 30 to 85 percent. Sanchez and his coauthors developed the new system, dubbed Jenga. For the past 10 years or so, improvements in computer chips' processing power have come from the addition of more cores. The chips in most of today's desktop computers have four cores, but several major chipmakers have announced plans to move to six cores in the next year or so, and 16-core processors are not uncommon in high-end servers. Most industry watchers assume that the core count will continue to climb. Each core in a multicore chip usually has two levels of private cache. All the cores share a third cache, which is actually broken up into discrete memory banks scattered around the chip. Some new chips also include a so-called DRAM cache, which is etched into a second chip that is mounted on top of the first. For a given core, accessing the nearest memory bank of the shared cache is more efficient than accessing more distant cores. Unlike today's cache management systems, Jenga distinguishes between the physical locations of the separate memory banks that make up the shared cache. For each core, Jenga knows how long it would take to retrieve information from any on-chip memory bank, a measure known as "latency." Jenga has to evaluate the tradeoff between latency and space for two layers of cache simultaneously, which turns the two-dimensional latency-space curve into a three-dimensional surface. Fortunately, that surface turns out to be fairly smooth: It may undulate, but it usually won't have sudden, narrow spikes and dips. That means that sampling points on the surface will give a pretty good sense of what the surface as a whole looks like. The researchers developed a clever sampling algorithm tailored to the problem of cache allocation, which systematically increases the distances between sampled points. Once it has deduced the shape of the surface, Jenga finds the path across it that minimizes latency. Then it extracts the component of that path contributed by the first level of cache, which is a 2-D curve. In experiments, the researchers found that this approach yielded an aggregate space allocation that was, on average, within 1 percent of that produced by a full-blown analysis of the 3-D surface, which would be prohibitively time consuming. Adopting the computational short cut enables Jenga to update its memory allocations every 100 milliseconds, to accommodate changes in programs' memory-access patterns. Jenga also features a data-placement procedure motivated by the increasing popularity of DRAM cache. Because they're close to the cores accessing them, most caches have virtually no bandwidth restrictions: They can deliver and receive as much data as a core needs. But sending data longer distances requires more energy, and since DRAM caches are off-chip, they have lower data rates. If multiple cores are retrieving data from the same DRAM cache, this can cause bottlenecks that introduce new latencies. So, after Jenga has come up with a set of cache assignments, cores don't simply dump all their data into the nearest available memory bank. Instead, Jenga parcels out the data a little at a time, then estimates the effect on bandwidth consumption and latency. Thus, even within the 100-millisecond intervals between chip-wide cache re-allocations, Jenga adjusts the priorities that each core gives to the memory banks allocated to it.

Source https://www.sciencedaily.com/releases/2017/07/170710172011.htm

Mechanical Engineering

3. Dual-Arm Construction Robot with Remote-Control Function

Object handling with hand mode

Gravel digging with shovel mode

Examples of work using tough robot hand.

A group of Japanese researchers developed a new concept construction robot for disaster relief situations. This robot has a double swing dual arm mechanism and has drastically improved operability and mobility compared to conventional construction machines. In disaster areas, operating heavy construction equipment remotely and autonomously is necessary, but conventional remote-controlled heavy equipment has problems such as insufficient operability, inability to perform heavy-duty work, limited mobility on slopes and stairs, and low work efficiency because of difficult remote control. Thus, fundamental solutions to such problems have been sought after. As part of the Impulsing Paradigm Challenge through Disruptive Technologies Program (ImPACT)'s Tough Robotics Challenge Program, researchers from Osaka University, Kobe University, Tohoku University, Tohoku University, The University of Tokyo, and Tokyo Institute of Technology, tackle these challenges. This group of researchers attempts to solve these challenges by developing a prototype robot with a double swing dual arm mechanism and hydraulic-powered robotic hands. Using this robot, this group aims for discontinuous innovation; they try to drastically increase the efficiency of work and movement through the dual arm robot capable of handling heavy objects and by excavating and gripping with its high-powered hands. Specifically, this robot has the following functions.

1. A double swing dual arm mechanism capable of performing heavy work with high operability and terrain adaptability (smooth mobility on slopes and stairs). In the double swing dual arm mechanism of this robot, its right and left arms and the rotating portion of its shoulders are on the same axis. Because of this, the robot can use bearings with far bigger diameter on its rotation portion as compared to humans and animals, whose shoulder joints are arranged on different axes. Also, these arms are supported close to the robot's centre of gravity, providing the robot with a high degree of stability. This structure allows the robot to withstand high loads and perform heavy-duty work. Additionally, since each coaxially-arranged arm rotates at 360 degrees, there is no distinction between right and left hands, which allows the user to freely change the layout of the robot's hands.

2. Multi-fingered hand for construction robots- This group has developed a 4-fingered hand for use with construction robots and has equipped it to one of the robot's arms. The operating modes -- excavation and grip -- can be selected by changing the hand's shape. It is also possible to change the hand according to the shape of objects and control a wide range of grip strength.

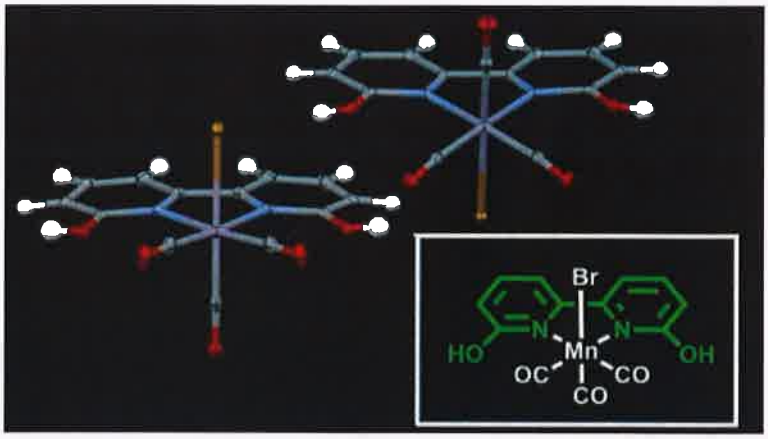
3. Basic technology for enhancement of remote controls -This robot has the capability to allow a remote operator to precisely control the robot with the senses of force and touch as if he/she is actually touching the target object. This robot is equipped with a multi-rotor unmanned aircraft vehicle UAV ("drone") with power supply through electric lines, which allows the operator to view objects and terrain from different viewpoints without a robot-mounted camera. This robot also has a bird's-eye view image composition system. These functions make the robot's precise tasks and movement over intricate terrain easy.

Researchers in this group think that these functions will dramatically increase construction equipment's capacity to deal with large-scale disasters and accidents and believe it is possible that the replacement of conventional construction equipment with this robot will drastically change civil engineering and construction methods. The researchers aim at achieving practical use of this robot to disaster relief situations within a few years through future improvement, integration with basic technology, and performance limit tests.

Source https://www.sciencedaily.com/releases/2017/06/170629085138.htm

Chemical Engineering

4. Recruiting Manganese to Upgrade Carbon Dioxide



The manganese atom (in purple) is at the center of the frame -- the ligand -- which facilitates the hydrogenation of carbon dioxide.

Carbon dioxide (CO_2) is known as a greenhouse gas and plays an essential role in climate change; it is no wonder scientists have been looking for solutions to prevent its release in the environment. However, as a cheap, readily available and non-toxic carbon source, in the past few years there have been efforts to turn carbon dioxide into valuable wares, or 'value-added' products. For instance, carbon dioxide enables energy storage by reacting with hydrogen gas -- called the hydrogenation process -- transforming the mixture into higher energy liquid compounds such as methanol that can be easily transported and used as fuel for cars. Similarly, carbon dioxide hydrogenation in the presence of other chemicals can lead to the formation of various value-added products widely used in industry such as formic acid, formamides, or formaldehyde. These chemicals can also potentially be used for energy storage as, for example, heating formic acid under certain conditions allow for the release of hydrogen gas in a controlled and reversible fashion. Conversion of carbon dioxide into useful products is complicated by the fact that CO_2 is the most oxidized form of carbon and as such a very stable and unreactive molecule. Therefore, the direct reaction of CO_2 with hydrogen requires high energy, making the process economically unfavorable. This problem can be overcome using catalysts, which are compounds used in small amounts to accelerate chemicals reactions. For CO_2 hydrogenation purposes, most known catalysts are based on precious metals such as iridium, rhodium or ruthenium. While excellent catalysts, the scarcity of these precious metals makes it difficult to use them at industrial scales. They are also hard to recycle and potentially toxic for the environment. Other catalysts use cheaper metals such as iron or cobalt but require a phosphorus-based molecule -- called phosphine -surrounding the metal. Phosphines are not always stable around oxygen and sometimes burn violently in an air atmosphere, which presents another problem for the practical applications. To overcome these issues, the OIST Coordination Chemistry and Catalysis Unit led by Prof. Julia Khusnutdinova developed novel and efficient catalysts based on an inexpensive and abundant metal: manganese. Manganese is the third most abundant metal in Earth's crust after titanium and iron, and presents much lower toxicity as compared to many other metals used in CO_2 hydrogenation. The scientists initially looked for inspiration within the natural world: hydrogenation is a reaction that occurs in many organisms that would not have access to precious metals or phosphines. They observed the structure of specific enzymes -- hydrogenases -- to understand how they could accomplish hydrogenation using simple, Earth-abundant materials. To facilitate the hydrogenation, enzymes utilize a 'smart' arrangement where the surrounding organic framework cooperates with a metal atom -- like iron- efficiently kick-starting the reaction. The main challenge of this study was to build an adequate frame -- called a ligand -- around the manganese to induce the hydrogenation. The scientists came up with a surprisingly simple ligand structure resembling natural hydrogenase enzymes with a twist from typical phosphine catalysts. In ligand design, the structure of a ligand is tightly linked to its efficiency. The new catalyst -- the ligand and the manganese together -- can perform more than 6,000 turnovers in a hydrogenation reaction, converting more than 6,000 times CO_2 molecules before decaying. And this new ligand is simple to manufacture and stable in the air. For now, the catalyst is able to transform carbon dioxide into formic acid, a widely-used food preservative and tanning agent, and formamide, which has industrial applications. But the versatility of this catalyst opens many other possibilities.

Source https://www.sciencedaily.com/releases/2017/07/170707095342.htm

5. Powerful New Photodetector Can Enable Optoelectronics Advances

UW-Madison electrical and computer engineering graduate student holds a dish containing photodetector samples. The sample colors vary depending on how they are tuned to absorb a specific light wavelength.

In today's increasingly powerful electronics, tiny materials are a must as manufacturers seek to increase performance without adding bulk. Smaller also is better for optoelectronic devices -- like camera sensors or solar cells -- which collect light and convert it to electrical energy. Think, for example, about reducing the size and weight of a series of solar panels, producing a higher-quality photo in low lighting conditions, or even transmitting data more quickly. However, two major challenges have stood in the way: First, shrinking the size of conventionally used "amorphous" thin-film materials also reduces their quality. And second, when ultrathin materials become too thin, they become almost transparent and actually lose some ability to gather or absorb light. Now, in a nanoscale photodetector that combines a unique fabrication method and light-trapping structures, a team of engineers from the University of Wisconsin-Madison and the University at Buffalo has overcome both of those obstacles. The researchers described their device as a single-crystalline germanium nano-membrane photodetector on a nano-cavity substrate. The device consists of nano-cavities sandwiched between a top layer of ultrathin single-crystal germanium and a reflecting layer of silver. Nano-cavities are made up of an orderly series of tiny, interconnected molecules that essentially reflect, or circulate, light. The researcher already has shown that the nano-cavity structures increase the amount of light that thin semiconducting materials like germanium can absorb. However, most germanium thin films begin as germanium in its amorphous form -- meaning the material's atomic arrangement lacks the regular, repeating order of a crystal. That also means its quality isn't sufficient for increasingly smaller optoelectronics applications. That's where their expertise comes into play. A world expert in semiconductor nano-membrane devices, a researcher Dr Ma used a revolutionary membrane-transfer technology that allows him to easily integrate single crystalline semiconducting materials onto a substrate. The result is a very thin, yet very effective, light-absorbing photodetector -- a building block for the future of optoelectronics. "It is an enabling technology that allows you to look at a wide variety of optoelectronics that can go to even smaller footprints, smaller sizes," says another researcher, who conducted computational analysis of the detectors. While the researchers demonstrated their advance using a germanium semiconductor, they also can apply their method to other semiconductors. "And importantly, by tuning the nano-cavity, we can control what wavelength we actually absorb," says a lead researcher . "This will open the way to develop lots of different optoelectronic devices."

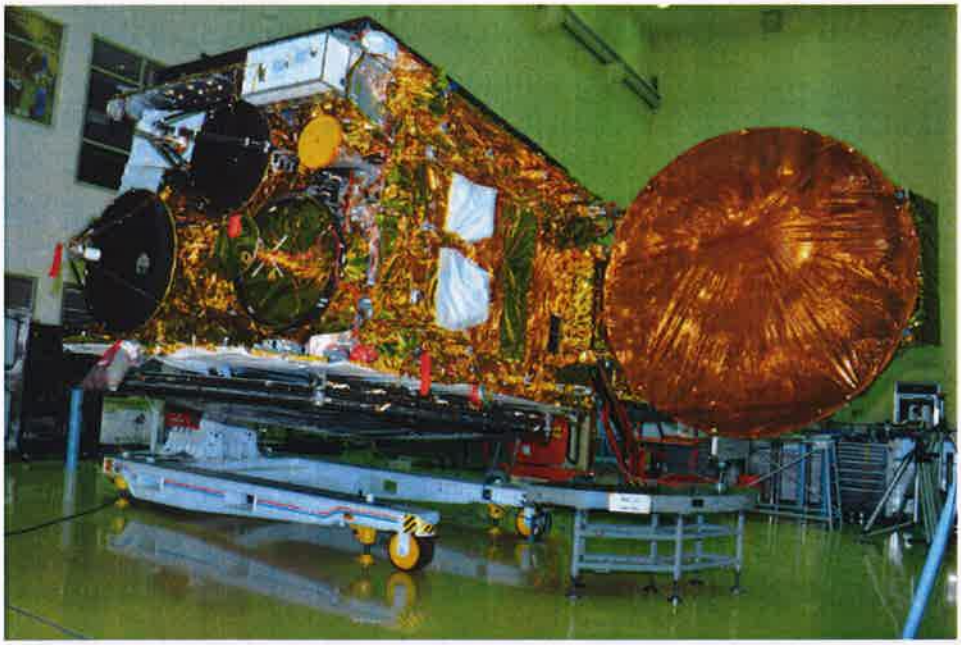
Source https://www.sciencedaily.com/releases/2017/07/170707211137.htm

6. Harnessing Hopping Hydrogens for High-Efficiency OLEDs

Excited-state intramolecular proton transfer (ESIPT) makes possible organic light-emitting diodes (OLEDs) that are highly efficient by creating the necessary conditions to enable thermally activated delayed fluorescence (TADF). After excitation of the emitting molecule, a hydrogen atom -- technically, just its nucleus -- is transferred to a different atom in the same molecule through a process called ESIPT. The reconfigured molecule can then undergo TADF to convert a high fraction of the excitations into light. Following emission, the molecule returns to its original state. This mechanism increases the molecular design strategies available for the creation of novel and improved light-emitting materials. Renewed investigation of a molecule that was originally synthesized with the goal of creating a unique light-absorbing pigment has led to the establishment of a novel design strategy for efficient light-emitting molecules with applications in next-generation displays and lighting. Researchers at Kyushu University's Center for Organic Photonics and Electronics Research (OPERA) demonstrated that a molecule that slightly changes its chemical structure before and after emission can achieve a high efficiency in organic light-emitting diodes (OLEDs). In addition to producing vibrant colours, OLEDs can be fabricated into everything from tiny pixels to large and flexible panels, making them extremely attractive for displays and lighting. In an OLED, electrical charges injected into thin films of organic molecules come together to form packets of energy -- called excitons -- that can produce light emission. The goal is to convert all of the excitons to light, but three-fourths of the created excitons are triplets, which do not produce light in conventional materials, while the remaining one-fourth are singlets, which emit through a process called fluorescence. Inclusion of a rare metal, such as iridium or platinum, in a molecule can enable rapid emission from the triplets through phosphorescence, which is currently the dominant technology for highly efficient OLEDs. An alternative mechanism is the use of heat in the environment to give triplets an energetic boost that is sufficient to convert them into light-emitting singlets. This process, known as thermally activated delayed fluorescence (TADF), easily occurs at room temperature in appropriately designed molecules and has the added advantage of avoiding the cost and reduced molecular design freedom associated with rare metals. However, most TADF molecules still rely on the same basic design approach. Currently, combinations of donating and accepting units are primarily used because they provide a relatively simple way to push around the electrons in a molecule and obtain the conditions needed for TADF. Although the method is effective and a huge variety of combinations is possible, new strategies are still desired in the quest to find perfect or unique emitters. The mechanism explored by the researchers this time involves the reversible transfer of a hydrogen atom -- technically, just its positive nucleus -- from one atom in the emitting molecule to another in the same molecule to create an arrangement conducive to TADF. This transfer occurs spontaneously when the molecule is excited with optical or electrical energy and is known as excited-state intramolecular proton transfer (ESIPT). This ESIPT process is so important in the investigated molecules that quantum chemical calculations by the researchers indicate that TADF is not possible before transfer of the hydrogen. After excitation, the hydrogen rapidly transfers to a different atom in the molecule, leading to a molecular structure capable of TADF. The hydrogen transfers back to its initial atom after the molecule emits light, and the molecule is then ready to repeat the process. Although TADF from an ESIPT molecule has been reported previously, this is the first demonstration of highly efficient TADF observed inside and outside of a device. This vastly different design strategy opens the door for achieving TADF with a variety of new chemical structures that would not have been considered based on previous strategies. Interestingly, the molecule the researchers used was most likely a disappointment when first synthesized nearly 20 years ago by chemists hoping to create a new pigment only to discover that the molecule is colourless. The advantages of this design strategy are just beginning to be explored, but one particularly promising area is related to stability. Molecules similar to the investigated one are known to be highly resistant to degradation, so researchers hope that these kinds of molecules might help to improve the lifetime of OLEDs. To see if this is the case, tests are now underway.

Source https://www.sciencedaily.com/releases/2017/07/170710103457.htm

7. ISRO's Communication Satellite GSAT-17 Launched from French Guiana

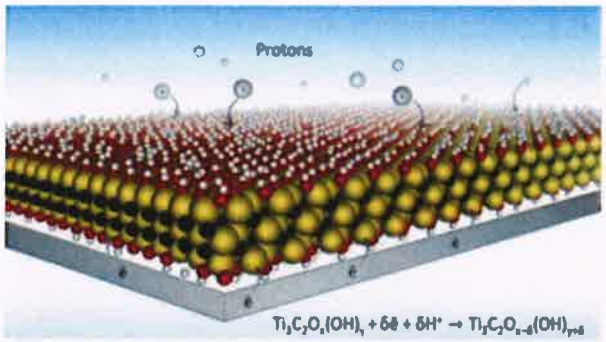


India's Space Research Organization (ISRO)'s communication satellite GSAT-17 was launched on June 29, 2017 by a heavy duty rocket of Arianespace from the spaceport of Kourou in French Guiana. The 3,477 kg GSAT-17 will carry payloads in normal C-band, extended C-band and S-band to provide various communication services. It carries equipment for meteorological data relay and satellite based search and rescue services being provided by earlier INSAT satellites. The European launcher Arianespace Flight VA238 blasted off from Ariane Launch Complex No 3 (ELA 3) at Kourou, a French territory located in northeastern coast of South America. GSAT-17 was injected shortly after orbiting co-passenger Hellas Sat 3-Inmarsat S EAN in a flawless flight lasting about 41 minutes. GSAT-17 successfully launched by Ariane-5 VA-238 from Kourou, French Guiana, the city headquartered ISRO announced after the mission. GSAT-17 that will strengthen ISRO's current fleet of 17 telecommunications satellites was launched into a Geosynchronous Transfer Orbit (GTO). This will be third satellite launch by ISRO this month, the other two being first developmental flight of GSLV MkIII and PSLV C-38 missions -- both from Sriharikota spaceport. GSLV MkIII successfully launched GSAT-19 satellite on June 5 while PSLV-C38 orbited Cartosat-2 Series satellite along with 30 co-passenger satellites on June 23 from the Satish Dhawan Space Centre. ISRO, which has been dependent on Ariane-5 rocket for carrying its heavier satellites, is developing GSLV Mk III for this purpose. Announcing the successful launch of the satellite, Arianespace CEO Stephane Israel tweeted: "Confirmed: GSAT-17 has successfully separated from its #Ariane5 launcher #VA238 @ISRO " Thanking Arianespace, Director Vikram Sarabhai Space Centre Dr K Sivan who watched the launch from the mission control centre called it a "text book mission". Noting it as a special mission for ISRO, he said "GSAT-17 is a need of the hour for ISRO and India as it provides the continuity in services of ageing two satellites, as well as augmenting our transponder capability, and widening our horizon to mobile satellite services as well as to Antarctica areas." GSAT-17's co-passenger Hellas Sat 3-Inmarsat S EAN is a two-payload "condosat" produced by Thales Alenia Space for Hellas Sat and Inmarsat. Once in orbit, the Hellas Sat 3 component will deliver direct-to-home and telecom services to maintain and expand Hellas Sat's business reach, while the Inmarsat S EAN component provides the satellite portion of Inmarsat's new European Aviation Network. Hellas Sat (member of the Arabsat Group) is a premium satellite operator, offering services in Europe, the Middle East and South Africa from the orbital position of 39 East. Inmarsat is the leading provider of global mobile satellite communications services. The total payload carried on Flight VA238 is approximately 10,177 kg. GSAT-17 will be the 21st satellite from ISRO to be launched by Arianespace, and its designed in-orbit operational life is about 15 years. After its injection into GTO, ISRO's Master Control Facility (MCF) at Hassan takes control of GSAT-17 and performs the initial orbit raising maneuvers using the Liquid Apogee Motor (LAM) of the satellite, placing it in circular Geostationary Orbit, the Indian space agency has said.

Source http://www.news18.com/news/world/isros-communication-satellite-gsat-17-launched-from-french-guiana-1446605.html

Mining, Metallurgical and Materials Engineering

8. In the Fast Lane: Conductive Electrodes Are Key to Fast-Charging Batteries

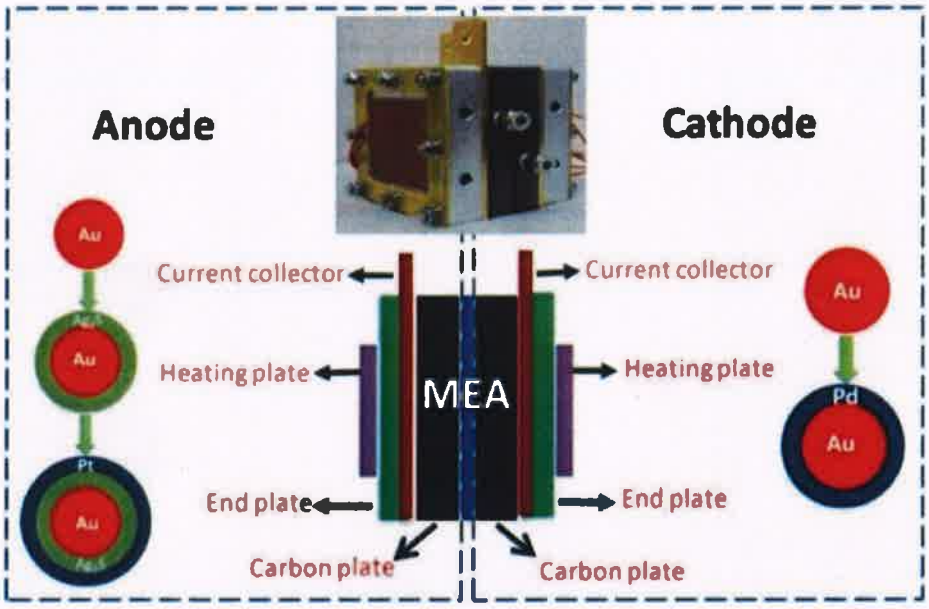


Drexel University researchers have developed two new electrode designs, using MXene material, that will allow batteries to charge much faster. The key is a microporous design that allows ions to quickly make their way to redox active sites.

Can you imagine fully charging your cell phone in just a few seconds? Researchers in Drexel University's College of Engineering can, and they took a big step toward making it a reality with their recent work unveiling of a new battery electrode design. The team, led by Yury Gogotsi, PhD, Distinguished University and Bach professor in Drexel's College of Engineering, in the Department of Materials Science and Engineering, created the new electrode designs from a highly conductive, two-dimensional material called MXene. Their design could make energy storage devices like batteries, viewed as the plodding tanker truck of energy storage technology, just as fast as the speedy supercapacitors that are used to provide energy in a pinch -- often as a battery back-up or to provide quick bursts of energy for things like camera flashes. "The work refutes the widely accepted dogma that chemical charge storage, used in batteries and pseudocapacitors, is always much slower than physical storage used in electrical double-layer capacitors, also known as supercapacitors," Gogotsi said. "We demonstrate charging of thin MXene electrodes in tens of milliseconds. This is enabled by very high electronic conductivity of MXene. This paves the way to development of ultrafast energy storage devices than can be charged and discharged within seconds, but store much more energy than conventional supercapacitors." The key to faster charging energy storage devices is in the electrode design. Electrodes are essential components of batteries, through which energy is stored during charging and from which it is disbursed to power our devices. So, the ideal design for these components would be one that allows them to be quickly charged and store more energy. To store more energy, the materials should have places to put it. Electrode materials in batteries offer ports for charge to be stored. In electrochemistry, these ports, called "redox active sites" are the places that hold an electrical charge when each ion is delivered. So, if the electrode material has more ports, it can store more energy -- which equates to a battery with more "juice." Collaborators from Université Paul Sabatier in France, produced a hydrogel electrode design with more redox active sites, which allows it to store as much charge for its volume as a battery. This measure of capacity, termed "volumetric performance," is an important metric for judging the utility of any energy storage device. To make those plentiful hydrogel electrode ports even more attractive to ion traffic, the Drexel-led team designed electrode architectures with open macroporosity -- many small openings -- to make each redox active sites in the MXene material readily accessible to ions. "In traditional batteries and supercapacitors, ions have a tortuous path toward charge storage ports, which not only slows down everything, but it also creates a situation where very few ions actually reach their destination at fast charging rates," said a researcher who conducted the research as part of the A.J. Drexel Nanomaterials Institute. The overarching benefit of using MXene as the material for the electrode design is its conductivity. Materials that allow for rapid flow of an electrical current, like aluminum and copper, are often used in electric cables. MXenes are conductive, just like metals, so not only do ions have a wide-open path to a number of storage ports, but they can also move very quickly to meet electrons there. The research collaborators from Bar-Ilan University in Israel, helped the Drexel group maximize the number of the ports accessible to ions in MXene electrodes. Use in battery electrodes is just the latest in a series of developments with the MXene material that was discovered by researchers in Drexel's Department of Materials Science and Engineering in 2011. Since then, researchers have been testing them in a variety of applications from energy storage to electromagnetic radiation shielding, and water filtering. This latest development is significant in particular because it addresses one of the primary problems hindering the expansion of the electric vehicle market and that has been lurking on the horizon for mobile devices. "If we start using low-dimensional and electronically conducting materials as battery electrodes, we can make batteries working much, much faster than today," Gogotsi said. "Eventually, appreciation of this fact will lead us to car, laptop and cell-phone batteries capable of charging at much higher rates -- seconds or minutes rather than hours."

Source https://www.sciencedaily.com/releases/2017/07/170710113728.htm

9. Selective Electrocatalysts Developed to Boost Direct Methanol Fuel Cell Performance

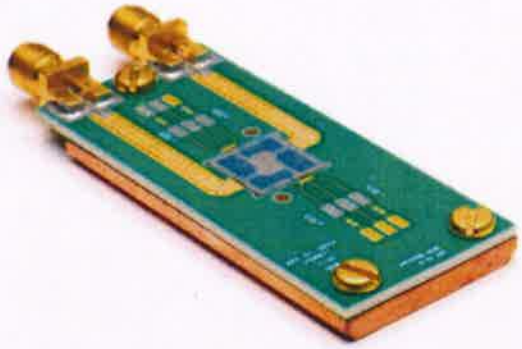


These are DMFC assemblies. Schematic illustration showing a DMFC fabricated with selective electrocatalysts at the anode and cathode chambers. Inlet is the photograph of the assembled cell.

A research group from the Institute of Process Engineering (IPE), Chinese Academy of Sciences recently reported the development of a new technology to boost performance of direct methanol fuel cells (DMFCs) using high-concentration methanol as fuel, shedding some light on the design of clean and affordable alternative energy sources for portable electric devices. When methanol, the fuel of DMFCs, crosses over from the anode to the cathode through the proton exchange membrane (PEM), fuel cell performance is significantly degraded, creating a major problem for the commercialization of DMFCs. Commonly, scientists use various strategies to improve DMFC performance at high concentrations of methanol. These include improving the fuel-feed system, membrane development, modification of electrodes, and water management. "These conventional strategies do not fundamentally overcome the key obstacle, but inevitably complicate the design of DMFCs and hence increase their cost," said YANG Jun, an IPE professor. YANG and co-workers used selective electrocatalysts to run a DMFC at methanol concentrations up to 15 M, an alternative method for solving the methanol crossover in DMFCs. The anode and cathode catalysts of DMFCs are commonly based on platinum (Pt). These catalysts are not selective for the methanol oxidation reaction (MOR) at the anode or the oxygen reduction reaction (ORR) at the cathode. With a deep understanding of the mechanisms of electrode reactions in DMFCs, the researchers designed and produced noble metal-based heterogeneous electrocatalysts with enhanced catalytic activity and high selectivity for MOR and ORR. Encouragingly, the DMFCs operated extremely well with high-concentration methanol as fuel by sufficiently making use of the structural uniqueness and electronic coupling effects among the different domains of the noble metal-based heterogeneous electrocatalysts. Ternary Au-Ag2S-Pt nanocomposites with core-shell-shell structures display superior anode selectivity due to the electronic coupling among their different domains, while core-shell Au-Pd nanoparticles with thin Pd shells exhibit excellent cathode selectivity because of the synergistic effects between their Au core and thin Pd shell. The as-fabricated DMFC with selective catalysts produces a maximum power density of 89.7 mW cm-2 at a methanol-feed concentration of 10 M, and maintains good performance at methanol concentrations up to 15 M. "Next, we are going to optimize the overall size of the catalysts, e.g., using Au nanoclusters with fine diameters as starting materials to further enhance the activity/selectivity for DMFC reactions," said YANG. In this way, new technologies will be created to help improve the design of more cost-effective and efficient DMFC systems.

Source https://www.sciencedaily.com/releases/2017/06/170630140747.htm

10. 'Noise Thermometry' Yields Accurate New Measurements of Boltzmann Constant



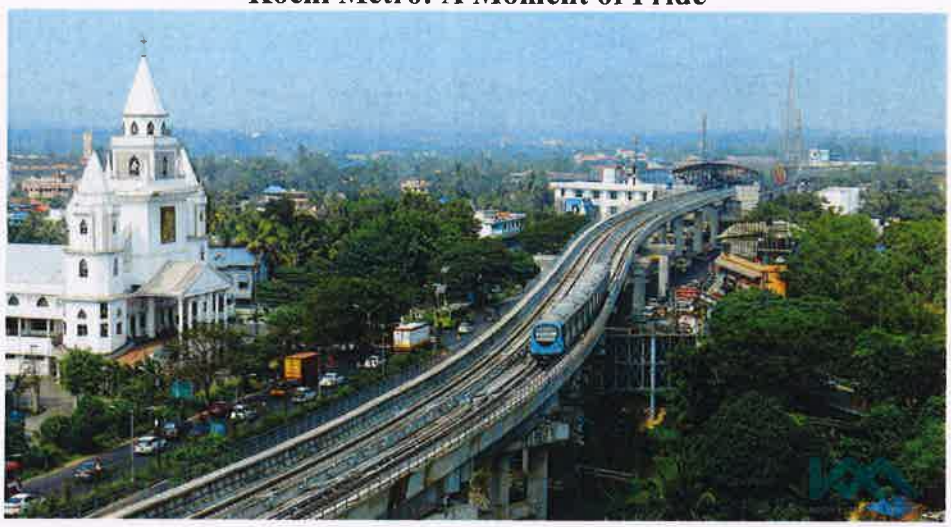
This quantum voltage noise source (QVNS) provides a fundamentally accurate voltage signal that can be compared to the voltage noise from electrons in a resistor. Measuring the voltage noise enabled researchers to determine the Boltzmann constant, which relates an energy of a system to its temperature.

By measuring the random jiggling motion of electrons in a resistor, researchers at the National Institute of Standards and Technology (NIST) have contributed to accurate new measurements of the Boltzmann constant, a fundamental scientific value that relates the energy of a system to its temperature. These results will contribute to a worldwide effort to redefine the kelvin, the international unit of temperature, and could lead to better thermometers for industry. Accurate temperature measurement is critical to any manufacturing process that requires specific temperatures, such as steel production. It's also important for nuclear power reactors, which require precise thermometers that are not destroyed by radiation and do not need to be regularly replaced by human workers. In late 2018, representatives from nations around the world are expected to vote on whether to redefine the international system of units, known as the SI, at the General Conference on Weights and Measures in France. When implemented in 2019, the new SI would no longer rely upon physical objects or substances to define measurement units. Instead, the new SI would be based on constants of nature such as the Boltzmann constant, which depends fundamentally on quantum mechanics, the theory that describes matter and energy at the atomic scale. To define the kelvin, scientists currently measure the triple point of water in a sealed glass cell. This method has drawbacks. For example, chemical impurities in the water can slowly lower the cell's temperature over time. Researchers must also make corrections due to the presence of different isotopes of water. And measurements at temperatures higher or lower than the triple point of water are inherently less precise. "By defining the kelvin in terms of the Boltzmann constant, you don't have to have these variations in uncertainty, and you can use quantum-mechanical effects," said a lead researcher. For the Boltzmann constant to be good enough to redefine the kelvin, there are two requirements established by the international group in charge of the issue, known as the Consultative Committee on Thermometry of the International Committee for Weights and Measures. There must be one experimental value with a relative uncertainty below 1 part per million -- and at least one measurement from a second technique with a relative uncertainty below 3 parts per million. So, researchers have been pursuing a variety of methods for measuring the Boltzmann constant. The most accurate method remains measurements of the acoustical properties of a gas. Scientists around the world have devised a variety of other techniques, including ones that measure other properties of gases. A completely different approach is a technique that does not rely on ordinary gases but instead mainly on electrical measurements. The technique measures the degree of random motion -- "noise" -- of electrons in a resistor. This "Johnson noise" is directly proportional to the temperature of electrons in the resistor -- and the Boltzmann constant. Past measurements of Johnson noise were plagued by the problem of measuring tiny voltages with parts-per-million accuracy; this problem is exacerbated by the Johnson noise of the measurement equipment itself. To address this issue, the NIST researchers in 1999 developed a "quantum voltage noise source" (QVNS) as a voltage reference for Johnson Noise Thermometry (JNT). The QVNS uses a superconducting device known as a Josephson junction to provide a voltage signal that is fundamentally accurate, as its properties are based on the principles of quantum mechanics. The researchers compare the QVNS signal to the voltage noise created by the random motions of electrons in the resistor. According to researchers, the improvement in the previous results came from better shielding of the experimental area from stray electrical noise and upgrades to the electronics. The researchers performed careful "cross-correlation" analysis in which they made two sets of measurements each of the Johnson noise and the quantum voltage noise source to reject other noise sources from the measurement. Other factors included increasing the size of the resistor for a larger source of Johnson noise and better shielding between the different measurement channels for the two sets of measurements. Beyond the new SI, devices based on Johnson thermometry have potential for being used directly in industry, including in nuclear reactors.

Source https://www.sciencedaily.com/releases/2017/06/170629230013.htm

Engineering Innovation in India

Kochi Metro: A Moment of Pride



Once again Kerala is in the news, thanks to the fastest and smartest Kochi Metro with many firsts to its credit, becoming a reality in record time. The credit goes to 'Metro Man', Shri E. Sreedharan and the team under him in the Kochi Metro Rail Corporation (KMRL) and the Delhi Metro Rail Corporation (DMRC), which together executed the project, and last but not the least the work force, engaged in the massive civil work. Kochi Metro, inaugurated by Hon'ble Prime Minister Shri Narendra Modi on 17 June, 2017 is the first in the country to have a Communication Based Train Control (CBTC) signalling system which reduces the element of human interference in operations of the metro rail. KMRL is also the first in India to generate a quarter of its power requirement through solar panels. About 99 per cent of braking energy of each train will be fed back into the grid and used by the train that follows the one ahead. Though the eighth metro rail project launched in India, Kochi Metro stands out, being the fastest and longest first phase to be commissioned. The innovative 'Kochi One' multi-purpose smart card introduced could be used across other modes of public transport in the city plus for all transactions all over the country. This is also the first metro to use 'Make in India' coaches. They were made by Alstom, the French collaborators at the Green City in Andhra Pradesh. The Railway Safety Commissioner had complemented Kochi Metro for its most safe and secure metro stations. Not a single accident occurred during the last four years when the project was underway. One sixth of the thousand-odd metro pillars will have a vertical garden which will use recycled municipal waste as manure, making it a Green Metro. This is also the first metro to have a waterway component. The total cost of Kochi Metro rail project stands at Rs 5,687.79 crore with equal stakes by the Central and State governments. The metro will span 25 km across 22 stations. Usually only a 6.8-km stretch is inaugurated in a metro rail's phase 1. But a 13-km stretch was inaugurated in this case — Aluva to Plarivattam. Kochi Metro has a social role too. Once fully operational, Kochi Metro will thus be the first in India to have a work force comprising of 80 per cent women. The second phase, from Palarivattom to Maharaja's College Grounds, stretching 5 km, is now in progress and is expected to be completed in the next six months. The third phase from Maharaja's College Grounds up to Thrippunithura, which is another 9 km, is scheduled to be commissioned by 2019.

Source http://businessworld.in/article/Kochi-Metro-A-Moment-Of-Pride/03-07-2017-121194/