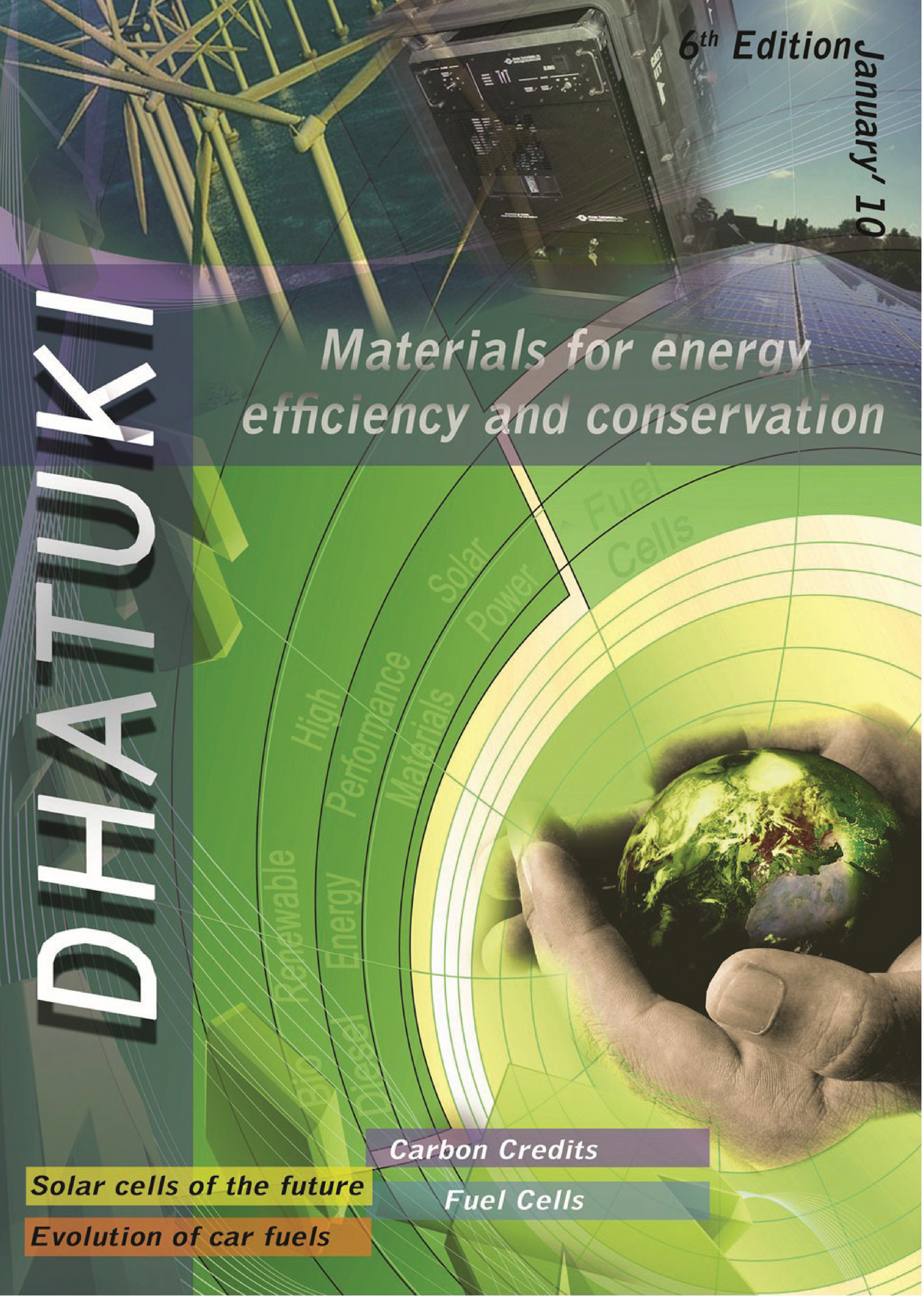
DHATUKI

6th Edition
January' 10

Materials for energy efficiency and conservation



Carbon Credits

Solar cells of the future

Fuel Cells

Evolution of car fuels


Developing Materials
BAYER
Increasing Safety
Science For A Better Life
In 1990, plastics accounted for about nine percent of the materials used in the average car. Today, the figure can be as high as 20 percent.
Bayer MaterialScience is one of the world's largest and most innovative suppliers to the auto industry, playing an active role in shaping the future of the automobile.
Developing windows made of plastics, for example, which offer increased safety benefits. And energy-absorbing polyurethane, which helps protect car passengers in an accident and -when used in bumpers - can reduce the risk of injury to pedestrians. For safer cars - and sheer driving pleasure, www.bayer.com
Bayer:
HealthCare
CropScience
MaterialScience

Dhatuki

this issue

From the editors

Hello readers!

Most of you must be tired of hearing about 'green products' and seeing everyone jump on the green bandwagon to draw consumer attention or financial mileage. Although overemphasizing may weaken the impact of the message being put across, deep down the fact remains that the present resource structure is far from being robust enough to withstand the demands of the future.

Before it crumbles, we need to replace it with better performing and more compatible alternatives for sustainable existence. From more efficient aircraft to thread made from chicken feathers, the world is awash with ingenious ideas. But we don't need to wait for ground breaking inventions or UN policies to do our bit for the environment. In a city like Mumbai with acute water crisis, rain water harvesting at home can save a lot of troubles.

The current issue offers solutions for sustainability, while retaining the regular features.

Enjoy the read!

Message from the HOD

Dear readers,

A Very Happy New Year-2010 and Welcome to an exciting reading of the 6th issue of DHATUKI on the role and importance of Materials for energy generation from renewable sources.

As in every technology materials are also the backbone of systems generating energy through renewable resources such as solar, wind, hydro and bio sources. The efficient generation of energy in usable form i.e. electricity or heat, relies heavily on efficient material performance. Take the example of photovoltaics (PV) or fuel cells. It is the materials that are primarily responsible for the efficiency of these devices.

The present issue of Dhatuki acquaints us with the various aspects of these technologies italicizing the importance of materials and materials processing so that one day mankind will live in an ecologically friendly environment, while still having all the comforts. In this issue we take you through these and also through the significant work being carried out in the Metallurgical Engineering and Materials Science Department at IIT Bombay in PV and fuel cells. The editorial team has once again done a fantastic job of collating very good articles from the researchers and students of the MEMS department as well as from other sources. I am confident that this issue like the earlier ones will be an enjoyable and enlightening reading experience.

Happy reading!

Prof. Rajiv Dusane
(Head of the Department)

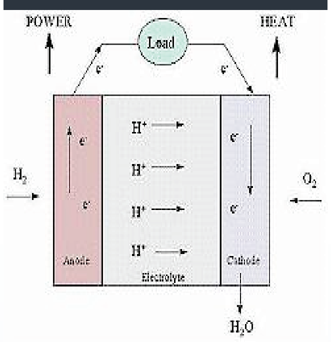
Discovery

The principle of fuel cells was discovered by German scientist Christian Friedrich Schönbein in 1838 .

Working

A fuel cell works by catalysis, separating the component electrons and protons of the reactant fuel, and forcing the electrons to travel through a circuit, hence converting them to electrical power. The catalyst typically comprises a platinum group metal or alloy.

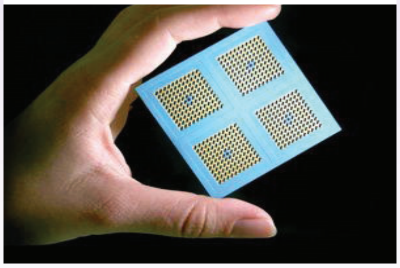
Another catalytic process puts the electrons back



in, combining them with the protons and oxidant to form waste products (typically simple compounds like water and carbon dioxide).

Fun Fact

Fuel cells exalted the stealth capabilities of the German U-boats by eliminating the acoustic and thermal signatures of the diesel generators which were used earlier to charge the onboard batteries.



FUEL CELLS:

Clean, Portable Energy

Aishwarya Ramakrishnan and Palak Ambwani take us on a tour of the world of Fuel Cells– the most promising candidates of energy in the near future.

Fuel cells are electrochemical devices that convert the chemical energy of a reaction directly into electrical energy. Despite their modern high-tech aura, fuel cells actually have been known to science for more than 160 years and have become the subject of intense research and development, especially since World War II.

Today, fuel cells are much in the news because they appear to be one of the most efficient and effective solutions to environmental problems that we face today. Their efficiencies are not limited by the Carnot cycle of a heat engine, and pollutant output from fuel cells is magnitudes lower than from conventional technologies.

Fuel cells are different from conventional electrochemical cell batteries in that they consume reactant from an external source, which must be replenished – a thermodynamically open system. By contrast, batteries store electrical energy chemically and hence represent a thermodynamically closed system. A fuel cell operates like a battery, but does not need to be recharged, and continuously produces power, when supplied with fuel and oxidant. The basic physical structure, or building block, of a fuel cell consists of an electrolyte layer in contact with a porous anode and cathode on either sides.

Fuel Cells can be classified into three types on the basis of fuel oxidizer:

Direct fuel cells:

Hydrogen or hydrogen containing fuel is directly supplied to the anode,

Indirect fuel cells:

Reformer is used, which converts the available fuel to hydrogen or some hydrogen rich gas, and then the reformed fuel is supplied to anode.

Regenerative fuel cells:

Fuel cell product is reconverted to reactants by using electrical, thermal, chemical energy.

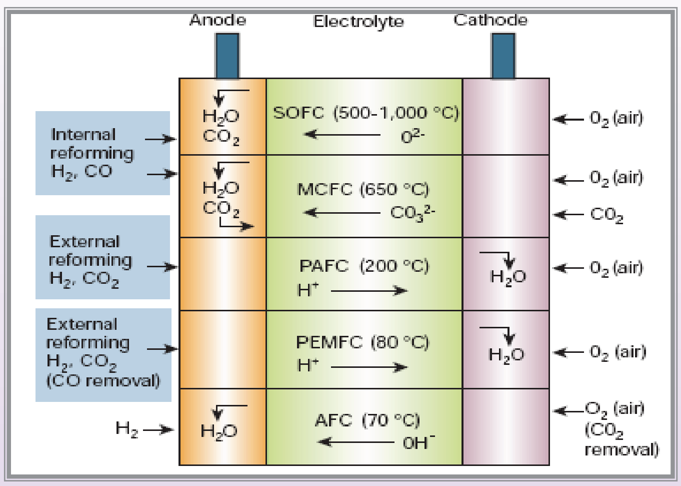
The difference between various cells is based on the species which is transferred inside the cell: proton-exchange fuel cells or oxygen ion exchange fuel cells, or on the materials used for construction of the anode, cathode and electrolyte. Ion exchange mechanisms in some of the popular fuel cell designs are shown in the figure below:

SOFC: Solid Oxide Fuel Cells

MCFC: Molten Carbonate Fuel Cell

PAFC: Phosphoric Acid Fuel Cell

PEMFC: Polymer Electrolyte Membrane Fuel Cell



Different ion exchange mechanisms in some of the popular fuel cell designs

Proton Exchange Fuel Cells:

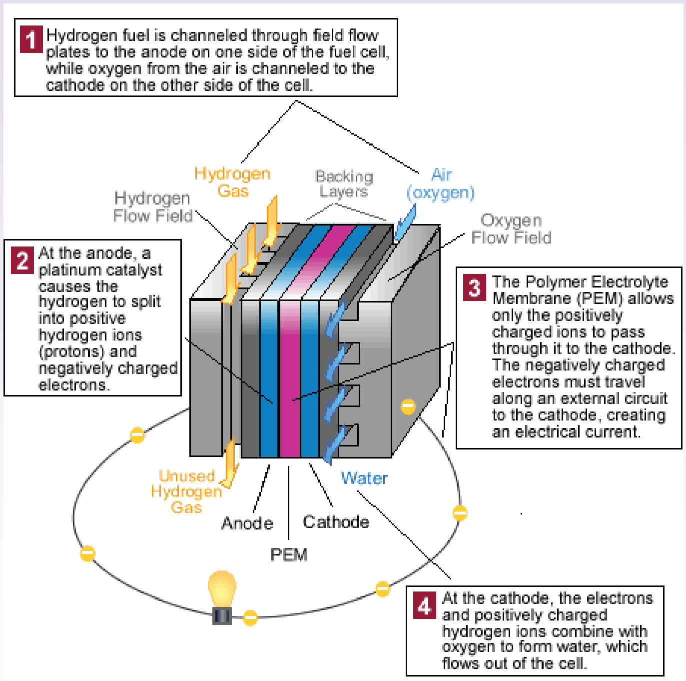
In a proton exchange fuel cell, a proton-conducting polymer membrane (the electrolyte) separates the anode and cathode sides. On the anode side, hydrogen diffuses to the anode catalyst where it dissociates into protons and electrons. The protons are conducted through the membrane to the cathode, but the electrons are forced to travel in an external circuit (supplying power) because the membrane is electrically insulating. On the cathode catalyst, oxygen molecules react with the electrons (which have traveled through the external circuit) and protons to form water.

Oxide Ion Fuel Cells:

In an oxide ion exchange fuel cell, like a solid oxide fuel cell, on the other hand, the anode and cathode are separated by an electrolyte that is conductive to oxygen ions but non-conductive to electrons. On the cathode side, oxygen catalytically reacts with a supply of electrons to become oxygen ions, which diffuse through the electrolyte to the anode side. On the anode side, the oxygen ions react with hydrogen to form water and free electrons. A load connected externally between the anode and cathode completes the electrical circuit.

Solid Oxide Fuel Cells:

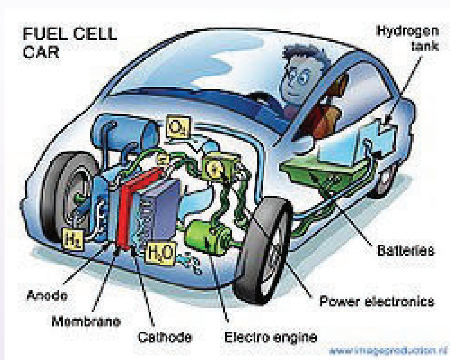
(SOFCs) are the most efficient type of fuel cell, and also the most fuel-flexible. That is, they can directly utilize a wide variety of commonly-available fuels, including natural gas, biogas, ethanol, methanol, hydrogen, carbon monoxide, and synthesis gas produced from coal or natural gas, without the thorough and extensive purification required for low-temperature fuel cells.



Working of a Proton Exchange Fuel Cell

Applications:

Fuel cells are very useful as power sources in remote locations, such as spacecraft, remote weather stations, large parks, rural locations, and in certain military applications. Fuels cells are capable of reaching energy efficiencies of up to 70%, along with high power densities. They have very low emissions and a very long life. And since water is the only product of the reaction, they are very safe for use in day-to-day applications. Different designs of fuel cells operate at different temperatures depending on the catalyst materials involved and the activation energy of the driving reaction. From high-temperature space applications to low-temperature automobile applications, they are used everywhere. A fuel cell system running on hydrogen can be compact and lightweight, and have no major moving parts. Because fuel cells have no moving parts and do not involve combustion, in ideal conditions they can achieve up to 99.9999% reliability. This equates to around one minute of down time in a two year period. This makes them a very robust and widely applicable energy source. Given their immense benefits, fuel cells stand-out as one of the most promising candidates of energy in the near-future.



“Fuel cells are very useful as power sources in remote locations, such as spacecraft, remote weather stations, large parks, rural locations, and in certain military applications.”

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“A fuel cell system running on hydrogen can be compact and lightweight, and have no major moving parts. Because fuel cells have no moving parts and do not involve combustion, in ideal conditions they can achieve up to 99.9999% reliability.”

Do It Yourself

Solar Water Heater

Solar water heaters can reduce or completely eliminate the need for "grid" power to heat hot water at home and save millions over the years while helping the environment at the same time. These heaters can be constructed with common building materials, and using several heaters chained together can provide as much hot water as required. The average homeowner can make a solar heater in about an hour.

Build the Solar Heater Box

Cut a rectangular section of plywood and screw 2-by-4's to one edge, creating a shallow box. Drill two holes, in opposing corners, into the 2-by-4's for pipe access.

Lay the Pipe

Run heat-rated water pipe from one of the drilled holes into a "radiator" pattern on the inside of the box. The pipe will run to one end, turn 90 degrees, run about 2 inches, then turn another 90 degrees and back to the first end. This will repeat until the box is full, and the pipe should exit out of the

SOLAR CELLS:

Tapping the source of all energy sources

Palak, Avinash and Priyanka explain photovoltaics and highlight their advantages over conventional energy sources.

Our generation is faced with a two-fold energy problem. Firstly, the energy demand is constantly increasing but the energy sources based on non-renewable fuels are constantly depleting. Secondly, the use of carbon based fuels is leading to immense environmental damage making them unpopular as sustainable sources of energy. The solution to both the problems lies in using renewable natural sources of energy like wind energy, solar energy, tidal energy etc. Not only do they provide a sustainable source of energy, they cause no environmental degradation or pollution in the process. Among these sources, solar energy has many advantages over others because of the following reasons :

1. Direct conversion of sunlight to electricity is possible without an intermediate step of conversion to mechanical energy, thus increasing efficiency.

2. Solar energy is universally available.

3. It can be used to power space vehicles and satellites along with remote terrestrial areas.

4. Use of solar energy does not involve altering the course of natural processes like storing river waters etc.

5. Photovoltaic devices are uniquely scalable from a scale of milliwatts to megawatts.

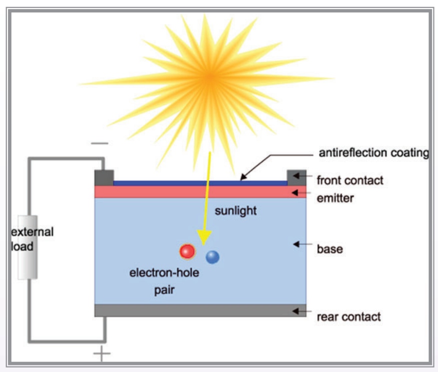
6. The materials involves in this energy conversion are non-toxic and easily available.

The biggest disadvantage of solar energy is the cost factor. Conversion of sunlight to electricity to obtain 1kWatt power costs around $ 3-4 as opposed to just $ 1/ kWatt for conversion of thermal energy to electricity.

The direct conversion of solar energy to electricity is achieved through what are known as photovoltaic materials and devices (solar cells). Many classes of materials and many device structures can function are photovoltaics. But the most common solar cell structure is the semiconductor p-n junction structure.

Working Principle of a Solar Cell

A solar cell is an electronic device which directly converts sunlight into electricity. Light shining on the solar cell produces both a current and a voltage to generate electric power (Photovoltaic effect). This process requires firstly, a material in which the absorption of light raises an electron to a higher energy state, and secondly, the movement of this higher energy electron from the solar cell into an external circuit. The electron then dissipates its energy in the external circuit and returns to the solar cell. A variety of materials and processes can potentially satisfy the requirements for photovoltaic energy conversion, but in practice nearly all photovoltaic energy conversions use semiconductor materials in the form of a *p -n* junction.



Cross section of a single-junction solar cell

A p-n junction is the most basic semi-conductor device which lies at the heart of solar cells, photodiodes, LEDs, lasers etc. P-n junctions are formed by joining n-type and p -type semiconductor materials. Since the n-type region has a high electron concentration and the p-type region has a high hole concentration, electrons diffuse from the n-type side to the p-type side and holes diffuse from the p-type side to the n-type side. When the electrons and holes move to the other side of the junction, they leave behind exposed opposite charges on dopant atom sites, which are fixed in the crystal lattice and are unable to move. An electric field forms between the positive ion cores in the n-type material and negative ion cores in the p-type material. This region is called the depletion region since the electric field quickly sweeps free carriers out, leaving the region depleted of free carriers.

Despite the presence of the electric field, which creates an impediment to the diffusion of carriers across the depletion region, some carriers still cross the junction by diffusion. Once a majority carrier crosses the junction, it becomes a minority carrier. It will continue to diffuse away from the junction and can travel a distance on an average equal to the diffusion length before it recombines. The current caused by the diffusion of carriers across the junction is called diffusion current. Minority carriers which reach the edge of the depletion region are swept across it by the electric field in the depletion region. This current is called the drift current. In equilibrium the drift current is limited by the number of minority carriers which are thermally generated within a diffusion length of the junction and is exactly balanced by the diffusion current.

The generation of current in an illuminated solar cell, known as the light-generated current, involves two key processes. The first process is the absorption of photons with energy greater than the semiconductor band-gap to create electron-hole pairs. However, electrons (in the p-type material), and holes (in the n-type material) are meta-stable and will only exist, on an average, for a length of time equal to the minority carrier lifetime before they recombine. If the carrier recombines, then the light-generated electron-hole pair is lost and no current or power can be generated.

A second process, the collection of these carriers by the p-n junction, prevents this recombination by using a p-n junction to spatially separate the electron and the hole. The carriers are separated by the action of the electric field existing at the p-n junction. If the light-generated minority carrier reaches the p-n junction, it is swept across the junction by the electric field at the junction, where it is now a majority carrier. If the emitter and base of the solar cell are connected together (i.e., if the solar cell is short-circuited), the the light-generated carriers flow through the external circuit. Silicon is the most commonly used semiconductor material used in solar cells because its band-gap matches the typical energy of photons coming from the sun.

Some novel designs of solar cells

1. **Quantum Dot Solar Cells**

Quantum Dots are semiconductor nano crystals composed of periodic groups of II-VI, III-V, or IV-VI materials that exhibit size and compositionally tunable band gaps. This is because the size of such a semiconductor crystal is so small that it approaches the size of the material's Exciton Bohr Radius (An exciton bohr radius is the distance in an electron-hole pair) and the electron energy levels can no longer be treated as continuousi.e that there is a small and finite separation between energy levels. The absorptive and emissive behavior of a quantum dot depends strongly on its size.

The greater the band gap of a solar cell semiconductor, the more energetic the photons absorbed, and the greater the output voltage. On the other hand, a lower band gap results in the capture of more photons including those in the red end of the solar spectrum, resulting in a higher output of current but at a lower output voltage. Thus, there is an optimum band gap that corresponds to the highest possible solar-electric energy conversion, and this can also be achieved by using a mixture of quantum dots of different sizes for harvesting the maximum proportion of the incident light. Another advantage of quantum dots is they can easily be molded in convenient shapes by combining with organic polymers, dyes, or made into porous films on substrates of various materials like glass, plastics and metal sheets.

2. **Organic solar cells**

Organic solar cells emerged in the late 1970s, based on conjugated polymers – polymers with alternating double and single carbon-carbon bonds – when it was discovered that doping these materials – i.e. slightly contaminating with appropriate chemical elements - increased conductivity several orders of magnitude . Since then these materials have found applications in the making of solar cells.

Organic photovoltaic solar cells bear an important potential of development in the search for low-cost modules for the production of domestic electricity. One of the main differences between inorganic and organic solar cells is that photo-excitation in these materials does not automatically lead to the generation of free charge carriers, but to bind electron–hole pairs (exciton) with a binding energy of about 0.4 eV. One of the biggest obstacles to organic solar cells is that it is difficult to control what happens after light is absorbed: whether the desired property is transmitting energy, storing information or emitting light. Experiments, however suggests it is possible to achieve control using quantum effects, even under relatively normal conditions.

Organic solar cells — made out of plastic-like polymers — are much cheaper when compared by the conventional inorganic, silicon and metal-based solar cells typically favored by the solar industry. They are also flexible and are very light. Their one main disadvantage, of course, is their relatively low efficiency of just 5.4% as compared to the 20 - 40% efficiencies regularly attained by inorganic crystalline solar cells.

3. **Dye sensitized solar cells**

A dye sensitized solar cell is a relatively new class of thin film, low-cost solar cells. It is based on a semiconductor formed between a photo-sensitized anode and an electrolyte which functions like a photochemical system. They are also known as Grätzel cells after their inventor.

Dye-sensitized solar cells separate the two functions provided by silicon in a traditional cell design. Normally the silicon acts as both the source of photoelectrons, as well as providing the electric second hole.

Paint the Interior of the Box

Using common spray paint, cover the pipes and interior of the box with a couple of coats of flat black color. The black color will absorb sunlight more readily than any other color and will improve the effectiveness of the heater.

Seal the Heater

Cover the top of the heater box with a section of plexiglass, and seal the edges with heat-resistant adhesive. This is a critical step, as the clear plexiglass will allow light to enter the box, then trap the heat around the pipes. The plexiglass can be secured by drilling small holes into it and mounting it with thin screws, but this can cause it to crack if heated and cooled over many years.

Mount the Solar Heater

Mount the box onto a flat surface that gets lots of direct sunlight. The bottom of the box can be secured with L brackets and screws to most surfaces, but roof installations will require sealant around the mounts to prevent leaking.

Connect the Pipes

Connect the pipes to the water system by linking the input and output pipes with the pipes from the old water heater. The water input should enter at the "top" pipe, and exit at the lower pipe, so that gravity can assist the flow of water through the solar heater.

field to separate the charges and create a current. In the

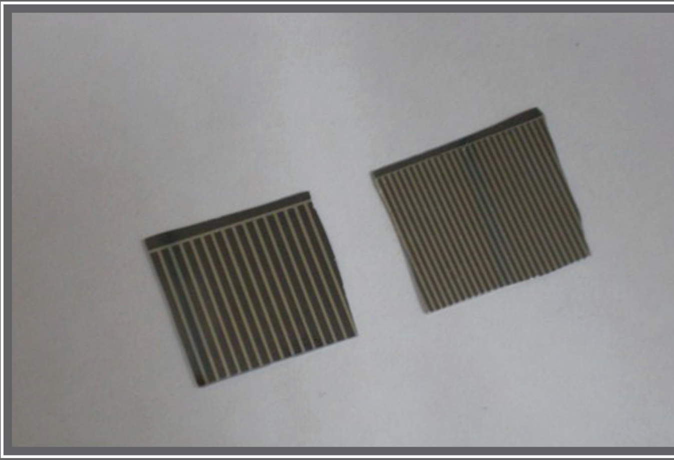
dye-sensitized solar cell, the bulk of the semiconductor is used solely for charge transport, the photoelectrons are provided from a separate photosensitive dye. Charge separation occurs at the surfaces between the dye, semiconductor and electrolyte. In quantum efficiency (the chance that one photon (of a particular energy) will create one electron) terms, these cells are extremely efficient. Due to their "depth" in the nanostructure there is a very high chance that a photon will be absorbed, and the dyes are very effective at converting them to electrons. DSSCs are currently the most efficient third-generation solar technology available.

4. **Tandem solar cells**

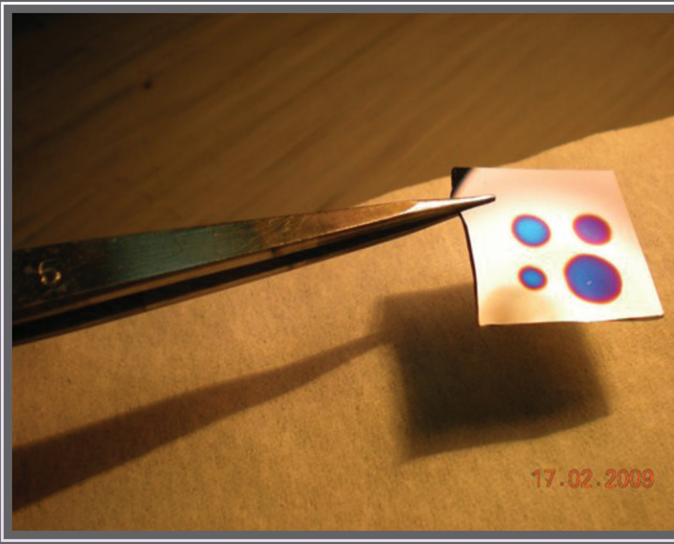
Multi junction photovoltaic cells are a sub-class of solar cells developed for higher efficiency. These multi junction cells consist of multiple thin films. Each type of semiconductor will have a characteristic band gap energy which, loosely speaking, causes it to absorb light most efficiently at a certain color, or more precisely, to absorb electromagnetic radiation over a portion of the spectrum. The semiconductors are carefully chosen to absorb nearly all of the solar spectrum, thus generating electricity from as much of the solar energy as possible. Tandem solar cells based on monolithic, series connected, gallium indium phosphide (GaInP), gallium arsenide GaAs and germanium (Ge) p-n junctions, are seeing demand rapidly rise as we can see reflected in the irse in cost of gallium and germanium. These solar cells are currently being utilized in the Mars rover missions. Triple-junction GaAs solar cells were also being used as the power source of the Dutch four-time World Solar challenge winners Nuna in 2005 and 2007, and also by the Dutch solar cars Solutra (2005) and Twente One (2007). A Dutch university set the record for thin film solar cell effiency using a single junction GaAs to 25.8% in August 2008 using only 4 µm thick GaAs layer which can be transferred from a wafer base to glass or plastic film.

Highlights of Research in our Department

Considerable amount of work is going on in the Semiconductor Thin Film and Plasma Processing laboratory in our department. The research is primarily focused on deposition of amorphous silicon solar cells, heterojunction with intrinsic thin layer solar cells and transparent conducting oxides. Silicon layers are deposited using Hot-Wire CVD whereas metallization and TCO deposition is done using Thermal Evaporation and RF Sputtering respectively. Efficiencies of up to 5% have been achieved with amorphous silicon solar cells. Studies are also being carried out to understand the interface properties of solar cells and how they effect the efficiencies of these cells.



Solar cells deposited in the department with grid-type aluminum as front contact of different grid spacing.



Solar cells deposited in the department with TCO as front contact. Cell Area is given by the area under the TCO layer (seen as blue dots).

CARBON CREDITS:

Rewards of Going Green

Emit less and add to your profits.

As nations have progressed, our earth is undoubtedly warming. This warming is largely attributed to emissions of Greenhouse Gases (GHG's) from human activities like fossil fuel combustion and deforestation. Some decades ago a debate started on how to reduce the emission of harmful gases that contributes to the greenhouse effect that causes global warming. So, countries came together and signed an agreement named the Kyoto Protocol.

The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries. Under CDM, a developed country can take up a greenhouse gas reduction project activity in a developing country where the cost of GHG reduction project activities is usually much lower. The developed country would be given credits (Carbon Credits) for meeting its emission reduction targets, while the developing country would receive the capital and clean technology to implement the project.

Carbon credits are certificates issued to countries that reduce their emission of GHG (greenhouse gases) which causes global warming. Carbon credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one tonne of carbon dioxide reduction.

But how does it work in real life?

Assume that British Petroleum is running a plant in the United Kingdom. Say, that it is emitting more gases than the accepted norms. It can tie up with its own subsidiary in, say, India or China (the developing countries) under the CDM. It can buy the 'carbon credit' by making Indian or Chinese plant more eco-savvy with the help of technology transfer. Later, towards the end of the financial year, an audit will be done of their efforts to reduce gases and their actual level of emission. The developing countries like India and China are ensuring that new technologies for energy savings are adopted so that they become entitled for more carbon credits. They are selling their credits to their counterparts in Europe. This is how a market for carbon credit is created. So now, as decided earlier, every year the European companies are required to meet certain norms, beginning 2008. By 2012, they should be able to achieve the required standard of carbon emission. This entire process was not understood well by many. Those who knew about the possibility of earning profits, adopted new technologies, saved credits and sold it to improve their bottom-line. Many companies did not apply for credit even though they had new technologies. Some companies used management consultancies to make their plan greener to emit less GHG. These management consultancies then scouted for buyers to sell carbon credits. However, the price to sell carbon credits at, was not available on a public platform. Today, one tonne of carbon credit fetches around Euro 22. It is traded on the European Climate Exchange. In India, carbon credits' trading is usually done in the MCX market i.e. Multi Commodity Exchange market.

People at MCX are getting price signals for the carbon for the delivery in next five years. Our exchange is only for Indians and Indian companies. Every year, in the month of December, the contract expires and at that time people who have bought or sold carbon will have to give or take delivery. The Indian government has not fixed any norms nor has it made it compulsory to reduce carbon emissions to a certain level. So, people who are coming to buy from Indians are actually financial investors that profit from sales in European regions of high demand for carbon credits.

In India, already 300 to 400 companies have carbon credits after meeting UNFCCC norms. There are already power, energy and metal companies trading heavily on MCX. These companies are high-energy consuming companies and they need better technology to emit less carbon. The market for carbon trading is undoubtedly high and is expected to gain momentum in coming future. Such conscious approaches of different countries will go a long way in making our world a better place.

Carbon Credit

The license to burn

A permit that allows the holder to emit one ton of carbon dioxide. Credits are awarded to countries or groups that have reduced their green house gases below their emission quota. Carbon credits can be traded in the international market at their current market price.

Copenhagen Summit

Market Impact

The fledgling carbon market is stumbling in confusion after the inconclusive end to the Copenhagen climate conference, pushing prices down on the official European exchange and stoking uncertainty among traders in North America. Despite lower prices, global carbon trading went up 68% in 2009.

Fun Fact

Success Story

In a landmark for carbon financing in India, the BMC earned Rs 26 crore from the Asian Development Bank in 2009 for the scientific closure of its Gorai dumping ground. The BMC hopes to earn a total of Rs 73 crore, which would be Rs 11 crore above the cost of the project.

CAR FUELS:

Evolution Over the Centuries

Ketan, Rahil and Sourabh acquaint us with how car fuels have evolved over time and highlight the car fuels currently popular all around the globe.

The conception and subsequent development of the motor car in the past century has been a significant contributing factor to the tremendous economic growth of the industrialized world. The development of the car is primarily due to the invention of the internal combustion engine, but also to the fact that volatile fuels based on hydrocarbons are particularly suitable for running car engines and that the oil industry has been able to produce these fuels in adequate, economic quantities and with constantly improving qualities.

Way back in 1680, Dutch physicist, Christian Huygens designed an internal combustion engine fueled with gunpowder. Nicolas Joseph Cugnot invented the first self-propelled road vehicle using a steam engine in 1769. In 1807, Francois Isaac de Rivaz of Switzerland invented an internal combustion engine that used a mixture of hydrogen and oxygen for fuel. In 1824, English engineer, Samuel Brown adapted an old steam engine to burn gas. In 1830s, Robert Anderson of Scotland invented the first crude electric carriage. In 1864, Austrian engineer, Siegfried Marcus designed a vehicle that a few historians have considered as the forerunner of the modern automobile by being the world's first gasoline-powered vehicle.

In the late 19th century, the most suitable fuels for the automobile were coal tar distillates and the lighter fractions from the distillation of crude oil. Petrol was used as the fuel for the first four-stroke cycle spark-ignition engine in 1884. Petrol was, at that time, considered to be an undesirable by-product of kerosene manufacturing.

From 1900 to 1920, there was an increase in demand for petrol and it ceased to be just a by-product and the more volatile fractions of kerosene were diverted to petrol. During the early 20th century, the oil companies were producing petrol as a simple distillate from petroleum, but automotive engines were rapidly being improved and their fuels needed to improve with them.

Thermal cracking was introduced in 1913 to convert a larger fraction of petroleum into petrol. Earlier investigations had shown that the heating of crude oil or certain fractions caused a split-up of molecules and thus increased the proportion of volatile fractions suitable for petrol manufacture.

Thermal cracking required elevated pressure for the process. In the 1920's, it was found that certain silica/alumina-based catalysts accelerated the reaction rate to the extent that high pressure became unnecessary. The advantages of catalytic cracking over thermal cracking were a higher petrol yield and a better quality of product.

Lead was first used as an anti-knock agent in 1926. The greater breakthrough in catalytic cracking came when the initially developed fixed-bed catalytic process was replaced by the fluid-bed catalytic process. The fluid-bed process allowed for excellent control of temperature and reaction, which permitted better yields of petrol from the refineries.

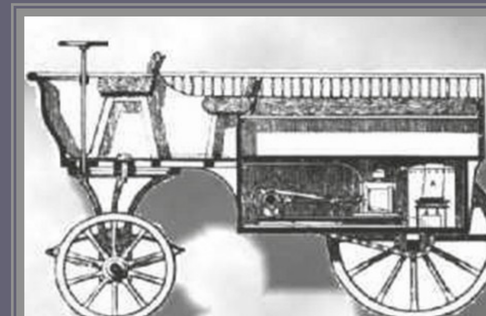
The introduction of the catalytic cracking process and catalytic reforming in the 1940's was significant for the manufacture of high-octane petrol components. The 1950's saw the start of the increase of the compression ratio in engines, requiring higher octane fuels. Octane ratings, lead levels, and vapor pressure increased. Minor improvements continued to be made to petrol formulations to improve yields and octane until the 1970s - when unleaded fuels were introduced to protect the exhaust catalysts that were being introduced for environmental reasons.

From the 1970's until 1990 petrols were slowly changed as lead began to be phased out, lead levels plummeted and octane ratings initially decreased, and then remained 2 to 7 numbers lower.

Most of the automobiles in use today are propelled by gasoline (also known as petrol) or diesel internal combustion engines, which are known to cause air pollution and are also blamed for contributing to climate change and global warming. Increasing costs of oil-based fuels, tightening environmental laws and restrictions on greenhouse gas emissions are propelling work on alternative power systems for automobiles. Efforts to improve or replace existing technologies include the development of hybrid vehicles, and electric and hydrogen vehicles which do not release pollution into the air.

Metamorphosis Of Design With Evolving Fueling Technology

Built in 1769, the very first self-propelled road vehicle was a military tractor invented by French engineer and mechanic, Nicolas Joseph Cugnot. Cugnot used a steam engine to power his vehicle.



An early gas powered car from the 19th century. The cars of these times saw coal gas, hydrogen-oxygen mixture and stove gas being used as fuels .

Robert Anderson created the first electric car during the 1830s. Practical and more successful electric road vehicles were invented around 1842 using non-rechargeable electric cells.

The 2007's Tesla Roadster is a fully electric car with zero emissions despite a top speed of 201 km/h. It can travel 393 km on a single charge of its lithium-ion battery pack, and accelerate from 0-97 km/h in 3.9 seconds. The Roadster's efficiency is equivalent to 100 kilometers for every 2.24 liters of gasoline.

The Koenigsegg CCXR of 2007 is a mid-engined roadster that drives on bio ethanol. The cooling properties of ethanol allowing for a higher pressure in the cylinder and the biofuel having a higher octane rating compared to gasoline give it that extra power.

The Toyota FCHV is a current hybrid fuel cell vehicle. Onboard compressed hydrogen tanks and a nickel-metal hydride battery provide power to the driving motors either singly or together. It is very similar to Toyota Prius but with the fuel cell replacing the petrol internal combustion engine, thus minimising GHG emissions .

Review of Predominant Fuels

Diesel: Diesel-engined cars have long been popular in Europe with the first models being introduced in the 1930s by Mercedes Benz and Citroen. The main benefit of diesel engines is a 50% fuel burn efficiency compared with 27% in the best gasoline engines. Many diesel-powered cars can run with little or no modifications on 100% biodiesel and combinations of other organic oils. A down-side of the Diesel engine is that the presence in the exhaust gases of fine soot particulates (called diesel particulate matter) harms the engine.

Gasoline: Gasoline engines have an advantage over diesel in being lighter and able to work at higher rotational speeds and they are the usual choice for fitting in high-performance sports cars. Most modern gasoline engines also are capable of running with up to 15% ethanol mixed into the gasoline With a small amount of redesign, gasoline-powered vehicles can run on ethanol concentrations as high as 85%. 100% ethanol is used in some parts of the world Most gasoline powered cars can also run on LPG. LPG produces fewer toxic emissions and is a popular fuel for fork-lift trucks that have to operate inside buildings.

Natural Gas: Natural gas is primarily methane. Because methane only has one carbon in its composition, it produces very low carbon emissions. Besides, it is more economical than gasoline. The energy efficiency is generally equal to that of gasoline engines, but lower compared with modern diesel engines. Gasoline/petrol vehicles converted to run on natural gas suffer because of the low compression ratio of their engines, resulting in a cropping of delivered power while running on natural gas. CNG-specific engines, however, use a higher compression ratio due to this fuel's higher octane number of 120–130.

Bio Ethanol: It is a renewable fuel because it's made from plants such as corn, grain sorghum, sugar cane, wheat, and biomass. Alcohols are used with gasoline for a variety of reasons - to increase octane, to improve emissions, and as an alternative to petroleum based fuel, since they can be made from agricultural crops. Many acres of cropland are needed to produce ethanol, and this makes it more expensive than gasoline. Ethanol also gets less miles per gallon than the same amount of gasoline.

Electric: Electric cars are far from new. They were driven as early as the 1830s and were manufactured through the late 1930s, but they were not very popular because of limited range and power. The need to develop more environment friendly and more efficient cars than gasoline powered cars brought them back. Modern hybrid electric vehicle (HEV) uses an electric motor and a gasoline engine. The engine charges the battery and extends the range and provides extra power. Still more eco friendly versions are the fuel cell - electric hybrids. The downside of fuel cells is that they are expensive, so they are not as popular as other cars. Hydrogen is also difficult to store and distribute.

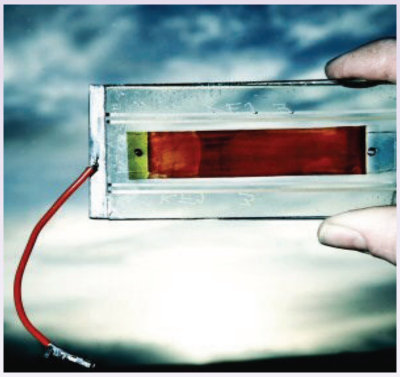
How DSSCs are different?

A dye sensitizer is used to absorb the light and create electron-hole pairs in a nanocrystalline titanium dioxide semiconductor layer. This is sandwiched in between a tin oxide coated glass sheet and a rear carbon contact layer, with a glass or foil backing sheet.

This cell is extremely promising because it is made of low-cost materials and does not need elaborate apparatus to manufacture. In bulk it should be significantly less expensive than older solid-state cell designs. It can be engineered into flexible sheets and is mechanically robust, requiring no protection from minor events like hail or tree strikes. Although its conversion efficiency is less than the best thin-film cells, its price/performance ratio (kWh/(m^2·annum·dollar)) should be high enough to allow them to compete with fossil fuel electrical generation.

Fun Fact

Hyundai's futuristic hybrid car- Blue Will has flexible dye-sensitized solar cells built into its panoramic roof to generate a trickle charge for a cabin cooling fan that reduces temperatures while the car is parked in the sun.



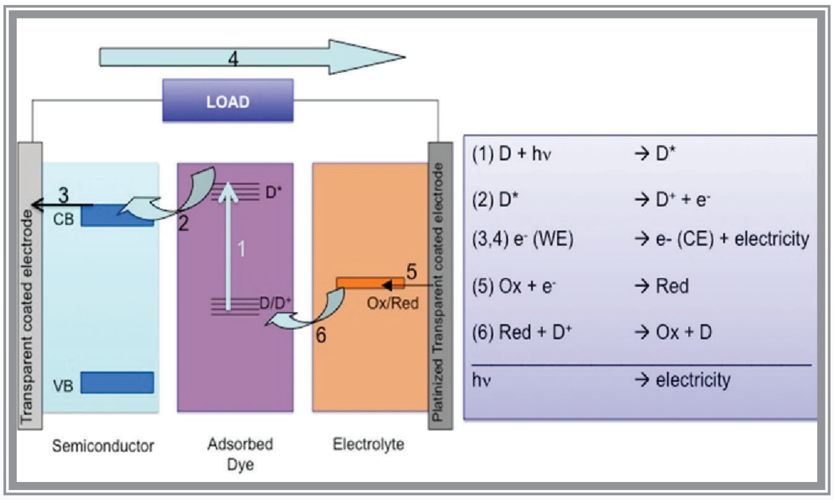
RESEARCH @ MEMS: Dye Sensitized Solar Cells

A new class of photovoltaics being explored by the Powder Metallurgy Lab.

The advances in nanotechnology have opened up new opportunities for easy and low-cost manufacture of solar cells, which, unlike conventional photovoltaic (PV) cells, work on the principle of photoelectrochemistry.

These cells contain a wide band gap semiconductor photoanode, a dye deposited on the semiconductor, and an electrolyte as three of its basic components. The nanoparticles of the semiconductor provide a large surface area for adsorption of the sensitizer, dye on it. This leads to absorption of sufficient amount of light by the dye in the cell. These cells are known as Dye Sensitized Solar Cells (DSSCs), or Gratzel Cells, named after Prof. Michael Gratzel who was the first man to study and prove the concept of dye sensitization of a wide band gap semiconductor and demonstrated its application in solar cells in the year 1991.

Dye sensitized solar cells operate differently from other types of solar cells in many ways with some remarkable analogies to the natural process of photosynthesis. Therefore, this system has repeatedly been described in terms of artificial photosynthesis. Like the chlorophyll in plants the monolayer of dye molecules (sensitizers) absorbs the incident light, giving rise to generation of positive and negative charge carriers. Figure below shows the schematic of internal structure of a DSSC.



Schematic describing the working mechanism of a DSSC

Construction

A DSSC consists of a mesoporous/nanoporous semiconductor layer made up of nanoparticles of the semiconductor sintered together in order to have electronic contact between the particles and allow electronic conduction through the layer. This semiconductor layer is coated on top of a conducting glass substrate and is sensitized by a monolayer of a dye and works as the photoanode. A redox couple such as iodide-triiodide couple (i.e. I^-/I_3^-) is used as the electrolyte, and the cathode is basically made up of a metal or a conducting glass which is usually coated with platinum or carbon as catalyst. The dye is often a metal-organic complex that absorbs in the visible range of the solar spectrum.

Polypyridil complexes of ruthenium and osmium are very common sensitizers being used in DSSCs. The general formula for these dyes can be written as ML_2X_2 where M stands for Ru or Os, L stands for 2,2´-bipyridyl-4,4-dicarboxylic acid and X stands for halide, cyanide, thiocyanate, acetylacetate, etc.

Working

A DSSC operates through following fundamental steps:

1. Photo-excitation of the dye by the light incident on it,

2. Electron injection from excited state of the dye to conduction band of TiO_2,

3. Reduction of triiodide, I_3^- at the counter electrode,

4. Diffusion of electron through the semiconductor layer,

5. Oxidation of I^- near the working electrode,

6. Regeneration of the oxidized dye.

On illumination with sunlight, the dye absorbs photons of wavelength corresponding to the energy difference between its highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO).

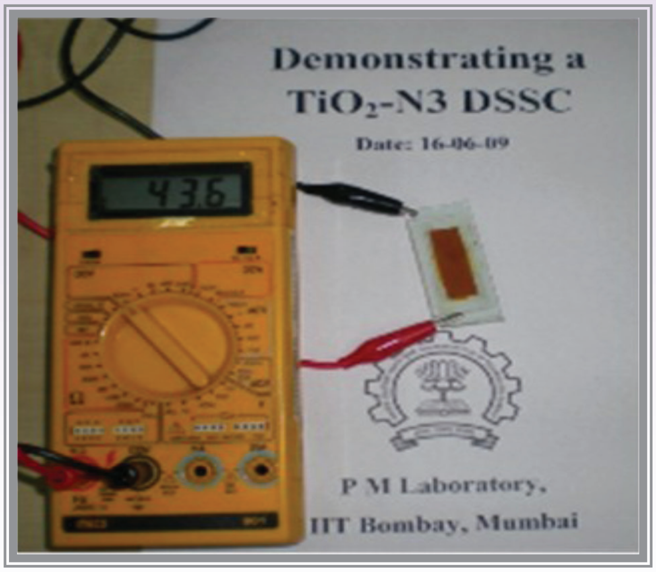
Electrons from the ground electronic state of the dye (S) are now promoted to excited state (S*). The life time of electron in the excited state is in nanoseconds and it can either fall back to ground state resulting in thermalization of the dye or can be injected into conduction band (CB) of TiO_2 if its CB edge is just below the excited state of dye.

For the DSSC to work electron from the dye is desired to be injected into CB of TiO_2 and this takes place in femtoseconds while the falling back of this electron to ground state of the dye is a very slow phenomenon. The CB electron of TiO_2, in a reverse manner, can also recombine with the oxidized dye, contributing to loss of efficiency. But this back reaction and thus reduction of the oxidized dye occurs in μs to ms range, which is several orders of magnitude slower than electron transfer to CB of TiO_2. The excited state of the dye can be reduced by the reduced species of the electrolyte (I^-) if present in excess. This process is known as reductive quenching of the dye and deactivates excited state of the dye. In order to avoid this reductive quenching of the dye it is always desired to take an optimum amount of the electrolyte which only takes part in hole conduction.

The electrons after being injected into CB of TiO_2 are transported through the semiconductor layer by diffusion to reach the conducting layer, ITO or FTO coating on glass substrate. The reduced species of the redox couple in electrolyte, for instance I^- in I^-/I_3^- couple, now donates electron to the oxidized dye (S^+) at anode and regenerates the dye. This dye regeneration occurs in nanoseconds range, which is typically 100 times faster than any recombination reaction and about 10^8 times faster than intrinsic life time of the oxidized dye. It is a two step electron transfer; reduction of the dye by I^- to form I_2^- followed by a disproportionation reaction to give I_3^-.

Triiodide is transported through liquid electrolyte to cathode where it is reduced back to I^- by gaining electrons that flow from anode through an external circuit . This process of reduction of I_3^- requires a catalytic amount of platinum or carbon on the cathode surface. The triiodide can also be reduced by CB electron of TiO_2 which is a recombination process and is part of the efficiency loss mechanism. But reduction of I_3^- at the cathode is faster than its recombination with CB electron.

Pilot Cell



An exploratory DSSC fabricated in the PM lab

Performance of Pilot Cell:

In sunlight : Voltage = **500mV**, Current = **1mA**

In a tube lit room in the lab: voltage= **43 mV**

Comparison of DSSCs with Conventional Solar Cells

Conventional p-n junction Silicon solar cells have an efficiency of 25 %. DSSCs, however, have efficiencies comparable to amorphous Silicon, that is, around 10-12 %.

Fabrication of conventional solar cells requires materials of ultra high purity, which is not the case with DSSCs.

Charge separation in conventional solar cells exists in the same material; while in DSSCs charge separation takes place in different materials. So recombination of charge carriers is less probable in DSSCs.

Material and processing costs of DSSCs are lower than those of conventional solar cells.

DSSCs work even in low-light conditions and are therefore able to work under cloudy skies and non-direct sunlight, whereas traditional designs would suffer a "cutout" at some lower limit of illumination, when charge carrier mobility is low and recombination becomes a major issue. The cutoff is so low they are even being proposed for indoor use, collecting energy for small devices from the lights in the house.

Challenges ahead

Lifetime and reliability is a concern arising from lack of good sealant materials that can prevent leakage of liquid electrolyte from the cells and ingress of moisture from outside

Desorption and degradation of dye sensitizers from semiconductor surface is another concern.

Identification of solid electrolytes that can replace liquid electrolytes and yet provide high cell efficiency is required for improving reliability and cost effectiveness.

INTERN EXPERIENCES: Diversity of Work and Interests

Aayesha, Prateek and Vikash share their experience of applying for and working on internships in various domains.

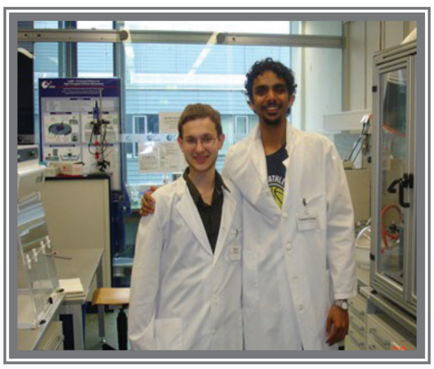
Foreign Research Internship

Come third year and the buzz is about internships. I had applied for an internship both in India and abroad and wanted to decide only once I had all my options clear. I secured an internship with the Department of Microsystems Engineering at the University of Freiburg and decided to take up the offer to gain international exposure, interact on a multicultural level and work in a new environment. Widely known as the world's leading research institute for bio-fuel cell among other microsystem technologies, it surely did live upto its name!

The University of Freiburg is considered one of Europe's most prestigious universities and is amongst its top research and teaching institutions. Once the internship was offered, most other formalities were smooth. The administration at the University was especially helpful and co-operative.

Well, most of my fellow internees were from other parts of Europe, Egypt, South Africa, New Zealand, Gulf and Iran (apart from a handful of people from US and Canada through the DAAD program) writing their diploma/master thesis as a compulsory part of their curriculum and were quite fascinated that I as an undergraduate student had come all the way from *Bombay*, that too voluntarily.

My project was in the implantable bio-fuel cell section. These people have been involved in state-of-the art research on these cells for many years now. They aim to develop an implantable cell for the pacemaker which would eliminate any requirement of replacing batteries. The energy for these cells would be provided by the glucose in our blood. The work involves a lot of materials science aspects for electrode materials, thin film organic depositions etc.



"My project was in the implantable bio-fuel section... aim to develop an implantable cell for the pacemaker which would eliminate any requirement of replacing batteries."

Internships in universities abroad are taken very seriously and organized in a highly professional manner. The work atmosphere is intellectually challenging yet very comfortable. There were no rigid timings to be followed, and weekends were strictly off.

The best part of the project was that while I was given stepwise guidance for the first two weeks, they allowed me to experiment with my own ideas there-on, and discuss only the thought process and results. I could order chemicals and other experimental devices (even expensive ones) on my own. There was continuous encouragement given to try out new and innovative ideas.

Germans are very particular about safety issues, and are known to re-check everything before proceeding. It sometimes got overwhelming, but just showed how they got so smart in engineering. In fact, an appreciable part of the German commodity market is domestically produced, and not many American or Chinese products can be seen on the shelves.

On the lighter side travelling on weekends in a new country is not only a great relief from work but also a new experience all together. We also had a Stammtisch (German for get-together) for internees every Tuesday which provided plenty opportunities for socializing.

Having said all this, the decision on applying and choosing a right internship was not easy for me. Some of us are confused on what to choose between a research and an industrial PT. I wouldn't be wrong in saying that for most of us the key focus on choosing an internship is the future prospect and rewards it holds.

Intuitively, we may feel that an industrial PT would improve the chances for a core job. While that is true to a certain extent it is however not wise to discount a research PT's value addition towards the above goals as well. As far as the PhD is concerned, a research PT helps in exploring a new area of study as well as provides you a potential recommender. The flip side being you can gain both the above in our department as well, which is unfortunately not the case with respect to gaining industrial exposure. An industrial experience enables one to experience hands on what has been learnt in theory.

However it is wise to weigh all the options in hand subjectively in accordance with your future goals before making the decision. I wish you all the best in choosing the right kind of internship!

Prateek Vidya

Non-Core Industrial Internship

My intern at Schlumberger was basically an industrial, technical coupled with a mix of financial one. Since most interns don't get financial work as part of their internship I will just highlight the other aspects of it. Schlumberger is basically a service provider company i.e. it doesn't itself trade the oil it extracts but it takes up contracts of companies which own oil fields and devises engineering solutions to get the best output from the well.

I was allotted the segment of Well Services which basically deals with the servicing of the well; a well exists and you want to either give it a proper form or you want to improve its productivity or you want to make it deeper. These are also the three sub-segments in Well Services, namely Cementing, Fracturing and Coil tubing. I was in the sub-segment of Fracturing which I also got to witness when sent on the oil-field location in Ahmedabad.

Fracturing of a well is done to improve its productivity by pumping in viscous fluids at very high pressure to force open the cracks in the well and fill up the opened cracks with a permeable path of 'proppants' or sand of a special type. So there are three basic components required to carry out a fracturing job: the fracturing fluids, the fracturing equipment and the people performing the required jobs. The fracturing fluids are the ones that fracture the formation (the earth below) and hence it is required to have the correct viscosity good enough to break open the cracks. Now these viscous fluids also need to carry the permeable sand so they should be able to give up the sand and then escape into the formation. Hence breakers are added to do the abovementioned job. A lot of lab tests are done to ensure the correct viscosity and the correct breaker action time. Also since each well behaves differently due to different rock morphology, these tests need to be conducted on the field itself in a mobile lab!

"I was allotted the segment of Well Services... improve its productivity or you want to make it deeper."

Moving on, the equipment are another major components since these are the ones that pump the fluids down at such high pressures. These equipment are monstrous in size and need to be positioned correctly according to their job requirements. Whenever the people are not working on the oil-field, they are busy maintaining these equipment. This reflects the importance of keeping the machines in a proper working condition.

Since I also got a chance to be on the job, I could witness the whole process completely. A fracturing job is spread over a minimum of 4 days. The first day is called the 'rig-up' where the instruments are placed in position, then comes the day of 'data-frac' where sample fluids are pumped into the well in a small quantity and the response of the well is measured. If everything is in place then on the 3rd day, " main-frac" is conducted where the actual fracturing is done. The 4th day being the last day is called the 'rig-down' where the machines are demobilized and sent back to the base-station.

So this is how the fracturing job is carried out and if the job has been done correctly then within a day, one would notice traces of oil coming out of the pipe.

My experience at Schlumberger was indeed a very enriching one and I got to work with people from almost 7 different nationalities! Overall a very nice experience to have!

Aayesha Ghanekar

Core Industrial Internship

Tata Steel, formerly known as TISCO, is the world's sixth largest steel company and the second largest private sector steel company in India in terms of domestic production. It has an annual crude steel capacity of 31 million tonnes.

I got the opportunity to work with them this summer. I was working in Long Product Technology Group (LPTG) which deals with rods, bars etc. This year Tata Steel had taken around 50 interns from all IITs and other top colleges except IIT Bombay. The reason cited for ignoring IIT Bombay was rejection of PPOs by our seniors and carelessness towards the internship process. I would like to thank Prof. Ballal for helping me in getting such a challenging project and internship at Tata Steel.

"My project was to develop a correlation between strength and thickness of TMT rebars."

My project was to develop a correlation between strength and thickness of TMT rebars. The project was aimed at deducing these correlations so that the physical property of the bars can be predicted directly on the basis of the micro structural rim thickness without doing microstructure characterization. I conducted various experiments and collected relevant data finally deducing an experimental relationship between the strength and the thickness of the bars. The project resulted in a lot of time saving as it bypasses the time consuming step of microstructural testing.

The internship provided me with an environment to look for new ways of doing things. This coupled with challenges, opportunities, recognition and enthusiasm made a wonderful experience. The project results were highly appreciated by the top management of TATA Steel and were published in the company's reputed annual magazine 'TATA Search'. It changed my outlook towards engineering as a whole and I realized the opportunities ahead in my field.

It was an enjoyable experience with excellent accommodation facilities, cultural nights, parties and sports events organized especially for the interns.

I would like to advise our juniors to tap the internship opportunity to get a practical exposure to what we learn in classes and in the process realize its relevance in the industry.

Vikash Anand

PADARTH ’09: A Look Back

Presenting before you, glimpses of the annual technical festival of the Department.

Padarth is the annual technical festival of the Department of Metallurgical Engineering and Materials Science at IIT Bombay organized by the MMA (Metals and Materials Association). It features a plethora of events ranging from lectures by eminent personalities to intriguing workshops to a wide strata of competitions like IDPs, Business Plan, and on the spot events like Materials Quiz and many more.

The third edition of Padarth was held in the first week of March. Much before the event, we had a series of online quizes, photography competitions etc. which received huge participation from students in India and abroad. Competitions at Padarth’09 were designed to provide a platform to students of metallurgical engineering and materials science to showcase their creativity and innovation. Some of the competitions that saw good participation were Materials Exposition where students took up the role of faculty members. There were participants from other departments as well. The B-plan competition saw some quality entries, whereas Breakthrough and Demotech were about demonstrating materials science phenomena.

The best seller of all times was the Materials Quiz, where the selected participants and audience were grilled on various topics in material science. Loads of freebies and prizes adorned this event.

The highlight of Padarth 2009 however was the Lecture Series. Spread across both the semesters, we had many acclaimed people from academia and industry. Some of them were Prof H.K.D.H. Bhadeshia and Prof A.L. Greer from Cambridge, Prof. Roger Doherty from Drexel, Prof. Michael McHenry from Carnegie Mellon University, Prof. H. Srikant of Florida University, Dr. Asim Tiwari who is currently working as a researcher in Materials Characterisation and Modelling Group at General Motors and Prof. Rinti Banerjee from Bio engineering Group at IIT Bombay. These lecturers spoke over a wide domain of topics encompassing materials science and the latest state-of-the art research that goes in there.

Applied Materials sponsored most of the events of Padarth 2009. We look forward to more enthusiasm from all the students towards Padarth 2010.

ENERGY SKEW:
Las Vegas vs. La Ouagou

Questioning rights to maintaining lifestyles for the sake of preserving environment and resources.

The United Nations says Africa's losing forests twice as fast as the rest of the world and it needs to draft new laws on climate change and invest in energy alternatives. A good fraction of African citizens don't have electricity. So they use charcoal because it's the cheapest and easiest way to meet the daily energy requirements. It's what fuels many African homes and businesses to heat buildings and to cook and boil water. There's a rudimentary electricity grid. And most poor countries haven't developed alternative energy sources like solar panels and wind farms. There are few jobs. Here, survival trumps sustainability.

Now, lets take a look at consumption patterns of the neon playground of the leader of all nations. Las Vegas generates more than eighty percent of its power by burning coal. That needs a lot of coal— mountains everyday. A single casino uses more than ten thousand times the energy consumed by a household with power bills reaching two million dollars a month. But as they say, electricity is the best advertising money can buy. From flashy night lights and neon signs to artificial wave pool and Eiffel Tower, everything sucks power. But if it can draw tourists, its worth every watt.

They will do almost anything to electrify the crowd. Sample this. The picture to the left captures the Luxor Sky Beam— a light of the size of a house. It's a quarter million watt gem set atop the pyramid of Las Vegas' Luxor Hotel. It's so bright, you can see it from outer space. And it serves no purpose, except to impress! The electric bill for this night light is more than a hundred and twenty five thousand dollars a year. The hotel believes that it gives a positive energy or better luck to the guests flying into Vegas through the light. It's a jewel of a statement, an icon of the new Las Vegas, where nothing is too expensive, too flashy or too big.

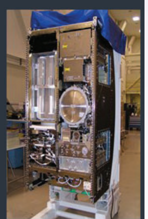
Spending such amounts of natural resources to create a neon playground is justified by citing the revenue it creates for the state. In that case, people of Africa are only too poor to buy enough carbon credits!

(Facts sourced from Megacities– a documentary series by Nat Geo.)

Zero Gravity Lab

Materials Science Research Rack

What's about the size of a large refrigerator, weighs a ton and may help pave the way for new and improved metals or glasses here on Earth?



It's the Materials Science Research Rack -- a new laboratory on board the International Space Station.

This facility will allow researchers to study a variety of materials -- including metals, alloys, semiconductors, ceramics, and glasses to see how the materials form, and learn how to control their properties. The results from experiments conducted in the facility could lead to the development of materials with improved properties on Earth.

The research rack will provide a powerful, multi-user materials science laboratory in a microgravity, or near weightless environment. Researchers can benefit from studying materials in space because they can isolate the fundamental heat and mass transfer processes involved that are frequently masked by gravity on the ground.

The research rack was launched to the space station aboard space shuttle Discovery on August 28 and installed in the U.S. Destiny Laboratory September 2, 2009.

ARBITECH:

The Technology Updates

Pick up some tech trivia.

Self Erasing Ink

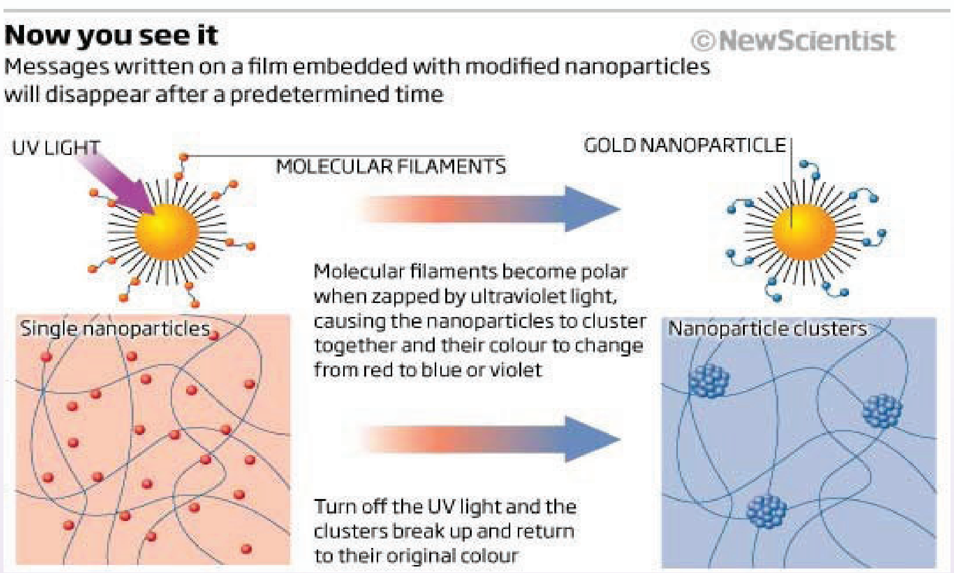
This article will self-erase within 10 seconds.

At least it would if it had been written on a film that exploits the color-changing ability of nanoparticles. The technology could make it possible to create documents that wipe themselves clean after they've been read.

Wondering whether we are bluffing, aren't you?

A team at Northwestern University in Evanston, Illinois, coated gold nanoparticles with a layer of hair-like molecules called *4-(11-mercaptoundecanoxy)azobenzene* or MUA. When zapped with ultraviolet light, these filaments change their shape and charge distribution, causing the nanoparticles to congregate together and change colour.

To put this color-changing ability to good use, the team dispersed the nanoparticles in a gel and sandwiched it between plastic sheets to produce a thin, red film. When lead researcher Bartosz Grzybowski and his colleagues shone UV light at the film, either through a patterned mask or using a UV pen, they found they could print a range of images or write words onto the film in just a few seconds.



The color change is not permanent. In the absence of UV light, the MUA gradually reverts to its original shape, allowing the nanoparticles to disperse and the images to disappear. Isn't this amazing? Maybe such technologies can be employed in the future to add additional identification features to currency bills so that they can be differentiated from the fake ones.

One Way Mirrors

We all have seen criminal suspects being questioned in movies while detectives watch from behind a one-way mirror. How does a piece of glass manage to reflect light from one side while remaining clear on the other?

The secret is that it doesn't. A one-way mirror has a reflective coating applied in a very thin, sparse layer -- so thin that it's called a half-silvered surface. The name half-silvered comes from the fact that the reflective molecules coat the glass so sparsely that only about half the molecules needed to make the glass an opaque mirror are applied. At the molecular level, there are reflective molecules speckled all over the glass in an even film but only half of the glass is covered. So a one way mirror is a sheet of glass coated with a layer of metal only a few dozen atoms thick, which reflects some percentage of the light incident on it and transmits the remainder to the other side.

So why doesn't the "criminal suspect" see the detectives in the next room? The answer lies in the lighting of the two rooms. The room in which the glass looks like a mirror is kept very brightly lit, so that there is plenty of light to reflect back from the mirror's surface. The other room, in which the glass looks like a window, is kept dark, so there is very little light to transmit through the glass. On the criminal's side, the criminal sees his own reflection. On the detectives' side, the large amount of light coming from the criminal's side is what they see. In many ways, it's the same as if people were whispering in one room while a loud stereo played in the other. The sound of the whisper might carry into the room with the stereo, but it would be drowned out by the intensity of the music.

If the lights in the room with the mirror are suddenly turned out, or the lights in the observation room suddenly turned on, then the one-way mirror becomes a window, with people in each room able to see those in the other. You can see this effect in any mirrored office building at night -- if the light is on in an office, you can see into the office just fine.

An art exhibit of a usable toilet enclosed in a cube of one-way glass is seen across the road from London's Tate Britain Museum. The person inside the outhouse can see passersby while remaining invisible to them.
Source: MSNBC

Fun Fact

A look-out toilet

Artist Monica Bonvicini created a minimalist glass cube containing a usable loo to stand at a construction site opposite the Tate Britain gallery in London.

The work, called Don't Miss A Sec, is made out of one-way glass which means you can see out but not in.

As museum-goers inquisitively press their noses to the reflective glass, and construction workers mill about, it isn't difficult to see why people would feel uneasy about using the glass outhouse.

Far from testing the viewers' levels of embarrassment versus exhibitionism, the artist, Italian-born Monica Bonvicini, conceived of the idea while watching people at art openings. Amid the gossip and pageantry, nobody wanted to leave the room for fear of missing a key entrance or comment. The "Don't Miss A Sec" exhibit -- which was unveiled in December -- reflects peoples' reluctance to leave the spectacle, and allows the art-goer to remain in the action, even while on the toilet.

The artwork takes the all-seeing power away from the surveillance cameras and gives it to the person on the toilet, while letting them remain invisible to the world. But peoples' fears of being seen with their pants down still hold strong.

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