E-TARANG

KIET ECE E-MAGAZINE

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Man of the issue
Sundar Pichai

Department of Electronics and Communication Engineering
KIET Group of Institutions, Ghaziabad

(NAAC ‘A+’ Grade, NBA Accredited and ISO 9001-2000)

KIET Group of Institutions, Ghaziabad, U.P.

Department of Electronics & Communication Engineering

VISION AND MISSION OF THE INSTITUTE

Vision statement

To become a leading institution nationally in the area of professional education, research & innovation for serving the global community.

Mission statements

- To impart quality professional education, skills and values through outcome-based innovative teaching learning process in all spheres.
- To undertake collaborative interdisciplinary research as a co-requisite for professional education and simultaneously solve problems faced by society and industry.
- To create an ambience of innovation, entrepreneurship and consultancy for future leaders and innovators.
- To keep faculty members enthusiastic by continuous professional development and positive working environment

VISION AND MI SSION OF THE DEPARTMENT

Vision:

To become a leading center of excellence in the technical education of Electronics & Communication Engineering and create competent professionals in thrust areas for the development of society and nation.

Mission:

- To educate the students with the state of the art technologies through innovative teaching-learning process.
- To enable the graduates to develop the skills required to solve complex real time problems using tools and techniques of Electronics & Communication Engineering practice.
- To develop the spirit of innovation and creativity by collaborating with industries and research establishments to fulfill the needs of society.
- To practice high standards of human values, professional ethics and accountability.

KIET Group of Institutions, Ghaziabad, U.P.

Department of Electronics & Communication Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) OF B.TECH. (ELECTRONICS & COMMUNICATION ENGINEERING)

Graduates of the program will:

I. Acquire fundamental knowledge of Electronics & Communication Engineering to become employable and capable of pursuing higher studies.

II. Have sound foundation required to develop hardware & software solutions necessary for analysis, design and implementation of modern Electronics & Communication Engineering systems

III. Develop effective communication skills and interpersonal behavior to become a cooperative team member and able leader.

IV. Provide quality and worthy service towards their profession with societal and ethical values.

V. Inculcate the habit of life -long learning needed for higher studies and research and continue to develop new methodologies and technologies.

PROGRAMME OUTCOMES (POs) and (PSOs) OF B.TECH. (ELECTRONICS & COMMUNICATION ENGINEERING)

Program Outcomes (POs)

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

PO2: Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Formulate the real-life problems and apply the concepts of semiconductor technology, signal processing and communication systems, VLSI etc., in the design and development of application-oriented engineering systems.

PSO2: Ability to identify, formulate and analyze complex problems in the field of Electronics and Communication Engineering using modern engineering tools, along with analytical and managerial skills either independently or as team.

KIET Group of Institutions, Ghaziabad, U.P.

Department of Electronics & Communication Engineering

GRADUATE ATTRIBUTES

The Graduate Attributes of Engineering Programs as identified by NBA are:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

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Dr. A Garg

Message

I am delighted to note that the Department of Electronics and Communication Engineering, KIET Group of Institutions, Ghaziabad is publishing (Online) Volume IV. Issue I, of KIET ECE E-Magazine, “E-TARANG”.

I appreciate the efforts on the part of the Editorial Committee in bringing out Volume-IV. Issue-I, of E-TARANG on various domains of Electronics & Communication Engineering.

I understand that the articles contributed for publication in the Volume III. Issue I, of are on almost all the current aspects of Communication Systems, Electronics systems and several others.

I have great pleasure in congratulating the Editors of KIET ECE E-Magazine, “E-TARANG” for their untiring efforts in bringing out this Volume III. Issue I, of E-TARANG which will be a valued treasure for all researchers, students and faculty in Communications, Networking, Microwave and Electronics Engineering areas.

Let me close with warmest regards.

Dr A Garg
President
KIET ECE E-Magazine, “E-TARANG”

FROM EDITOR'S DESK

It gives me immense pleasure in writing this foreword for the second volume, first issue of the KIET ECE E-Magazine, "E-TARANG" being published by the Department of Electronics and Communication Engineering, KIET Group of Institutions, Ghaziabad.

This magazine is targeted towards researchers, professionals, educators and students to share innovative ideas, issues, recent trends and future directions in the field of Electronics and Communication Engineering. Furthermore, it will enable the students in the various domains to foster the exchange of concepts, prototypes, research ideas and the results of research work which could contribute to the academic arena and also benefit business and industrial community.

I am sure that this magazine would greatly benefit researchers, students and faculty. Young students and technocrats will find the contents of the magazine helpful to set roadmaps for their future endeavors.

Dr. Sanjay Sharma
Professor & Head, ECE DepartmentKIET Group of Institutions

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NEWS

Engineers create a better way to boil water, with industrial, electronics applications

Engineers at Oregon State University have found a new way to induce and control boiling bubble formation, which may allow everything from industrial-sized boilers to advanced electronics to work better and last longer.

Advances in this technology have been published in *Scientific Reports* and a patent application filed. The concept could be useful in two ways, researchers say -- either to boil water or create steam more readily, like in a boiler or a clothing iron; or with a product such as an electronics device to release heat more readily while working at a cooler temperature.

"One of the key limitations for electronic devices is the heat they generate, and something that helps dissipate that heat will help them operate at faster speeds and prevent failure," said Chih-hung Chang, a professor of electrical engineering in the OSU College of Engineering. "The more bubbles you can generate, the more cooling you can achieve.

"On the other hand, if you want to create steam at a lower surface temperature, this approach should be very useful in boilers and improve their efficiency. We've already shown that it can be done onlarge surfaces and should be able to scale up in size to commercial use."

The new approach is based on the use of piezoelectric inkjet printing to create hydrophobic polymer "dots" on a substrate, and then deposit a hydrophilic zinc oxide nanostructure on top of that. The zinc oxide nanostructure only grows in the area without dots. By controlling both the hydrophobic and hydrophilic structure of the material, bubble formation can be precisely controlled and manipulated for the desired goal.

This technology allows researchers to control both boiling and condensation processes, as well as spatial bubble nucleation sites, bubble onset and departure frequency, heat transfer coefficient and critical heat flux for the first time.

In electronics, engineers say this technology may have applications with some types of solar energy, advanced lasers, radars, and power electronics -- anywhere it's necessary to dissipate high heat levels.

In industry, a significant possibility is more efficient operation of the steam boilers used to produce electricity in large electric generating facilities.

This work was supported by the OSU Venture Development Fund and the Scalable Nanomanufacturing Program of the National Science Foundation.

Diamonds closer to becoming ideal semiconductors

Along with being a "girl's best friend," diamonds also have remarkable properties that could make them ideal semiconductors. This is welcome news for electronics; semiconductors are needed to meet the rising demand for more efficient electronics that deliver and convert power.

The thirst for electronics is unlikely to cease and almost every appliance or device requires a suite of electronics that transfer, convert and control power. Now, researchers have taken an important step toward that technology with a new way to dope single crystals of diamonds, a crucial process for building electronic devices.

"We need the devices to manipulate the power in the way that we want," said Zhengqiang (Jack) Ma, an electrical and computer engineering professor at the University of Wisconsin-Madison. He and his colleagues describe their new method in the *Journal of Applied Physics*, from AIP Publishing.

For power electronics, diamonds could serve as the perfect material. They are thermally conductive, which means diamond-based devices would dissipate heat quickly and easily, foregoing the need for bulky and expensive methods for cooling. Diamond can also handle high voltages and power. Electrical currents also flow through diamonds quickly, meaning the material would make for energy efficient devices.

But among the biggest challenges to making diamond-based devices is doping, a process in which other elements are integrated into the semiconductor to change its properties. Because of diamond's rigid crystalline structure, doping is difficult.

Currently, you can dope diamond by coating the crystal with boron and heating it to 1450 degrees Celsius. But it's difficult to remove the boron coating at the end. This method only works on diamonds consisting of multiple crystals stuck together. Because such polydiamonds have irregularities between the crystals, single-crystals would be superior semiconductors.

You can dope single crystals by injecting boron atoms while growing the crystals artificially. The problem is the process requires powerful microwaves that can degrade the quality of the crystal.

Now, Ma and his colleagues have found a way to dope single-crystal diamonds with boron at relatively low temperatures and without any degradation. The researchers discovered if you bond a single-crystal diamond with a piece of silicon doped with boron, and heat it to 800 degrees Celsius, which is low compared to the conventional techniques, the boron atoms will migrate from the silicon to the diamond. It turns out that the boron-doped silicon has defects such as vacancies, where an atom is missing in the lattice structure. Carbon atoms from the diamond will fill those vacancies, leaving empty spots for boron atoms.

This technique also allows for selective doping, which means more control when making devices. You can choose where to dope a single-crystal diamond simply by bonding the silicon to that spot.

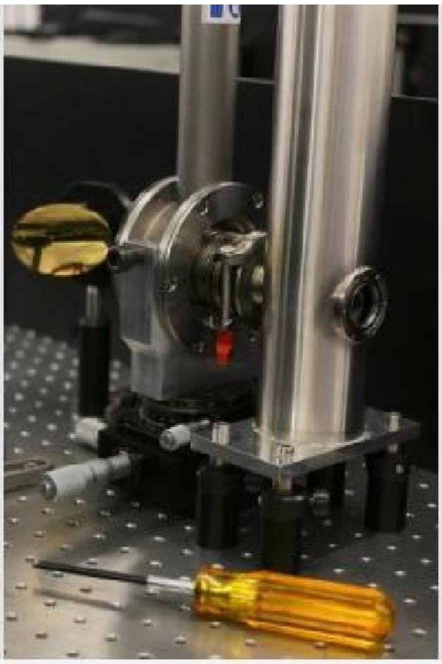
The new method only works for P-type doping, where the semiconductor is doped with an element that provides positive charge carriers (in this case, the absence of electrons, called holes).

"We feel like we found a very easy, inexpensive, and effective way to do it," Ma said. The researchers are already working on a simple device using P-type single-crystal diamond semiconductors.

But to make electronic devices like transistors, you need N-type doping that gives the semiconductor negative charge carriers (electrons). And other barriers remain. Diamond is expensive and single crystals are very small.

Still, Ma says, achieving P-type doping is an important step, and might inspire others to find solutions for the remaining challenges. Eventually, he said, single-crystal diamond could be useful everywhere -- perfect, for instance, for delivering power through the grid.

New tabletop instrument tests electron mobility for next-generation electronics



The table-top sized terahertz cyclotron resonance spectrometer.

Credit: S. Hammersley, The University of Manchester

The National High Magnetic Field Laboratory, with facilities in Florida and New Mexico, offers scientists access to enormous machines that create record-setting magnetic fields. The strong magnetic fields help researchers probe the fundamental structure of materials to better understand and manipulate their properties. Yet large-scale facilities like the MagLab are scarce, and scientists must compete with others for valuable time on the machines.

Now researchers from the United Kingdom, in collaboration with industry partners from Germany, have built a tabletop instrument that can perform measurements that were only previously possible at large national magnet labs. The measurements will help in the development of next generation electronic devices employing 2-D materials, said Ben Spencer, a post-doctoral research associate working in Darren Graham's group at the University of Manchester's Photon Science Institute, who helped develop the new instrument.

The researchers describe their work in a paper in the journal *Applied Physics Letters*, from AIP Publishing.

Since the 1950s, experiments conducted with magnetic fields have played a pivotal role in the development of semiconductors devices -- like transistors and light-emitting diodes -- that have changed the world.

One magnetic field technique is called cyclotron resonance. In a magnetic field, the charged particles in a material start to move in circles around the magnetic field lines. The orbiting particles interact with light differently depending on properties like their mass, concentration, and on how easily they move through the material. By shining light on the material in the magnetic field and recording what frequency and how much light is absorbed, scientists can learn important information about how easily charged particles move, a critical property in electronic devices.

One of the main obstacles to wide-spread use of cyclotron resonance is that some materials require an extremely high magnetic field to get the charged particles to move fast enough to interact with the light.

Recently researchers created a small, high-powered magnet that can generate fields of around 30 Tesla, about 600,000 times stronger than the Earth's magnetic field and 20 times stronger than the MRI scanners typically used in hospitals.

The new magnet is compact enough for a tabletop machine, yet the magnet can only generate a field in short pulses that each last for a fleeting one-hundredth of a second.

"The challenge in doing cyclotron resonance with these pulsed magnets is being able to record your data within the brief time period that the magnet is on," Spencer said. "The breakthrough we have made is in the measurement technique."

Spencer and his colleagues used an approach called an asynchronous optical sampling technique to increase the number of measurements during one pulse to around 100. Previous experiments with a similar magnet system were limited to four measurements per pulse.

The team worked with researchers from Laser Quantum, a laser manufacturer, to incorporate ultrafast lasers into the new instrument. The "Taccor" lasers they used run at repetition rates of 1 billion cycles per second, more than 10 times higher than the typical repetition rates for ultrafast laser systems, Spencer said. The fast laser allowed data acquisition times on the order of one ten- thousandth of a second, which meant up to a hundred measurements could be taken during the transient magnet pulse.

"It is this leap forward that will now enable routine cyclotron resonance measurements on a tabletop in a laboratory environment," Spencer said.

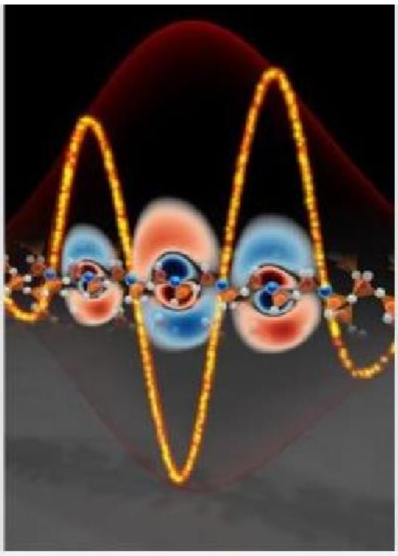
The team tested their system by measuring the properties of electrons at the interface of the two semiconductors AlGaN and GaN. Such interfaces could form an important part of new, energy-saving transistors.

"This work is feeding into a programme of work at Cambridge University on developing AlGaN/GaN- based high electron mobility transistors. These promise much lower power consumption than current devices, which will ultimately lead to energy savings in a wide range of consumer electronic devices. We are also starting to investigate a range of other two-dimensional materials using this instrument, including the new wonder 2-D material graphene," Graham said.

Ultimately, the team hopes their new instrument could facilitate rapid progress in many areas of semiconductor device development. The system can be easily moved to different universities, and it makes it easy to think of a measurement, and simply perform it the next day, without having to apply for time at a national magnet facility, the researchers say.

"We're sure that when people realise that we can do such measurements in the lab they will be lining up to use our instrument. We've already been contacted by several groups interested in having measurements made on their samples," Graham said.

A switch for light wave electronics



Atoms in silicon dioxide are hit by the yellow light wave (from the left) causing the electrons around each atom to oscillate. This displacement absorbs energy from the light wave. At the end of the cycles the absorbed energy is returned to the light wave. Recording of the temporal evolution of the light field after passage through the sample allows the first real-time observation of the attosecond-speed electron motion inside solids.

Credit: Image courtesy of Max Planck Institute of Quantum Optics

Light waves might be able to drive future transistors. The electromagnetic waves of light oscillate approximately one million times in a billionth of a second, hence with petahertz frequencies. In principle also future electronics could reach this speed and become 100.000 times faster than current digital electronics. This requires a better understanding of the sub-atomic electron motion induced by the ultrafast electric field of light. Now a team of the Laboratory for Attosecond Physics (LAP) at the Max-Planck Institute of Quantum Optics (MPQ) and the Ludwig-Maximilians-Universität (LMU) and theorists from the University of Tsukuba combined novel experimental and theoretical techniques which provide direct access to this motion for the first time.

Electron movements form the basis of electronics as they facilitate the storage, processing and transfer of information. State-of-the-art electronic circuits have reached their maximum clock rates at some billion switching cycles per second as they are limited by the heat accumulating in the process of switching power on and off.

The electric field of light changes its direction a trillion times per second and is able to move electrons in solids at this speed. This means that light waves can form the basis for future electronic switching if the induced electron motion and its influence on heat accumulation is precisely understood. Physicists from the Laboratory for Attosecond Physics at the MPQ and the LMU already found out that it is possible to manipulate the electronic properties of matter at optical frequencies.

In a follow-up experiment the researchers now, in a similar way as in their previous approach, shot extremely strong, few femtosecond- laser pulses (one femtosecond is a millionth part of a second) onto glass (silicon dioxide). The light pulse only includes one single strong oscillation cycle of the field, hence the electrons are moved left and right only once. The full temporal characterization of the light field after transmission through the thin glass plate now for the first time provides direct insight into the attosecond electron dynamics, induced by the light pulse in the solid.

This measurement technique reveals that electrons react with a delay of only some ten attoseconds (one attosecond is a billionth of a billionth of a second) to the incoming light. This time-delay in the reaction determines the energy transferred between light and matter. Since it is possible to measure this energy exchange within one light cycle for the first time the parameters of the light matter interaction can be understood and optimized for ultimate fast signal processing. The more reversiblethe exchange is and the smaller the amount of energy which is left behind in the medium after the light pulse is gone, the better the interaction is suitable for future light field-driven electronics.

To understand the observed phenomena and identify the best set of experimental parameters to that end, the experiments were backed up by a novel simulation method based on first principles developed at the Center for Computational Sciences at University of Tsukuba. The theorists there used the K computer, currently the 4-th fastest supercomputer in the world to compute the electron movement inside solids with unprecedented accuracy.

The researchers succeeded in optimizing the energy consumption by adapting the amplitude of the light field. At certain field strengths energy is transferred from the field to the solid during the first half of the pulse cycle and is almost completely emitted back in the second half of the light. These findings verify that a potential switching medium for future light-driven electronics would not overheat. The 'cool relationship' between glass and light might provide an opportunity to dramatically accelerate electronic signal- and data processing, up to its ultimate frontiers.

Liquid catalysts boost efficiency of lithium-air batteries

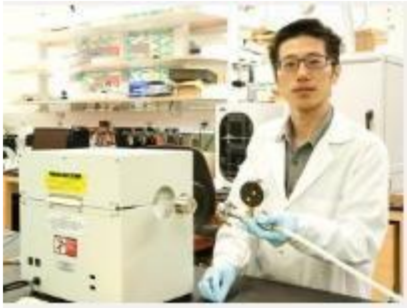
―There‛s huge promise in lithium-air batteries. However, despite the research being done by groups all over the world, those promises are not being delivered in real life,‖ said professor Kyeongjae Cho. ―Our collaboration team has demonstrated that this problem can be solved. Hopefully, this discovery will revitalise research in this area and create momentum for further development.‖

According to Cho, lithium-air batteries feature low efficiency, poor rate performance, instability and unwanted chemical reactions.

Cho and researcher Yongping Zheng, both at the University of Texas Dallas, are focusing on the electrolyte catalysts which, when combined with oxygen, initiate energy transfer in the battery.

The claim is that soluble catalysts possess significant advantages over conventional solid catalysts, generally exhibiting higher efficiency. In particular, they found that only certain organic materials can be used a soluble catalysts. Based on this, they collaborated with researchers led by Dr Kisuk Kang at Seoul National University to create a new catalyst called dimethylphenazine, which possesses higher stability and increased voltage efficiency. ―The catalyst should enable the lithium-air battery to become a more practical energy storage solution,‖ said Zheng. Cho warned people not to get too excited, and that it could take five to 10 years before the research translates into new batteries that can be used in consumer devices and electric vehicles. The work is published in Nature, and funded by car maker Hyundai and the National Research Foundation of Korea.

Dr. Kyeongjae Cho



Yongping Zheng

E- PRODUCTS

Transparent Smartphones

Jhalak Mittal, IV year

Inventors, Jung Won Seo, Jae-Woo Park, Keong Su Lim, Ji-Hwan Yang and Sang Jung Kang, who are scientists at the Korean Advanced Institute of Science and Technology, have created the world's first transparent computer chip.

The chip, known as (TRRAM) or transparent resistive random access memory, is similar to existing chips known as (CMOS) or metal-oxide semiconductor memory, which we use in new electronics.

The difference is that TRRAM is completely clear and transparent. What is the benefit of having transparency?

"It is a new milestone of transparent electronic systems," says Jung Won Seo. "By integrating TRRAM with other transparent electronic components, we can create a total see-through embedded electronic systems."

The technology could enable the windows or mirrors in your home to be used as computer monitors and television screens.

This technology is expected to be available within 3 to 4 years.

Hollow Flashlight

Saransh Agarwal, IV year

Ann Makosinski is a 16-year-old student who competed against thousands of other young inventors from around the world to win first prize and a $25,000 scholarship at Google's International Science Fair.

She invented a battery-free flashlight. A free energy device that is powered by the heat in your hand.

While visiting the Philippines, Ann found that many students couldn't study at home because they didn't have electricity for lighting.

Unfortunately, this is a common problem for developing regions where people don't have access to power grids or can't afford the cost of electricity.

Ann recalled reading how the human body had enough energy to power a 100-watt light bulb.

This inspired her to think of how she could convert body heat directly into electricity to power a flashlight. She knew that heated conductive material causes electrons to spread outwards and that cold conductive material causes electrons to condense inwards.

So, if a ceramic tile is heated, and it's pressed against a ceramic tile that is cool, then electrons will move from the hot tile towards the cool tile producing a current.

This phenomena is known as the thermoelectric effect. image of parts of no-battery flashlight

Ann started using ceramic tiles placed on top of each other with a conductive circuit between them (known as Peltier tiles) to create the amount of electricity she needed for her flashlight.

Her idea was to design her flashlight so that when it was gripped in your hand, your palm would come in contact with the topside of the tiles and start heating them.

To ensure the underside of the tiles would be cooler, she had the tiles mounted into a cut-out area of a hollow aluminum tube.

This meant that air in the tube would keep the underside of her tiles cooler than the heated topside of the tiles. This would then generate a current from the hot side to the cold side so that light emitting diodes (LEDS) connected to the tiles would light-up.

Ann Makosinski demonstrated her new electronic invention but although the tiles generated the necessary wattage (5.7 milliwatts), Ann discovered that the voltage wasn't enough. So she added a transformer to boost the voltage to 5V, which was more than enough to make her flashlight work.

Ann successfully created the first flashlight that didn't use batteries, toxic chemicals, kinetic or solar energy, and that always works when you picked it up.

She credits her family for encouraging her interest in electronics and derives her inspiration from reading about inventors such as Nikola Tesla and Marie Curie.

She told judges at the Google competition that her first toy was a box of transistors.

Time Magazine listed Ann as one of the 30 people under 30 who are changing the world.

She is working on bringing her flashlight to market and is also developing a headlamp based on the same technology.

Smartbox Technology

Himani Agarwal, IV year

Insurance companies are implementing smartbox technology so good drivers can benefit from cheap insurance rates.

The smartbox, similar to a black box for airplanes, records details about how your car is driven, which can result in cheap car insurance for responsible drivers.

The device is connected to the electronics in your car and collects wide criteria of information such as time, speed, braking, cornering, acceleration and location.

The smartbox data is wireless transferred in real time to the insurance company and provides a profile of when, where and how you drive. This profile is then used to compare insurance rates and to reward low-risk driving behavior with cheap insurance rates.

Drivers are high-risk when they drive irresponsibly such as speeding, frequent lane changing, driving in high-risk locations or at high-risk times such as in heavy traffic or late at night.

These new electronic inventions are intended to replace the standard practice of categorizing drivers into group behavior to determine insurance coverage and premium payments.

For example, young drivers are more likely to drive fast, drive at night. And use a cell phone while driving. Statistically, young drivers are more likely to cause an accident so insurance companies charge them higher rates to cover the costs of accident claims.

So even if you're a young, responsible driver, you will pay high insurance rates because of group behavior.

This technology allows you to provide proof that your driving behavior doesn't fit the pattern of your demographic group.

All the information collected about your driving can be viewed online - including what you're doing well and what could be improved. Your insurance premium is then calculated according to your driving profile.

Electronic Pills - Collecting Data Inside The Body

After years of investment and development, wireless devices contained in swallowable capsules are now reaching the market.

Companies such as SmartPill based in Buffalo, New York and Israel-based Given Imaging (PillCam) market capsules the size of vitamin tablets.

These pills contain sensors or tiny cameras that collect information as they travel through the gastrointestinal tract before being excreted from the body a day or two later.

These new electronic inventions transmit information such as acidity, pressure and temperature levels or images of the esophagus and intestine to your doctor's computer for analysis.

Doctors often use invasive methods such as catheters, endoscopic instruments or radioisotopes for collecting information about the digestive tract. So device companies have been developing easier, less intrusive ways, to gather information.

Digestive diseases and disorders can include symptoms such as acid reflux, bloating, heartburn, abdominal pain, constipation, difficulty swallowing or loss of appetite.

new electronic inventions "One of the main challenges is determining just what is happening in the stomach and intestines." says Dr. Anish A. Sheth, Director of the Gastrointestinal Motility Program at Yale-New Haven Hospital.

Doctors can inspect the colon and peer into the stomach using endoscopic instruments. But some areas cannot be easily viewed, and finding out how muscles are working can be difficult.

Electronic pills are being used to measure muscle contraction, ease of passage and other factors to reveal information unavailable in the past.

WEB PULSE

Solar generation is powering up, but faces a range of materials issues

In 2015 the global installed capacity for photovoltaics hit 180GW and the European Photovoltaic Industry Association reckons more than 0.5TWwill be generated from solar cells by the start of the next decade. Government incentives intended to stave off climate change and falling costs have helped push up production, but one of the ironies of a technology meant to change the way we harness energy is the amount that it takes to produce each square centimetre of photon-harnessing panel.

Silicon still accounts for the majority of solar cell production. As that has to be purified from sand – a process that involves cleaving the incredibly stable silicon-oxygen bond – the energy inputs can be huge. The energy required can reach 500kWh per square metre of solar-panel area for the highest- performing monocrystalline form of silicon – an amount that pays back normally within several years of operation. Multicrystalline silicon more or less halves the energy cost of silicon purification, but is about 25% less efficient at capturing photons.

Bringing costs down

Although improved manufacturing can bring the energy cost down, the absorption profile of silicon means that it needs to be made relatively thick to improve the probability of harnessing each photon that breaks through the surface. Thin-film cells made from lower-grade and even lower-efficiency amorphous silicon have largely given way in the past decade to successive waves of more capable chemistries. First came cadmium telluride (CdTe), which was propelled into mass production by First Solar. Despite cadmium's toxic nature, governments have treated the pollution risk from these solarcells to be minimal as long as old panels are recycled properly.

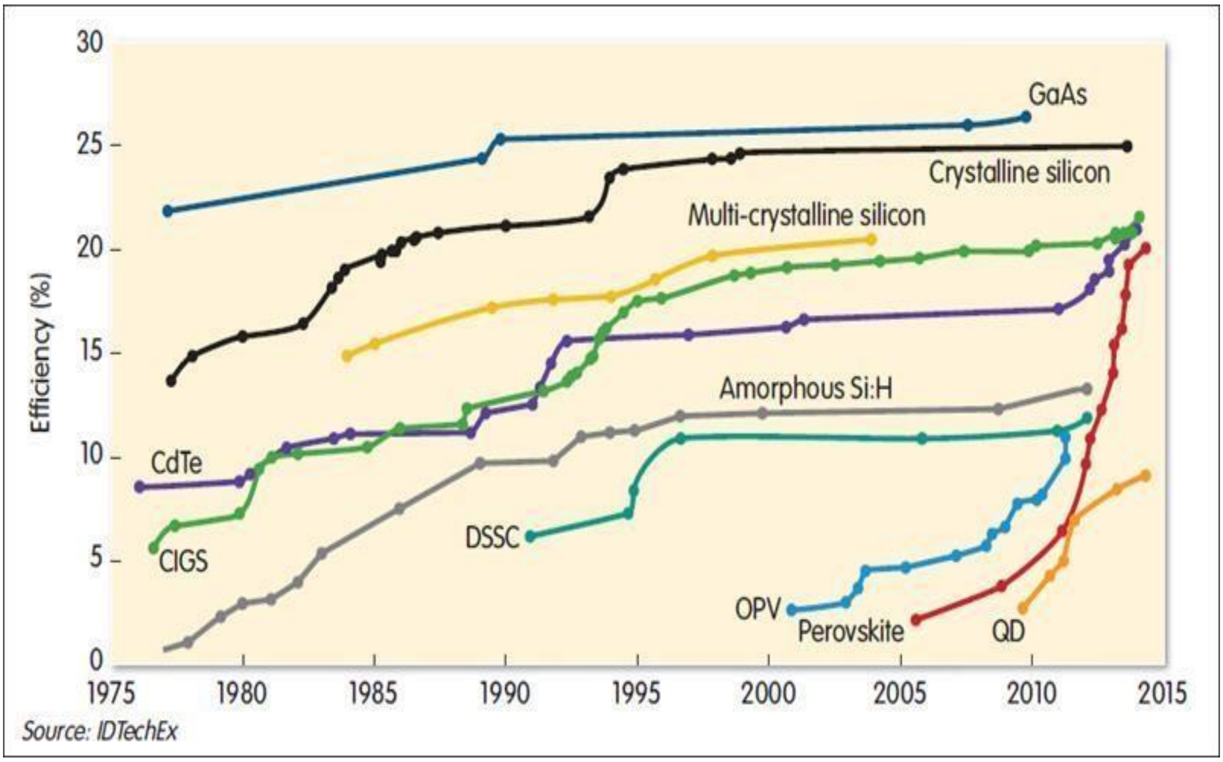
A competitor to CdTe is a mixture of copper, indium, gallium and selenium (CIGS) that encouraged even semiconductor foundry TSMC to buy into solar production at the end of the last decade. Although it managed to create a module with record CIGS conversion efficiency of 16.5%, the company was priced out of the business and quit five years after entering the market.

Another way to deal with the problem of the high cost of purifying semiconductor materials is to try to reduce the surface area. For years, III-V and germanium-based solar cells have boasted higher efficiency than silicon, but are more expensive to make. The answer is to use a concentrator, in whicha lens is placed over a small die of the material to focus more light onto the collector. But, as with someone aiming the sun ray's through magnifying glass, high temperatures create their own reliability problems.

As production ramps, most existing technologies other than silicon face the problem of material availability. Tellurium is a by product of copper mining, so is reasonably easy to obtain but relatively uncommon. In 2000, it cost around $35/kg. A decade later, the price peaked at more than $600/kg before settling back to around $300.

CIGS manufacturers have similar problems, not just with gallium and selenium, but especially indium, where they compete for supplies with flat-panel display manufacturers. So researchers continue to pursue other options, preferably materials that do not suffer from such constrained supplies. A cheaper choice that shares many of the same properties as CdTe and CIGS is iron disulphide – fool's gold – and neither of those elements is going to be in short supply.

On paper, iron disulphide looks good in terms of both band gap and optical absorption, but the material showed less than 3% quantum efficiency when tried as a photovoltaic. The problem is many common crystal phases have smaller band gaps than the material's nominal 0.95eV, which slashes overall efficiency. The hope for a viable use for fool's gold in solar rests on advances in nanotechnology that can avoid growing dud crystals.



Source: IDTechEx

While the efficiency of a range of PV technologies has improved in the last four decades, none matches the improvement shown by perovskite solar cells

Organic materials

Given the carpet of green that covers much of the world, organic materials should also be good, cheap candidates for use in solar cells. However, biotechnology has not progressed to the point where it can harness the same kinds of electrochemical reactions that take place in chlorophyll-loaded living cells.

The increased interest in organic semiconductors for making large-area electronic circuits – such as cheap RF tags and displays – also helped drive research into solar cells made on similar organic chemicals. The same solution-based chemistry and coating processes could support lower-cost production than is possible with many of the other inorganic solar technologies.

Despite good progress in the early 2000s, efficiency for small-scale ‗hero' cells based on organic compounds failed to match the performance of even the cheapest, amorphous form silicon. They have, so far, topped out at around 10% efficiency.

Some researchers and startups involved in organic research have switched their focus to inorganic materials that can be spin coated onto a substrate and which seem to be highly compatible with interface layers developed for plastic photovoltaics. The current favourites are combinations of elements – sometimes including small organic molecules such as methyl-ammonium – that form a cubic crystal structure resembling the calcium-based mineral perovskite.

Perovskites became a major focus in photovoltaic research at the start of this decade because researchers could improve efficiency much faster than any other technology so far. Some of this may be to do with the experience with chemically similar organic materials and the production processes developed for them. Even so, efficiency for perovskite based laboratory cells quickly surpassed that of organics and currently challenges multi-crystalline silicon and thin-film chemistries at around 20%.

As with other technologies, the efficiency of cells suitable for integration into modules lags. Earlier this month, IMEC spinout Solliance demonstrated a design with a reported efficiency of 10%, becoming the top performer so far. The group reckons 15% is achievable, although there is, as with organic materials, a big challenge in developing barrier materials that will last for more than a few years.

As the best perovskite materials so far need to use lead, the need for a reliable barrier materials is more than just one of useful lifetime. The barrier needs to make lead contamination of the environment highly unlikely – with recycling used to recapture the poisonous metal before disposal.

Work using computational materials design to select a crystal that has similar, but less carcinogenic properties, may yet yield an efficient alternative.

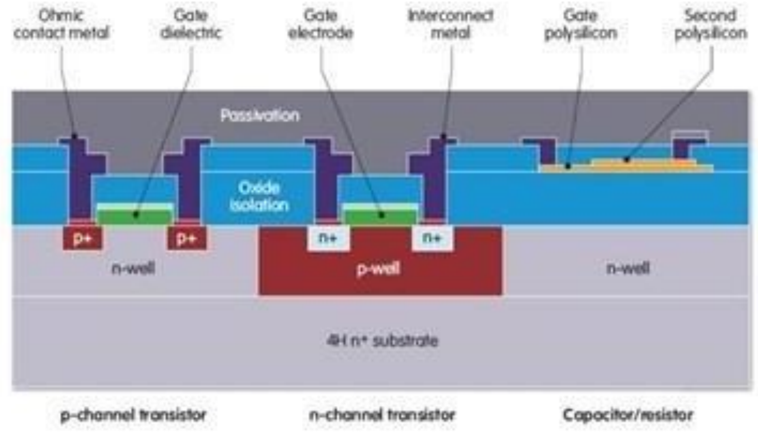
Another potential drawback with perovskite chemistry, in common with organic and silicon, is that it will probably need thicker layers than those used in the thin-film technologies such as CdTe, which will increase production costs. That could still be more than offset by the elements themselves being cheaper to extract by miners.

Combining technologies

Rather than trying to eke a few more percentage points out of the quantum efficiency of a given solar technology, another approach is to combine two or more technologies in one cell or module. If they have different band gaps and are transparent enough to let enough light pass through, they will capture a greater proportion of the incoming photons. This seems to be one way in which organic photovoltaics may stage a comeback at the research, though even combination cells have only reached around 13% efficiency – a record set by Heliatek in February – versus close to 50% for the best stacks of heterojunction semiconductors.

Combination with perovskite layers may mean that organic photovoltaics still stand a chance, just as long as the industry can come up with long-lasting barrier layers. Whichever individual technology wins, the huge areas needed for an even larger rollout of solar generation will tend to favour the technologies with the lowest material cost, even if that means a more complicated assembly process.

The quest for high temperature analogue and mixed signal electronics is taking advantage of silicon carbides's properties



Raytheon's HiTSiC process allows for the creation of p- and n-channel transistors within a thin layer of monolithic 4H Silicon Carbide substrate. The doping profiles, dielectrics and deposited films are designed to allow 15V operation at more than 300°C.

While silicon based components dominate the electronics industry, their operational limits – imposed by silicon's material properties – restrict the extent to which they can be used in harsh environments.

Specifically, device ambient temperature must be kept well below 150°C to keep semiconductor junction leakages low enough not to affect circuit operation adversely. Technology variants, such as silicon on insulator (SoI), can raise the bar by circa 100°C, but most industrial applications require the use of thermal management to ensure the semiconductor junctions remain at a safe working level. In some sectors – aerospace for instance – thermal management is not desired because of the weight penalty imposed by heatsinks and cooling regimes.

Accordingly, alternative semiconductor materials are needed to extend the use of electronics further into harsh environments. Silicon carbide (SiC) is one such material and can be used to create switches, rectifiers and integrated circuits where the low leakage properties can be exploited, making highly integrated circuits feasible at very high temperatures.

To date, though, much of the development focus has been in power electronics and on exploiting SiC's ability to switch high voltages with low switching and on-state losses and to dissipate internally generated heat.

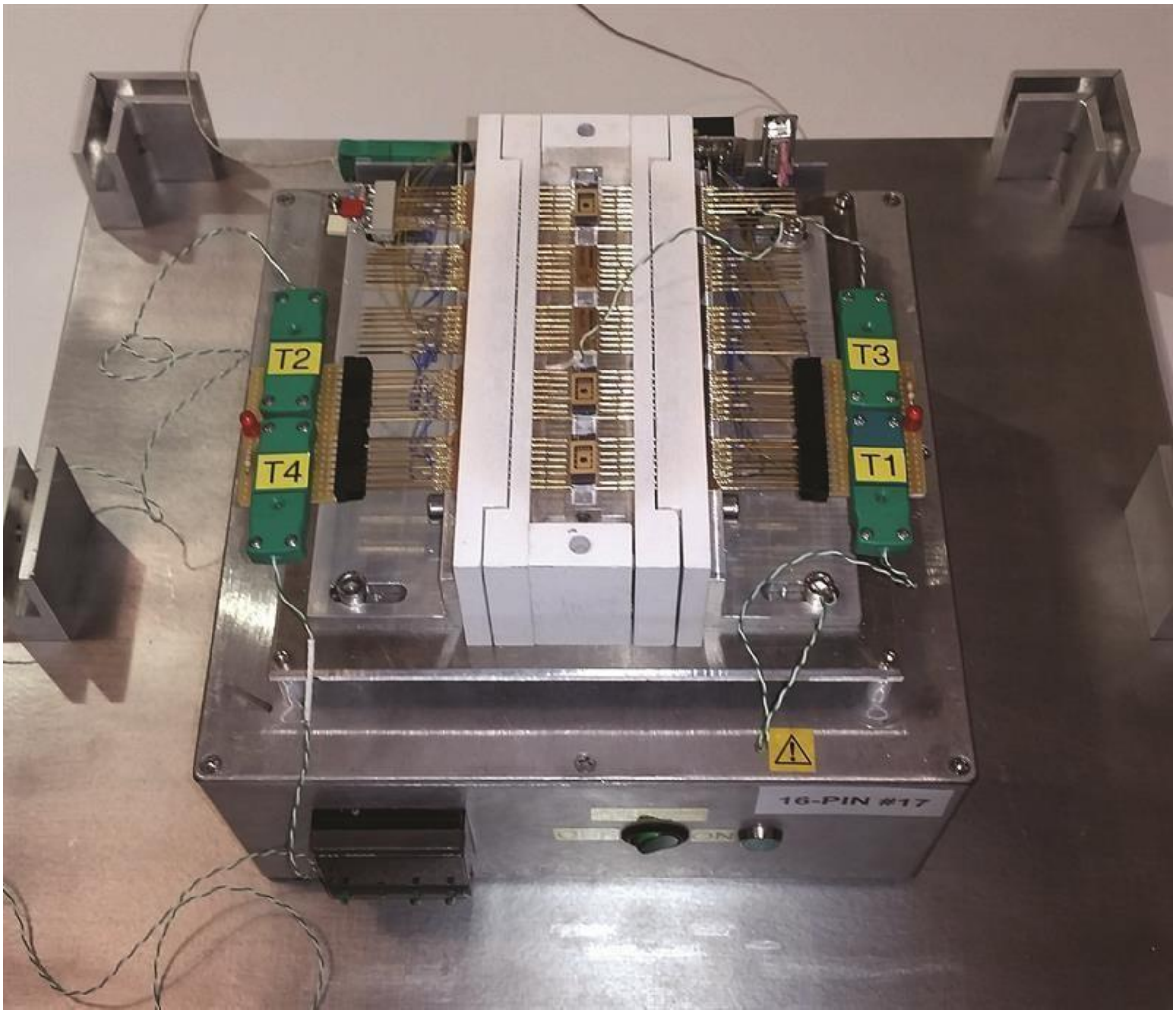
However, SiC can also be used for small signal electronics – such as analogue and mixed-signal devices – making possible the locating of monitoring and control circuitry much closer to heat sources. Research groups have been exploring various integrated circuit technologies, such as SiC NMOS or JFET based transistors.

Raytheon UK, for instance, has been developing a true CMOS technology with both PMOS and NMOS transistors integrated on the same substrate, interconnected with a refractory metal interconnect system. CMOS in SiC, which Raytheon calls HiTSiC, offers the benefits one would expect from a CMOS process, such as integration density and low current operation.

Electronics which can operate in a high temperature environment is of great appeal in the aerospace industry, for instance, where;

- to improve gas turbine efficiency and combustion control, it will be desirable to make accurate measurements of exhaust gas temperatures with electronics in close proximity to that heat source.
- to reduce electronic noise pick up, sensing electronics can be moved closer to the heat source.
- weight can be saved through a reduction in cabling and heat management hardware.

A number of core small-signal building block integrated circuits already exist as high temperature devices and Raytheon UK's semiconductors business unit, based in Glenrothes, recently built a thermocouple multiplexer demonstration unit.



Raytheon's thermocouple multiplexer demonstration unit has a five chip circuit comprising a 555 timer, two dual D-types providing a counter function and two 4:1 analogue multiplexers. All five chips are SiC-based CMOS devices mounted on a temperature-controlled heated bar and fabricated using Raytheon's proprietary HiTSiC CMOS process. The devices were gold wire bonded inside 14pin ceramic *packages and the pin to pin connectivity (to create the circuit) was achieved using pogo-pins and wire wrap in light of traditional solder‗s melting point of 220°C.*

Currently, the demonstrator‗s mixed signal components have amassed more than 80 hours of operation working at 300°C; with a 4:1 analogue multiplexer benefitting in particular from SiC‗s ultra- low leakage property. The device is stable, with an aggregate switch leakage of less than 50nA in the application across temperatures ranging from 23 to 400°C. Also worthy of note is that, in a separate study, HiTSiC digital device performance has amassed more than 1500hr at 300°C.

Though the results are, so far, promising, the industry is some way off having high temperature equivalents of all the Si based devices with which electronics engineers are familiar. Circuits operating at very high temperatures suffer from changes in the semiconductor driven by temperature and time. One particular issue with MOS transistors is the phenomenon of drift in the threshold voltage.

Raytheon UK is working on a Knowledge Transfer Partnership (KTP) project, in conjunction with researchers at Newcastle University, to study the characteristics of the interface between SiC and silicon dioxide – the region which critically impacts on the performance of a MOSFET. The partnership received financial support from the KTP, which aims to help businesses improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside with the UK Knowledge Base. KTPs are supported by Innovate UK, the UK‗s innovation agency.

Defects known as ‗traps‗ in the SiC-SiO2 interface can fill with electrons during operation and this, in turn, affects the MOSFET threshold voltage value. A detailed understanding of the interface behaviour is enabling Raytheon UK to optimise its SiC CMOS manufacturing processes to minimise the occurrence of traps.

Progress in this field is encouraging, with the stability of HiTSiC NMOS transistors being at least as good as that of any SiC power device available on the open market, but work is continuing to optimise the PMOS transistors. This raises an interesting challenge, since both the NMOS and PMOS transistors are manufactured on the same substrate and the same processing steps are used. However, processing steps optimised for NMOS transistors do not necessarily produce optimum PMOS transistors, and vice versa.

Work is progressing on the development of complementary bipolar transistors integrated along with complementary MOS transistors. This work opens the door to developing precision analogue components which will operate at extremely high temperatures, integrated with conversion and control functions.

Aiming high

The end markets for extreme environment sensors and instrumentation for use in aerospace, oil and gas and geothermal exploration are all set to grow as the technology develops and components capable of high temperature operation become more generally available. SiC-based analogue and mixed-signal devices will certainly have a role to play in serving those markets.

The exploration of HiTSiC technology is not stopping at 300°C, or even 400°C. Research groups are looking at circuit applications which extend operating temperature to more than 500°C – to the point where SiC starts glowing red – and results are emerging where devices survive with good functional operation for tens of hours under these conditions. However, SiC has a theoretical operating temperature of nearly 1000°C.

Although the SiC manufacturing processes are maturing and are producing increasingly stable devices, a variety of packaging and connectivity issues will need to be solved, only some of which were encountered during the development of the thermocouple multiplexer demonstrator.

Wireless sensor networks offer engineers the chance to monitor ageing infrastructure and extend their lifetimes

Swapnil Mishra, IV year

Across the developed world, one of the greatest challenges facing civil engineers is the maintenance of ageing infrastructure. Nowhere is this more apparent than in the bridges, tunnels and pipes in cities around the world.

Much of that infrastructure was built 50 to 100 years ago and, as a result, there is growing evidence of deterioration. In many cases, new construction has impacted on existing infrastructure, whether through the use of deep excavation or tunnel construction.

Rapid urbanisation means cities are becoming increasingly crowded and complicated and safety issues arise when infrastructure ages or requires maintenance, hence an increasing demand for monitoring solutions to ensure structural integrity and safety.

The scale of the problem was illustrated by the US Department of Transportation (DOT), which found that, in 2014, 24% of the US' 611,000 public bridges were considered either structurally or functionally deficient.

Managing underground structures – tunnels or pipes – is often problematic; inspection is difficult as they are in constant use. Their long term structural performance tends not to be understood through lack of available historical data and, as a result, the number of research projects investigating the impact of the damage to which these structures are susceptible is growing.

Much of the deterioration is as a result of the wear and tear generated by increased traffic loads, much of which is beyond the original design specification. As a result, infrastructure is ageing far more rapidly than originally anticipated.

Whether monitoring structures above or below ground, there is a growing role and demand for wireless sensor networks in the management of infrastructure networks and the mitigation of damage.

Raghu Das, CEO of IDTechEx, said: ―Developments in sensor and energy harvesting technology are helping to drive this market. The growing deployment of sensors on structures to monitor problems associated with vibration and strain, in the case of bridges and tunnels for example, is growing rapidly.

―Many of these devices tend to be deployed where structures may need to be repaired, but engineers are unsure. For example, with bridges supporting two or three lanes of traffic, up to 300 sensors can be deployed to monitor the structure over a period of three to six months. Once the data has been collected and processed, an informed decision can then be made as to whether maintenance or further action is required.‖

Monitoring systems based on wireless networks are relatively simple today, but are expected in the future to comprise of autonomous modes capable of integrating specific sensing capabilities with communication, data processing and power management.

These networks of sensors could be scattered across engineering systems to not only monitor damage from daily usage, but also to extend their lifetime.

Structural damage tends not to be obvious and may only become apparent when the structure fails.

Practical solutions

Wireless monitoring systems offer a practical structural health monitoring (SHM) solution, avoiding the expense of wired systems and enabling simpler placement in existing infrastructure. But it is the use of energy harvesting techniques to power these sensors that is helping to avoid the safety and costs associated with maintenance especially where devices are battery powered.

Powered by a variety of environmental sources – solar, thermal and vibration – the choice of SHM wireless sensor nodes is determined less by technical considerations and more by the logistics, costand maintenance requirements associated with a specific structure.

―Bridges and roads that support large amount of traffic tend to deploy sensors powered by solar energy harvesting,- explains Raghu, -while in other situations, we are seeing the use of thermoelectrical generators, where power is generated across the structure by variations in temperature.‖

Vibrational energy is another ready source of power for roads and bridges as it is neither reliant on sunlight nor large temperature changes. Using piezoelectric devices to generate power from the vibrations of passing vehicles allows multiple wireless sensors to be placed across a road or bridge. Embedding them is relatively easy; whether in a new construction or an existing piece of infrastructure.

Piezoelectric devices, typically fixed on one end to form a cantilever, will then deliver an voltage proportional to the deformation of its crystalline structure. These devices produce AC voltage output when allowed to flex both above and below its resting plane.

In operation, they will produce a maximum voltage output at a natural frequency determined by a combination of the device‗s characteristics and how it has been attached to the structure. Using devices possessing a natural frequency close to that of the predominant ambient vibrational source is preferred, but the natural frequency can be tuned by adding mass.

―Linear Technology‗s LTC3588-1 combines an on-chip full-wave bridge rectifier, buck converter and power management circuitry that has been specifically designed to maximise energy harvesting from the piezoelectric devices described above. It includes an under voltage lockout capability and can accumulate charge on an input capacitor until the buck converter can transfer a portion of the stored charge to the output,‖ says Richard Miron, technical content engineer at Digi-Key Electronics.

Wireless sensor nodes powered by environmental factors typically combine a low voltage microcontroller, an RF transceiver and an energy-harvesting subsystem for power conditioning and management. For vibrational energy, the harvesting subsystem relies on a full bridge to convert the AC output of the piezoelectric into a useable voltage.

Power management ICs will be deployed to monitor the harvested energy, regulate the voltage supplied to the load and route any excess energy to a storage device such as a rechargeable battery.

While the energy harvesting subsystem provides power, the functional capability of a wireless sensor node relies on sensors, processors and communications capabilities. In a typical SHM application, vibration, moisture and temperature sensors tend to be combined.

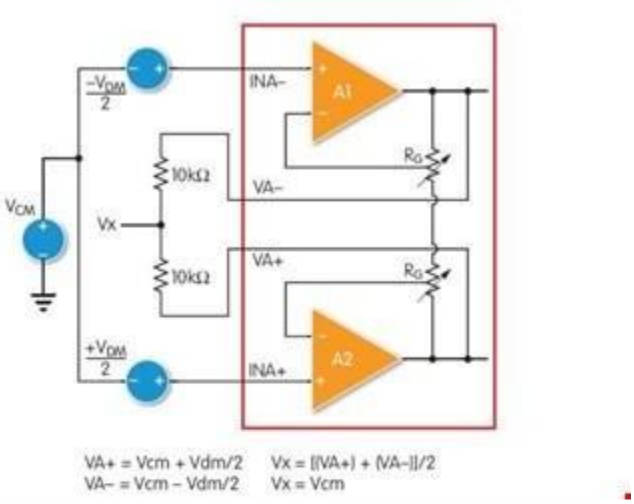
―The MCU and wireless transceiver in these systems will dominate the power budget and require the selection of ultra low-power devices,‖ explains Miron. ―MCUs, such as the AVR ATiny 8bit MCU from Atmel, can operate from supplies as low as 1.8V while consuming 200µA/MHz. The C8051F9xx 8bit MCU family from Silicon Laboratories can operate with a supply as low as 0.9V. For more demanding applications, designers can use TI‛s MSP430 MCU family (160µA/MHz). In fact, TI‛s MSP430FR5969 MCU takes advantage of the low power requirements of its FRAM based on chip memory to achieve a power consumption level of only100µA/MHz.‖

For wireless communications, transceivers capable of operating at sub GHz frequencies can achieve an optimum blend of low power and extended range, with RF transmitters that require about 5mA to support serial data rates of up to 10kbit/s over ranges of up to 1km.

Structural health monitoring is becoming an ever more critical requirement for ensuring the safety of public infrastructure.

The ability to monitoring the health of roads and bridges over time requires wireless sensor nodes that can extract power from a number of energy sources, but provide a continuous sensing capability while removing the need to replace batteries.

Why instrumentation amplifiers are the circuits of choice for sensor applications



Many industrial and medical applications use instrumentation amplifiers (INA) to condition small signals in the presence of large common-mode voltages and DC potentials.

The three op amp INA architecture can perform this function, with the input stage providing a high input impedance and the output stage filtering out the common mode voltage and delivering the differential voltage. High impedance, coupled with high common mode rejection (CMR), is key to many sensor and biometric applications.

The input offset voltage of all amplifiers, regardless of process technology and architecture, will vary over temperature and time. Manufacturers specify input offset drift over temperature in terms of volts per degree Celsius. Traditional amplifiers will specify this limit as tens of µV/°C.

Offset drift can be problematic in high precision applications and cannot be calibrated out during initial manufacturing. In addition to drift over temperature, an amplifier's input offset voltage can drift over time and can create significant errors over the life of the product. For obvious reasons, this drift is not specified in datasheets.

Zero drift amplifiers inherently minimise drift over temperature and time by continually self correcting the offset voltage. Some zero drift amplifiers correct the offset at rates of up to 10kHz. Input offset voltage (Vos) is a critical parameter and a source of DC error encountered when using instrumentation amplifiers (INA) to measure sensor signals. Zero drift amplifiers, like the ISL2853xand ISL2863x, can deliver offset drifts as low as 5nV/°C.

Zero drift amplifiers also eliminate 1/f, or flicker noise; a low frequency phenomenon caused by irregularities in the conduction path and noise due to currents within the transistors. This makes zero-drift amplifiers ideal for low frequency input signals near DC, such as outputs from strain gauges, pressure sensors and thermocouples.

Consider that the zero drift amplifier's sample and hold function turns it into a sampled data system, making it prone to aliasing and foldback effects due to subtraction errors, which cause the wideband components to fold back into the baseband. However, at low frequencies, noise changes slowly, so the subtraction of the two consecutive noise samples results in true cancellation.

Monitoring of sensor health

The ability to monitor changes to the sensor over time can help with the robustness and accuracy of the measurement system. Direct measurements across the sensor will more than likely corrupt the readings. A solution is to use the INA's input amplifiers as a high impedance buffer. The ISL2853x and ISL2863x give the user access to the output of the input amplifiers for this purpose. VA+ is referenced to the non-inverting input of the difference amplifier, while VA- is referenced to the inverting input. These buffered pins can be used for measuring the input common mode voltage for sensor feedback and health monitoring. By tying two resistors across VA+ and VA-, the buffered input common mode voltage is extracted at the midpoint of the resistors (see fig 1). This voltage can be sent to an A/D converter for sensor monitoring or feedback control, thus improving precision and accuracy over time.

Advantages of a PGA

It is widely accepted that you cannot build a precision differential amplifier using discrete parts and obtain good CMR performance or gain accuracy. This is due to the matching of the four external resistors used to configure the op amp into a differential amplifier. An analysis shows that resistor tolerances can cause the CMR to range from as high as the limits of the op amp to as low as -24.17dB2. While integrated solutions improve on-chip resistor matching, there remains a problem with absolute matching to the external resistors used to set amplifier gain. This is because the tolerance between on-chip precision resistor values and external resistor values can vary by up to 30%. Another source of error is the difference in thermal performance between internal and external resistors; it is possible for the internal and external resistors to have opposite temperature coefficients.

A programmable gain amplifier solves this problem by having all the resistors on board. The gain error for this type of amplifier can be less than 1%, while offering typical trim capabilities of the order of ±0.05% and ±0.4% maximum across temperature.

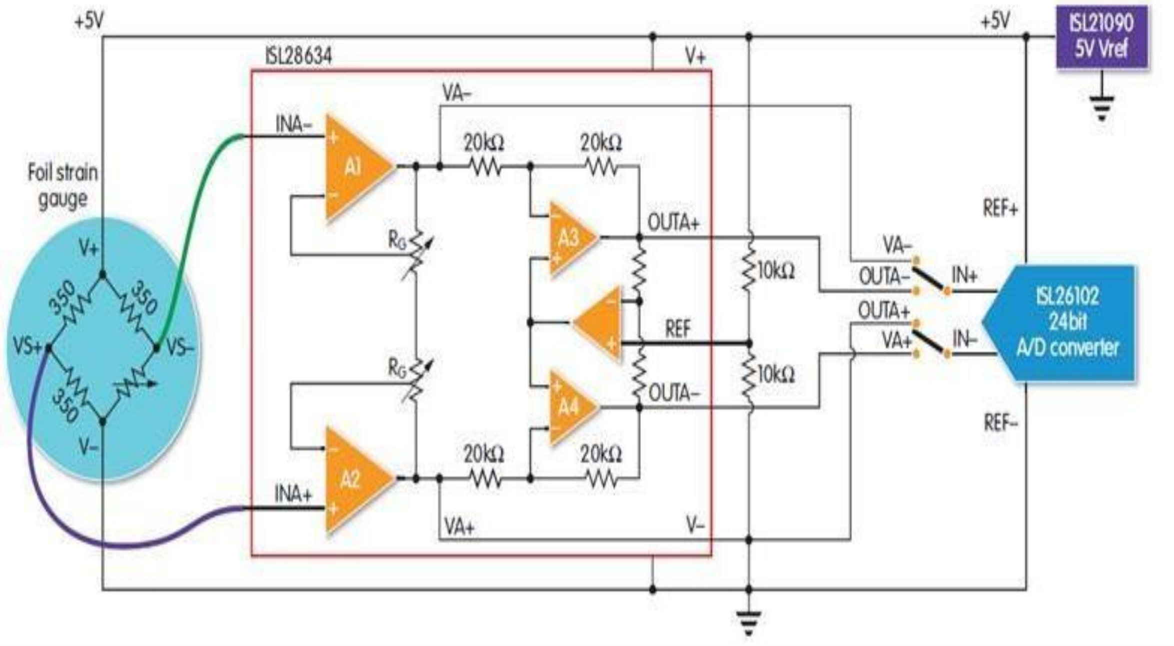
The ISL2853x and ISL2863x families offer single ended and differential outputs with three different gain sets. Each gain set has nine settings, with the gain sets determined for specific applications.

Sensor health monitor

A bridge type sensor uses four matched resistive elements to create a balanced differential circuit. The bridge can be a combination of discrete resistors and resistive sensors for quarter, half and full bridge applications. The bridge is driven by a low noise, high accuracy voltage reference on two legs. The other two legs are the differential signal, whose output voltage change is analogous to changes in the sensed environment.

In a bridge circuit, the common mode voltage of the differential signal is the ‗midpoint' potential voltage of the bridge excitation source. For example, in a single supply system using a +5V reference for excitation, the common mode voltage is +2.5V.

The concept of sensor health monitoring is to keep track of the bridge impedance within the data acquisition system. Changes in the environment, degradation over time or a faulty bridge resistive element will cause measurement errors. Since the bridge differential output common mode voltage is half the excitation voltage, you can use this to monitor the sensor's impedance health (see fig 2). By monitoring the common mode voltage of the bridge, the user can get an indication of the sensor's health.



The figure above represents Schematic for a sensor health monitor application

Reverse Active shield guard drive

Sensors that operate at a distance from signal conditioning circuits are subject to noise that reduces the signal to noise ratio into an amplifier. Reducing the noise that the INA cannot reject (high frequency noise or common mode voltage levels beyond supply rail) improves measuring accuracy. Shielded cables offer excellent rejection of noise coupling into signal lines, but cable impedance mismatch can result in a common mode error into the amplifier. Driving the cable shield to a low impedance potential reduces this mismatch.

The cable shield is usually tied to chassis ground as it is easily accessible. While this works well in dual supply applications, it may not be the best potential voltage to which to tie the shield for single supply amplifiers.

In certain data acquisition systems, the sensor signal amplifiers are powered with dual supplies (±2.5V). Tying the shield to analogue ground (0V) places the shield's common mode voltage right atthe middle of the supply bias, where the best CMR performance is obtained. With single supply amplifiers (5V) becoming more popular for sensor amplification, tying the shield at 0V is at the amplifier's lower power supply rail, which is typically where CMR performance degrades. Tying the shield at common mode voltage of mid supply results in the best CMR.

An alternative solution is to use the VA+ and VA- pins of the ISL2853x and ISL2863x for sensing common mode and driving the shield to this voltage. Using these pins generates a low impedance reference of the input common mode voltage. Driving the shield to the input common mode voltage reduces cable impedance mismatch and improves CMR performance in single supply sensor applications. For further buffering of the shield driver, the additional unused op amp on ISL2853x devices can be used, reducing the need for an external amplifier.

MAN OF THE ISSUE

Sundar Pichai

Meet Sundar Pichai, one of the most powerful CEOs in the world

Google CEO Sundar Pichai just got a big payday.

He received roughly $183 million in company stock, which will vest over the next four years.

According to Bloomberg, this is the highest pay package that Google has ever given to an executive whose equity grants have been reported in filings.

Although Larry Page is still CEO of Google parent company Alphabet, Pichai has the incredibly important job of making sure that the company's core businesses and cash cow stay strong.

He interviewed at the Googleplex on April Fools' Day in 2004 — the same day the company launched Gmail. Everyone, Pichai included, initially thought that the free email service was one of Google's infamous pranks. He started working on Google's search toolbar.

That product ended up being important in 2006, when Microsoft created a "Doomsday" scenario for Google by making Bing the new default search engine on Internet Explorer. Pichai helped convince computer manufacturers to preinstall the Toolbar on their hardware to mitigate the effect of this change. The Toolbar site when Pichai started in 2004.

That problem led him to one of his other biggest early achievements: convincing cofounders Larry Page and Sergey Brin that Google should build its own browser. The result, Chrome, is now the most used option out there.

As a leader, Pichai was always well-liked and more focused on results instead of standing out. That "substance over overt style" attitude attracted attention, though, and he started getting more responsibility.

Like Android. Pichai took over the division in 2013.

One of the major efforts he spearheaded was Android One, Google's push to make low-cost smartphones for "the next 5 billion" people coming online.

He was also incredibly instrumental in making sure that Android was better integrated with Google proper. Before he took over, it was run basically as a completely separate business.

Another landmark in Pichai's rise: He was reportedly instrumental in helping put together Google's $3.2 billion Nest acquisition in 2014. Pichai was also behind the Chrome OS operating system that powers Google's inexpensive Chromebook laptops. He has remained a loyal Googler despite being approached by Twitter for high-ranking roles a couple of times.

That knack and his success with Chrome, Apps, and Android led to his next important promotion in late 2014, when Page put him in charge of almost all of the company's product areas, including search, maps, Google+, commerce and ads, and infrastructure. He essentially became Page's second in command.

Life of Sundar Pichai:

Pichai Sundararajan better known as Sundar Pichai was born 12 July 1972. Pichai grew up in Chennai, India. His father was as an electrical engineer and his mother a stenographer before having him and his younger brother. The family wasn't wealthy, and the boys slept together in the living room of their two-room apartment. Early on, Pichai had a talent for remembering numbers, which his family realized when he could recall every phone number he had ever dialed on their rotary phone. He will still sometimes show off his memorization skills at meetings, to colleagues' awe.

After becoming interested in computers — the first software program he wrote was a chess game — Pichai studied metallurgical engineering at the Indian Institute of Technology Kharagpur. His success there won him a scholarship to Stanford.

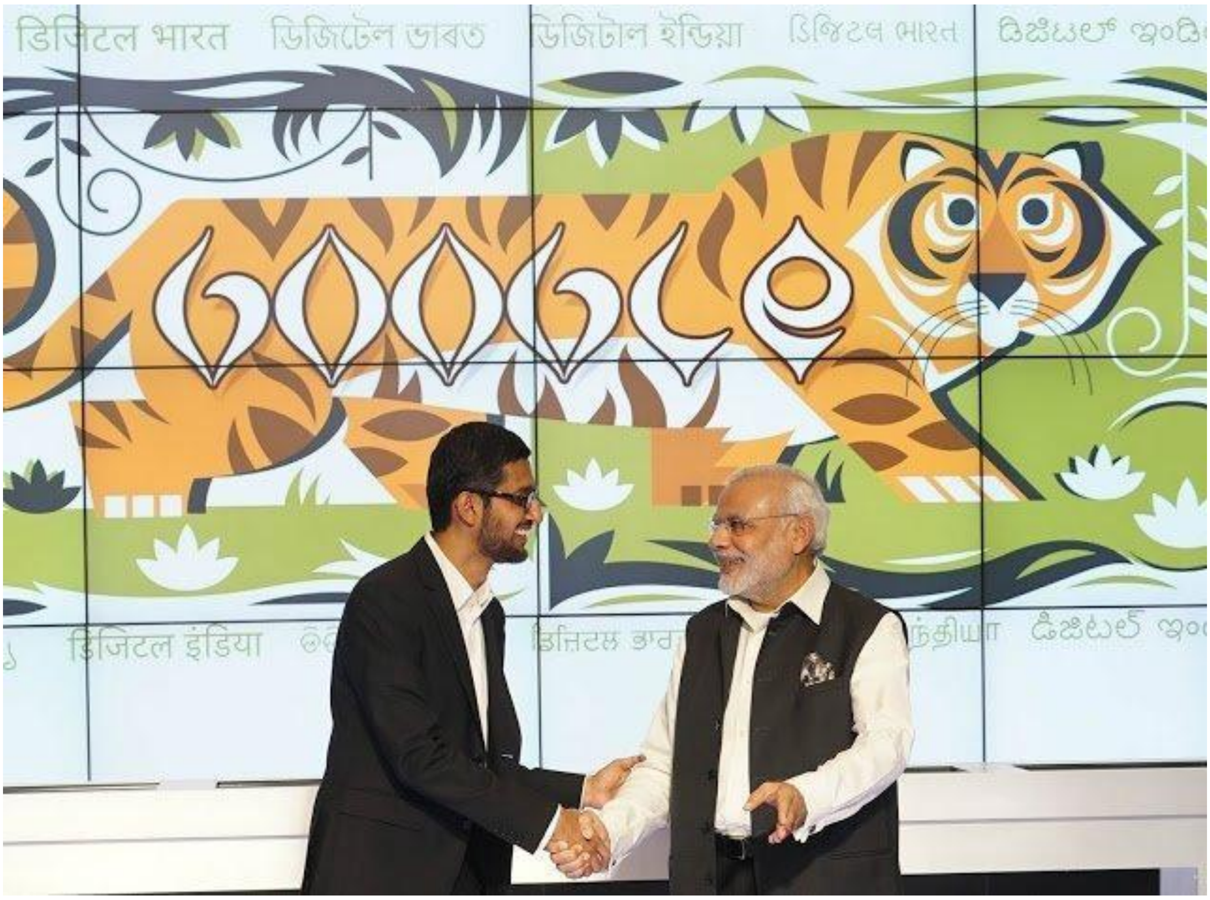
Moving to California was a huge leap. "I always loved technology and while growing up I had dreams of Silicon Valley," Pichai said in a recent interview. "I used to read about it, hear stories from my uncle."

When he got to America, he couldn't believe how expensive everything was — a backpack for $60! He also missed his girlfriend, Anjali. The two eventually got married and have a son and daughter.

At Stanford, Pichai earned his MS and then attended the University of Pennsylvania's Wharton School for his MBA. Before Google, he had stints at Applied Materials and consulting firm McKinsey & Co.

In his home country, Pichai is seen as something of a hero. "You've done what everyone has dreamed of doing," interviewer Harsha Bhogle said while Pichai did a Q&A session with students at a Delhi University.

Here he is meeting with Indian Prime Minister Narendra Modi.



Throughout his meteoric rise, he's remained incredibly humble: "It is always good to work with people who make you feel insecure about yourself. That way, you will constantly keep pushing your limits."

COMPANY OF THE ISSUE

Samsung Electronics

Samsung Electronics Co., Ltd. is a South Korean multinational electronics company headquartered in Suwon, South Korea. Through extremely complicated ownership structure with some circular ownership it is a part of the Samsung Group, accounting for 70% of the group's revenue in 2012. It is the world's second largest information technology company by revenue, after Apple. Samsung Electronics has assembly plants and sales networks in 80 countries and employs around 370,000 people. Since 2012, Kwon Oh-hyun has served as the company's CEO.

Samsung has long been a major manufacturer of electronic components such as lithium-ion batteries, semiconductors, chips, flash memory and hard drive devices for clients such as Apple, Sony, HTC and Nokia.

In recent years, the company has diversified into consumer electronics. It is the world's largest manufacturer of mobile phones and smartphones fueled by the popularity of its Samsung Galaxy lineof devices. The company is also a major vendor of tablet computers, particularly its Android-powered

Samsung Galaxy Tab collection, and is generally regarded as pioneering the phablet market through the Samsung Galaxy Note family of devices.

Samsung has been the world's largest television manufacturer since 2006 and world's largest manufacturer of mobile phones since 2011. Samsung Electronics displaced Apple Inc. as the world's largest technology company in 2011 and is a major part of the South Korean economy. In June 2014, Samsung published the Tizen OS with the new Samsung Z.

History:

Samsung Electric Industries was established as an industry Samsung Group in 1969 in Suwon, South Korea. Its early products were electronic and electrical appliances including televisions, calculators, refrigerators, air conditioners and washing machines. In 1970, Samsung Group established another subsidiary, Samsung-NEC, jointly with Japan's NEC Corporation to manufacture home appliances and audiovisual devices. In 1974, the group expanded into the semiconductor business by acquiring Korea Semiconductor, one of the first chip-making facilities in the country at the time. The acquisition of Korea Telecommunications, an electronic switching system producer, was completed at the start of the next decade in 1980.

By 1981, Samsung Electric Industries had manufactured over 10 million black-and-white televisions. In February 1983, Samsung's founder, Lee Byung-chull, along with the board of the Samsung industry and corporation agreement and help by sponsoring the event, made an announcement later dubbed the "Tokyo declaration", in which he declared that Samsung intended to become a DRAM (dynamic random access memory) vendor. One year later, Samsung became the third company in the world to develop a 64 kb DRAM. In 1988, Samsung Electric Industries merged with Samsung Semiconductor & Communications to form Samsung Electronics, as before that, they had not been one company and had not been a leading corporation together, but they were not rivals, as they had been in talks for a time, until they finally merged.