Computer Society of India

PILLAI INSTITUTE OF INFORMATION TECHNOLOGY, ENGINEERING, MEDIA STUDIES & RESEARCH
EDUCATIONAL INSTITUTION NUMBER: I00643

byte STREAM 2014

CSI PIIT
ASSOCIATION ESTD. SINCE 2010

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Formed in 1965, the Computer Society of India has been instrumental in guiding the Indian IT industry the right path since its formative years. Today, the CSI has 70 chapters all over India, 418 student branches and more than 90000 members including India's most famous IT industry leaders, brilliant scientists and dedicated academicians.

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CSI individual members have full access to CSI knowledge portal with unique id and a password. CSI provides an excellent oppurtunity for virtual networking with other members using blogs, communities and forums. Members get an oppurtunity to offer workshops/training on profit sharing basis in collabaration with CSI and also get oppurtunity to deliver guest lectures in educational institutes associated to CSI across India.

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SBC: Prof. Varunakshi S. Bhojane

Faculty Co-ordinators:
Prof.Madumitta Chatterjee
Prof. Sharvari Govilkar
Prof. Satish Varma

" Hon. Dr. K.M. Vasudevan Pillai"
An inspirational Personality . A strong support to today's youth, visionary founder and CEO of Mahatma education Society.
Lots of Gratitude...

COMPUTER SOCIETY OF INDIA

ESTD. 1965

सर्वे भवन्तु सुखिनः

byte STREAM 2014

MAHATAMA EDUCATION SOCIETY'S

Pillai Institutte of Information Technology , Enginnering

Media and Rechaers,

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byteSTREAM 2014

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Shubham Singh

Student Branch Co-ordinator :

Prof. Varunakshi S. Bhojane

Faculty Co-ordinators :

Dr. Madhumita Chatterjee

Prof. Satish Varma

Prof. Sharvari S. Govilkar

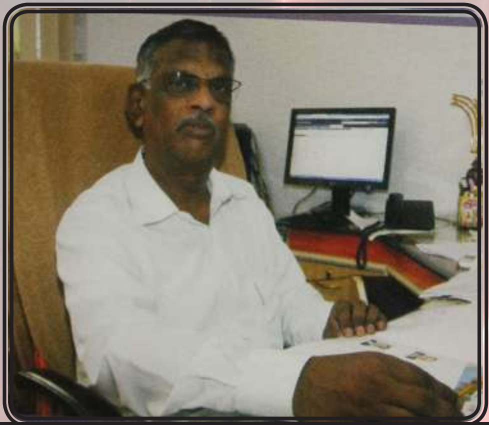
Greetings

Dr. Priam Pillai

Dear Campus Community,

Today we are delighted that our students have taken the initiative and started byte stream which promises to be one of the leading magazines in navi mumbai. It will provide our students a new avenue to demonstrate their skills in scientific and technical writing , art as well as administaring and publishing a state of the art magazine. PIIT has become one of the leading colleges in mumbai partly due to the talent, dedication and hard work of its students and we, the management wish the new magazine and its creators the best of luck for the future.

Dr. Priam Pillai,
COO of Mahatma Education Socirty (MES)



Dr. R. I. K. Moorthy

Dear Students,

It gives me immense pleasure and a sence of pride to see the growth of the CSI chapter of PIIT. CSI, being a premier and one of the oldest association for IT/Computer professionals , the CSI membership comands respect among fellow professionals aa well as It organizations. I am happy that we have an active and vibrant student..

Chapter of CSI-PIIT,

The professional bodies like CSi, IEEE, SAE and others help the students with the comprehensive perception of the professional life, the industry trend from time to time and the industry expectations from young professionals. The chapter create a platform for the students to interact with the senior professionals from Industry compete with their colleagues from different institutions and showcase their talent in their respective fields.

Dr. R.I. K. Moorthy,
Principal, PIIT.

From the Student Branch Co-ordinator's Desk

It's my great pleasure to be associated with CSI-PIIT Student Branch. From last three years, it has evolved gradually the launching of this magazine makes me feel prouud and satisfied. I am happy to see that all members of CSI-PIIT student committee have actively participated and worked hard during the execution of various workshop, alongwith their academic schedule.

I congratulate the magazine and Creative Team for launching this second annual magazine. They have been working hard to compile every bit of byte stream. I wish them all the best to keep this enthusiasm for further edition of the magazine.

With Best Wishes,
Prof. Varunakshi S. Bhojane.

From the Computer HOD's Desk

I feel proud to see CSI-PIIT come up with the second edition of it's magazine byte stream. This magazine gives me yet another opportunity to feel satisfied and proud at the same time. The efforts that have been put in by everyone are praiseworthy. I am pleased to see how students have actively participated in extracurricular activity and performed remarkably well . their interest in the technical field and the desire to improve their knowledge adds to my delight.

The first edition of byte stream not only gives students an experience of bringing up a magazine, but it helps them get in touch with latest trends in the IT world. I am sure, in futre many more students will come forword and aactively contribute for the magazine.

My heartiest congratulation to the team of byte stream for commendably designingthis magazine and I hope CSI-PIIT keeps up the good work and comes up with similar start ups. I wish the whole magazine team
All the best!!!

Regards,
Dr. Madhumita chatterjee

From the IT HOD's Desk

Our students are blessed with a lots of opportunities with the great infrastructure to work at the CSI Chapter at MES's PIIT Campus. It has been a beautiful journey and had a great learning experience with CSI in the past few years. Our students and staff have been the part of this journey to express their ideas within the group to explore and conduct various activities to conribute and make the difference.

I'm proud of the fact that the CSI committee have moved forword and come up with CSI Magazine. I personally congratulate them big success in their endeavours.

Regards,
Prof. Satish Varma

From The Chairman's Desk

It gives me immense pleasure and pride to introduce you to the second edition of CSI-PIIT's annual magazine byteSteam. The magazine is a compilation of attractive and commendably designed sections including both technical and non-technical articles which will engross the reades and hopefully add to their knowledge.

I would like to express my immense gratitude to Hon. Dr. K. M. Vasudevan Pillai for his support and inspiration. I obliged also to thank our Principal, Dr. R.I.K. Moorthy for encouraging us every step of the way. I am highly obliged to our Student Branch Co-ordinator, Prof. Varunakshi Bhojane for the firm support and guidance in bringing out this magazine and putting CSI-PIIT on remarkable peak. I heartly congratulate the passionate Fenil Dedhia-Editor in chief and his team & Shubham Singh-Creative Editor and her team who have been working hard dedicatedly to make byteStream an interesting publication for everyone. At last, I whole-heartedly thank my entire team and hope that this second issue of byteStream will be a huge success.

Regards,
Prasad Patil

From the Creative Editor's Desk

As the name suggests, the magazine is a stream of information that we bring to you to help increase your technical know-how. Formatting and graphically editing this stream is important so that the magazine reaches out to all the tech-junkies,regular folk, and amateurs.

I, Shubham Singh, am honoured to work as the Creative Editor for the second edition of byteStream under the banner of CSI-PIIT. Needless to say, I and my team are grateful for the opportunities it provided. imagining, crafting, and creatively editing the look-n-feel of contents of the magazine has been a new and exhilarating experience. designing the cover for the magazine has been a fairly interesting challenge and I do hope that it is well received by the readers. I have strived hard to design the cover to signify the importance of byteStream being born.

Regards,
Shubham Singh

The Editor's Note

we're living in an interesting world today. Technology is rapidly evolving since past few years and becoming a part of everyone's life with a blink of an eye, with its own positive and negative sides. Just like music, technology too is not an exception to fusion. We're packing music players into phones, toasters into microwaves cameras into music players, phones in cars, games into cameras. I feel like my universe is collapsing on itelf, but that is a discussion for another time.

I, Shilpa Kolagani am honoured to work as the CSI-PIIT Magazine Committee Head 2013-2014 and the Editor's in chief of byteStream 2014.I humbly welcome all readers to this first and hopefully successful magazine of CSI-PIIT. This is my first time as an Editor of a magazine and while the making of it I developed newly found love for writing. As it is the first magazine under the CSI banner for PIIT, it was a big responsibility to set a standard and deliver a good magazine interesting, simple and readable so that readers will enjoy reading! I can gladly say that I had good experiance working on bytestream. I hope that byteStream is a success and wish lots of luck to future byteStream teams!

The purpose of this magazine is to help you, entertain you and enrich you with technical know-how, information on new technogies, and interesting information.
Out of all the people that I wish to thank, the first one would be my friend and Creative Editor Mr. Shubham Singh without whom this magazine wouldn't have been possible & as I had wanted! I would like to thank Prof. Varunakshi Bhojane for her firm support & valuable feedback and the Entire Magazine Team for their work and contribution. Also I would like to thank the whole CSI-PIIT for their support.

Warm Regards,
Shilpa Kolagani

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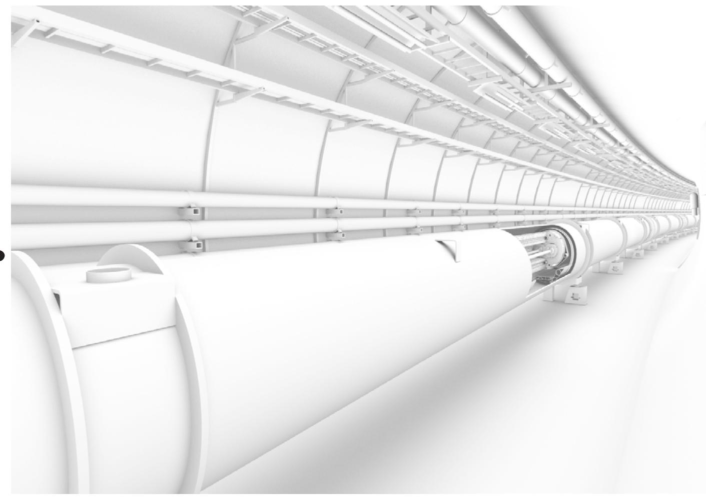
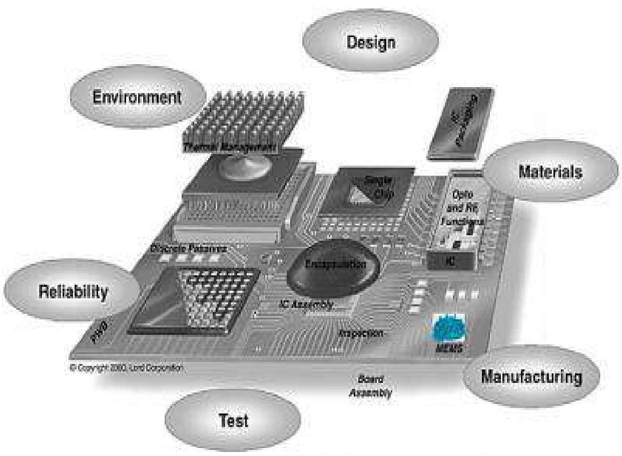
1. Artificial Hearts, a Prosthetic Device

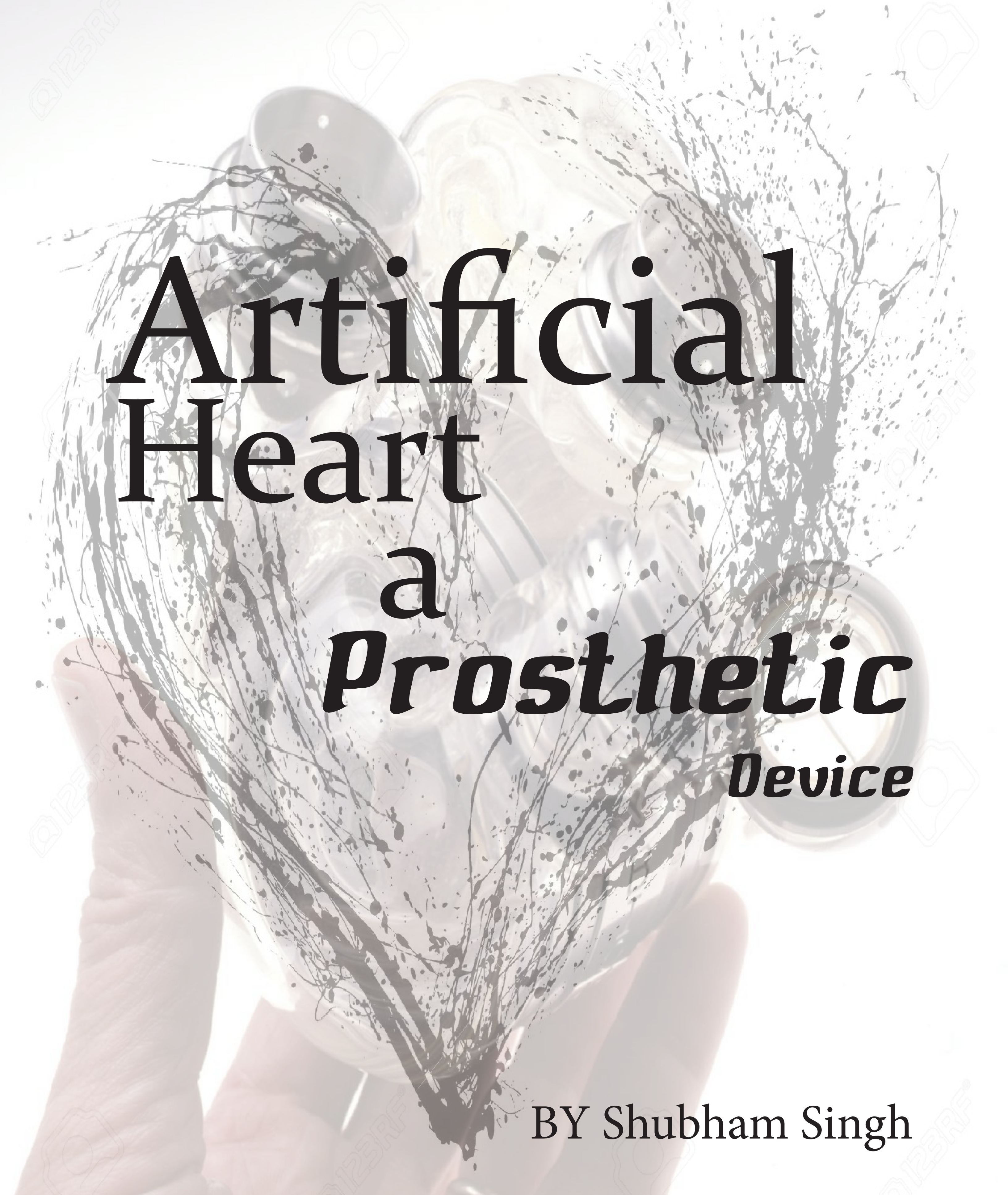
2. Driverless Car

3. Large Hadron Collider (LHC)





4. MEMS: Micro-Electromechanical Systems

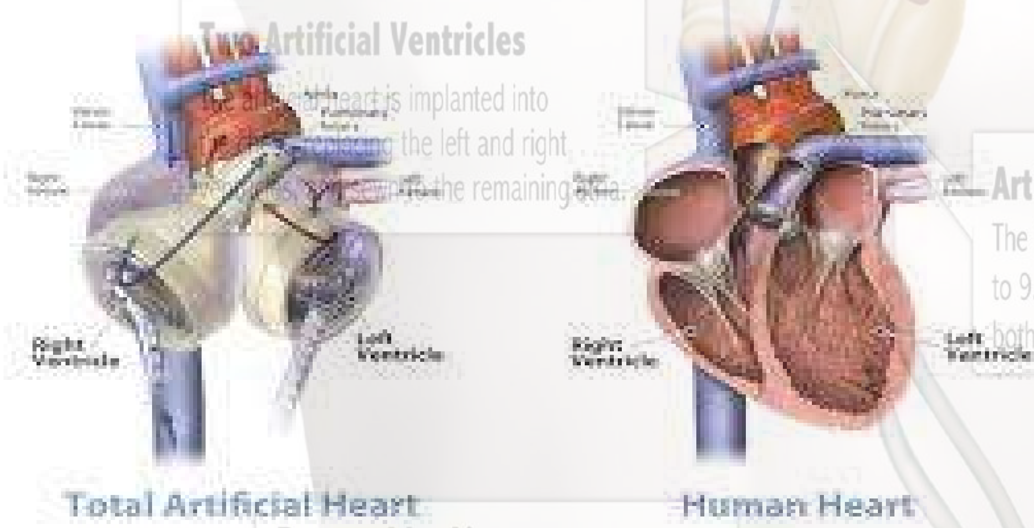


Artificial Heart a Prosthetic Device

BY Shubham Singh

ARTIFICIAL HEART

An artificial heart is a prosthetic device that is implanted into the body to replace the original biological heart.
It is distinct from a cardiac pump, which is an external device used to provide the functions of both the heart and the lungs.
Thus, the cardiac pump need not be connected to both blood circuits.
Also, a cardiac pump is only suitable for use not longer than a few hours, while for the artificial heart the current record is 17 months.
This synthetic replacement for an organic mammalian heart (usually human), remains one of the long-sought goals of modern medicine.
Although the heart is conceptually a simple organ,



it embodies complex subtleties that defy straightforward emulation using synthetic materials and power supplies.
The obvious benefit of a functional artificial heart would be to lower the need for heart transplants, because the demand for donor hearts greatly exceeds supply.

HOW ARTIFICIAL HEARTS WORK

Your heart is the engine inside your body that keeps everything running. Basically, the heart is a muscular pump that maintains oxygen and blood circulation through your lungs and body. In a day, your heart pumps about 2,000 gallons of blood. Like any engine, if the heart is not well taken care of it can break **down and pump less efficiently, a condition called heart failuar.**

Until recently, the only option for many severe heart failure patients has been heart transplants. However, there are only slightly more than 2,000 heart transplants performed in the United States annually, meaning that tens of thousands of people die waiting for a donor heart. On July 2, 2001, heart failure patients were given new hope as surgeons at Jewish Hospital in Louisville, Kentucky, performed the first artificial heart transplant in nearly two decades. The AbioCor Implantable Replacement Heart is the first completely self-contained artificial heart and is expected to at least double the life expectancy of heart patients.

HYDRAULIC-DRIVEN HEART

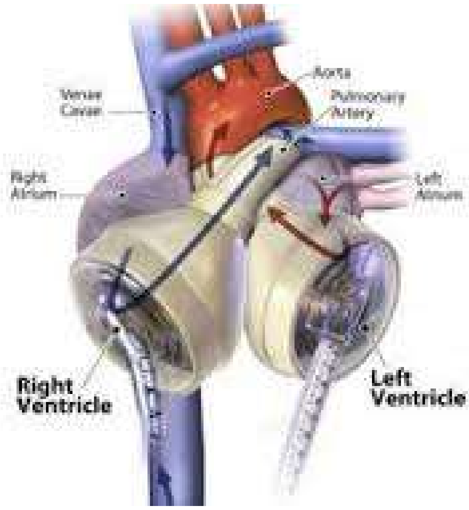
The **average adult human heart pumps blood at a**

rate of 60 to 100 beats per minute.Heart contracts in two stages:

In the first stage, the right and left atria contract at the same time, pumping blood to the right and left ventricles.

In the second stage, the-ventricles contract together to propel blood out of the heart.

The heart muscle then relaxes before the next heartbeat. This allows blood to fill up the heart again.



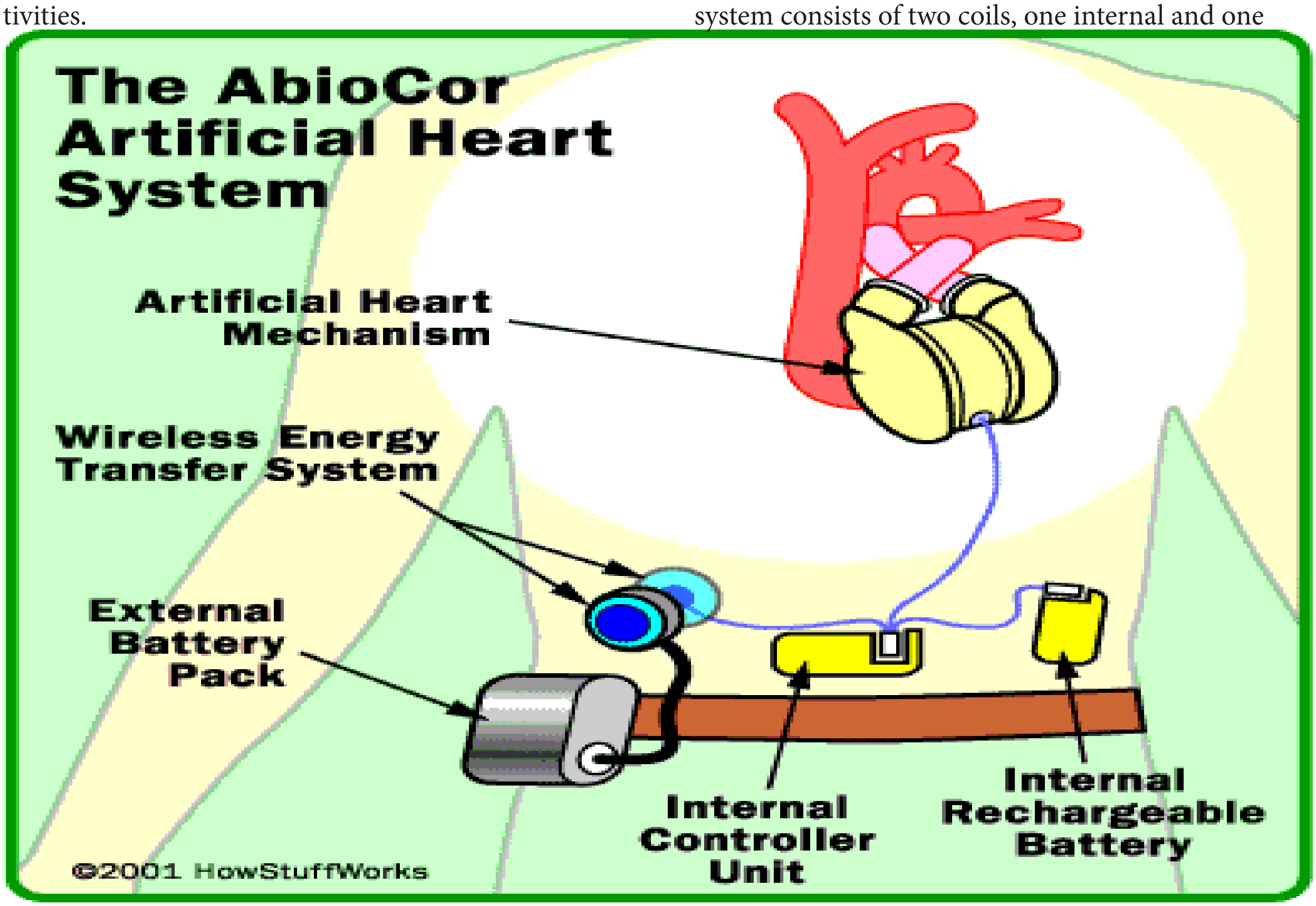
Patients with an implanted AbioCor heart will still have atria that beat at the same time, but the artificial heart, which replaces both ventricles, can only force blood out one ventricle at a time. So, it will alternately send blood to the lungs and then to the body, instead of both at the same time as a natural heart does. The AbioCor is able to pump more than 10 liters per minute, which is enough for everyday activities.

The AbioCor, developed by Abiomed, is a very sophisticated medical device, but the core mechanism of the device is the hydraulic pump that shuttles hydraulic fluid from side to side. To understand how it works, let's look at the various components of the system:

Hydraulic pump - The basic idea with this device is similar to the Hydraulic pumps used in heavy equipment. Force that is applied at one point is transmitted to another point using an incompressible fluid. A gear inside the pump spins at 10,000 revolutions per minute (rpm) to create pressure.

Porting valve - This valve opens and closes to let the hydraulic fluid flow from one side of the artificial heart to the other. When the fluid moves to the right, blood gets pumped to the lungs through an artificial ventricle. When the fluid moves to the left, blood gets pumped to the rest of the body.

Wireless energy-transfer system - Also called the Transcutaneous Energy Transfer (TET), this system consists of two coils, one internal and one



external, that transmit power via magnetic force from an external battery across the skin without piercing the surface. The internal coil receives the power and sends it to the internal battery and controller device.

Internal battery - A rechargeable battery is implanted inside the patient's abdomen. This gives a patient 30 to 40 minutes to perform certain activities, such as showering, while disconnected from the main battery pack.

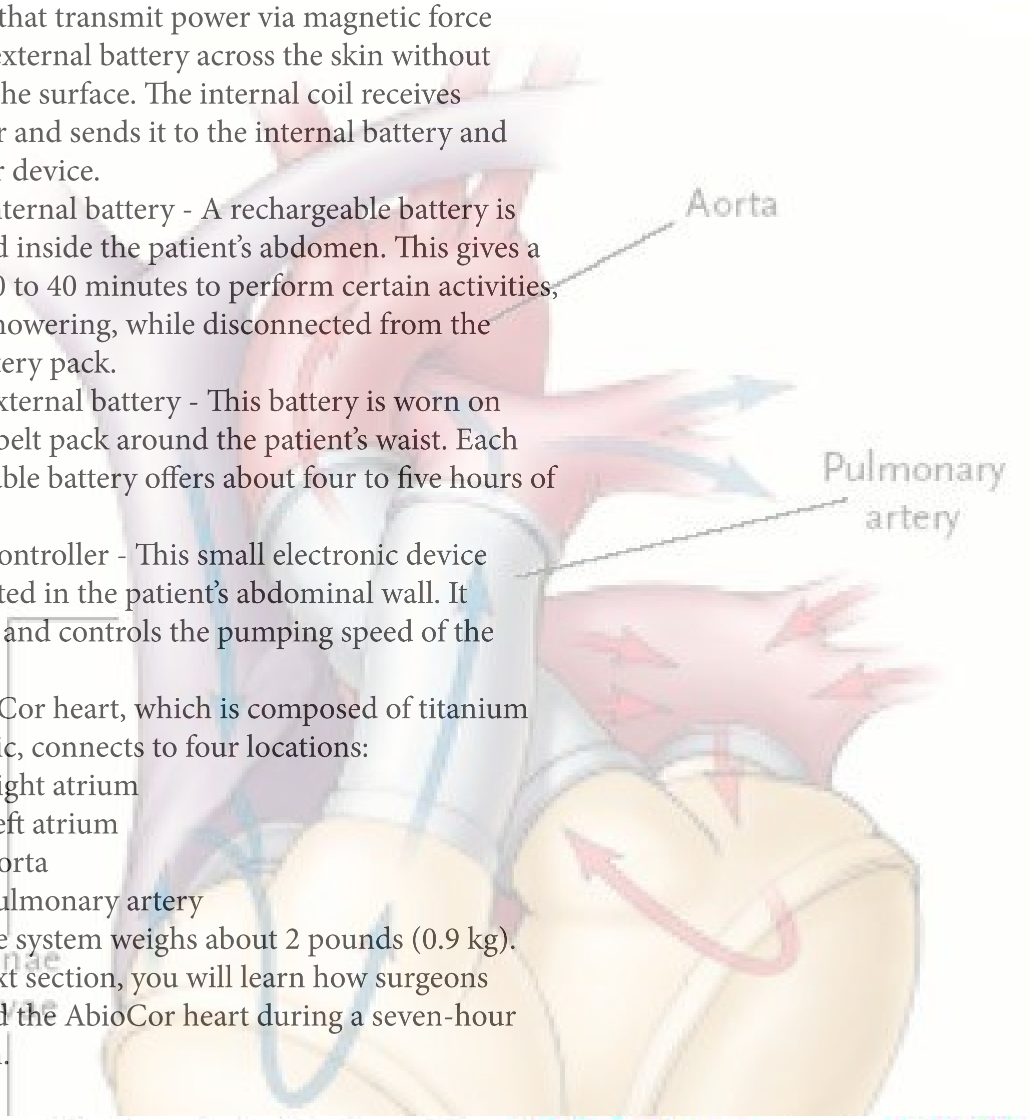
External battery - This battery is worn on a Velcro-belt pack around the patient's waist. Each rechargeable battery offers about four to five hours of power.

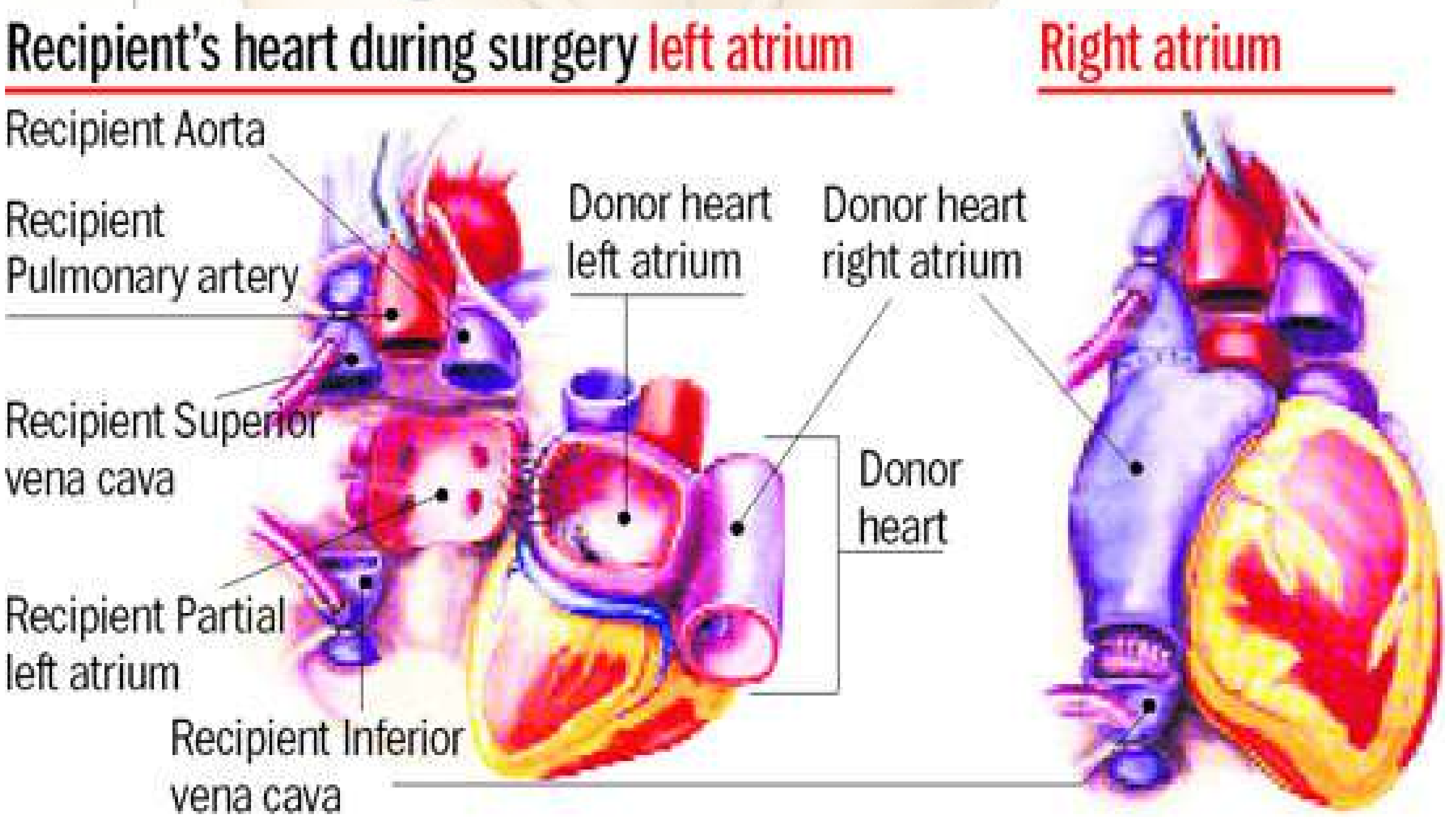
Controller - This small electronic device is implanted in the patient's abdominal wall. It monitors and controls the pumping speed of the heart.

The AbioCor heart, which is composed of titanium and plastic, connects to four locations:

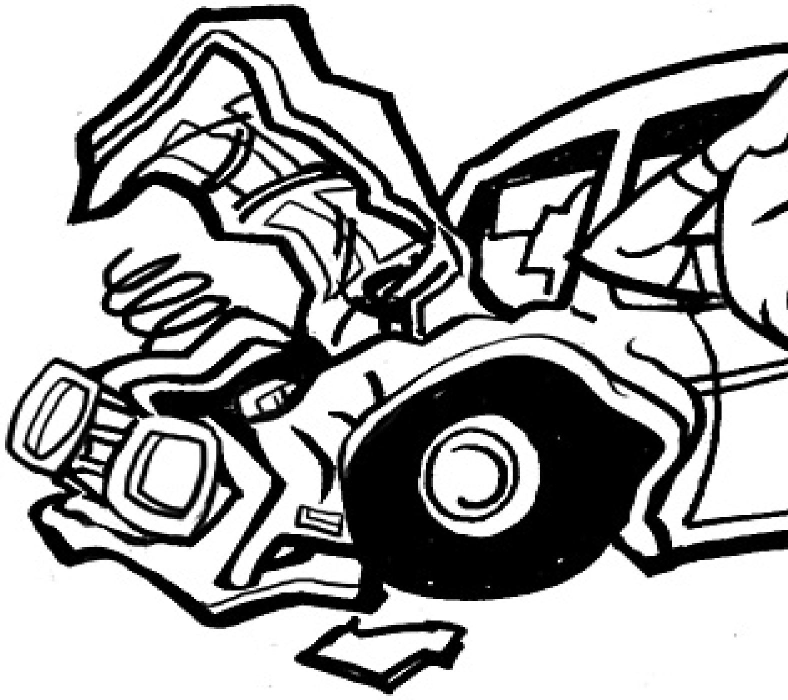
- Right atrium
- Left atrium
- Aorta
- Pulmonary artery

The entire system weighs about 2 pounds (0.9 kg). In the next section, you will learn how surgeons implanted the AbioCor heart during a seven-hour operation.





DRIVERLESS CAR



BY Raghunath Iyer

A driverless car (sometimes called a self-driving car, an automated car or an autonomous vehicle) is a robotic vehicle that is designed to travel between destinations without a human operator. To qualify as fully autonomous, a vehicle must be able to navigate without human intervention to a predetermined destination over roads that have not been adapted for its use.

How driverless cars will work

The “driver” sets a destination. The car’s software calculates a route and starts the car on its way.
A rotating, roof-mounted LIDAR (Light Detection and Ranging - a technology similar to radar) sensor monitors a 60-meter range around the car and creates a dynamic 3-D map of the car’s current environment.
A sensor on the left rear wheel monitors sideways movement to detect the car’s position relative to the 3-D map.
Radar systems in the front and rear bumpers calculate distances to obstacles.
Artificial intelligence (AI) software in the car is connected to all the sensors and has input from Google Street View and video cameras inside the car.
The AI simulates human perceptual and decision-making processes and controls actions in driver-control systems such as steering and brakes.

The car’s software consults Google Maps for advance notice of things like landmarks and traffic signs and lights.
An override function is available to allow a human to take control of the vehicle.

Proponents of systems based on driverless cars say they would eliminate accidents caused by driver error, which is currently the cause of almost all traffic accidents. Furthermore, the greater precision of an automatic system could improve traffic flow, dramatically increase highway capacity and reduce or eliminate traffic jams. Finally, the systems would allow commuters to do other things while traveling, such as working, reading or sleeping.

ESS

Dawn of the driverless car

You can't just jump head-first into driverless cars. That's a recipe for driverless disaster, my friend. One of the earliest driverless cars was Stephen King's "Christine," remember, so let's all be grateful that idea didn't make it to market before the quirks had been worked out.

An early and non-murderous first step toward driverless cars came in the 1980s, and it's still with us today: anti-lock brakes (ABS, according to that terrifying light on the dashboard). Technically, anti-lock brakes do need the driver to step on the brake pedal in order to work, but they perform a function that drivers used to have to do themselves. When a car is braking hard and doesn't have anti-lock brakes, the wheels can lock up, sending the car into an out-of-control skid. In a car without anti-lock brakes, the driver has to pump the brake pedal to keep the wheels from locking up. With anti-lock brakes, the system does the pumping for you and it does it better and much faster than you ever could, thanks to speed sensors in the wheels.

Source: Google

About ten years later, manufacturers used those same sensors to take the next step toward driverless cars: traction and stability control. These systems are a step up the sophistication ladder from ABS. They use the sensors at the wheels to detect when a car might go into an out-of-control skid or roll over, and then they use ABS and engine management to keep the car on the road and the shiny side up. Unlike a driver, these systems can apply the brakes and increase or decrease power to individual wheels, which is often better than brakes or power being applied to all four wheels by a human foot mashing the brake pedal in a blind panic.

THE DARPA URBAN CHALLENGE :

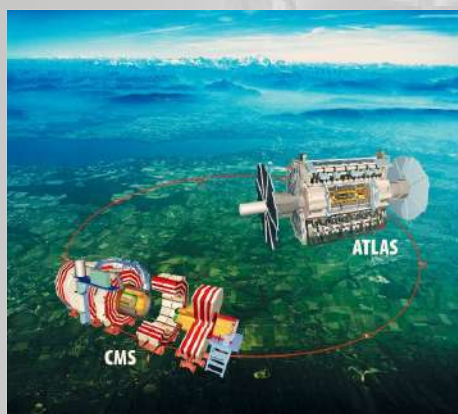
Some of this future driverless car tech may be closer than you think. The DARPA (Defense Advanced Research Projects Agency) Urban Challenge pits teams against each other to create cars that can negotiate traffic autonomously. The goal of the program isn't just to reduce traffic accidents and congestion, however: it's to produce driverless vehicles for combat, keeping soldiers far from the front lines.

Large Hadron Collider (LHC)

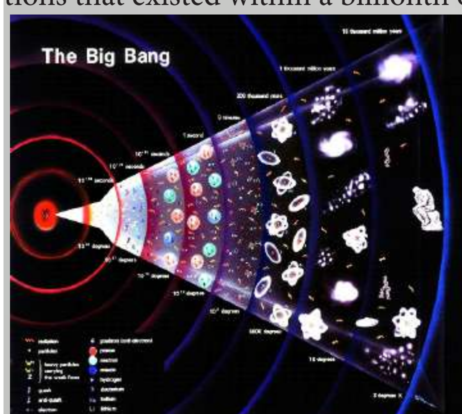
Large Hadron Collider (LHC)

BY Sahil Johari

The Large Hadron Collider (LHC) is by far the most powerful particle accelerator built to date. Following an upgrade, the LHC now operates at an energy that is 7 times higher than any previous machine! The LHC is based at the European particle physics laboratory CERN, near Geneva in Switzerland. CERN is the world's largest laboratory and is dedicated to the pursuit of fundamental science.



The LHC allows scientists to reproduce the conditions that existed within a billionth of a second after the Big Bang by colliding beams of high-energy protons or ions at colossal speeds, close to the speed of light. This was the moment, around 13.7 billion years ago, when the Universe is believed to have started with an explosion of energy and matter. During these first moments all the particles and forces that shape our Universe came into existence, defining what we now see.



The LHC is exactly what its name suggests - a large collider of hadrons (any particle made up of quarks). Strictly, LHC refers to the collider; a machine that deserves to be labelled 'large', it not only weighs more than 38,000 tonnes, but runs for 27km in a circular tunnel 100 metres beneath the ground. Particles are propelled in two beams going around the LHC to speeds of 11,000 circuits per seconds, guided by massive superconducting magnets! These two beams are then made to cross paths and some of the particles smash head on into one another.

However, the collider is only one of three essential parts of the LHC project. The other two are:

The Detectors

Each of the four main detectors sit in huge chambers around the LHC ring to detect the outcomes of the particles colliding. ATLAS, ALICE, CMS and LHCb.

Worldwide LHC Computing Grid (WLCG)

A global network of computers and software that is essential to processing the masses of data recorded by all of the LHC's detectors.

fig : LHC Computing Grid Globe into the computer center

How the Large Hadron Collider Works

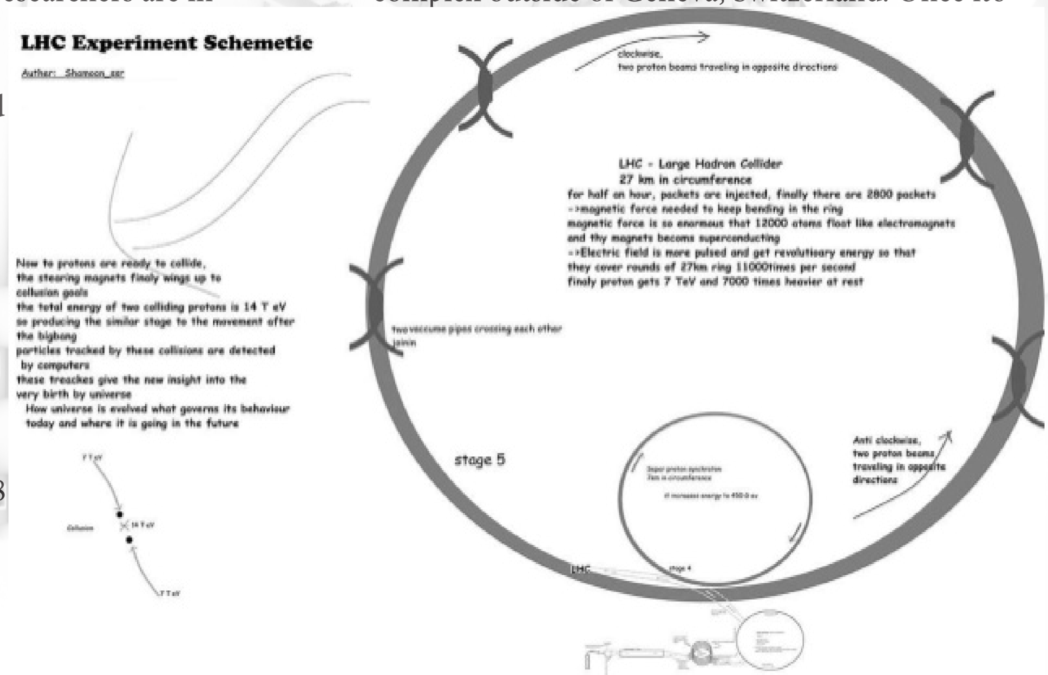
The LHC is truly global in scope because the LHC project is supported by an enormous international community of scientists and engineers. Working in multinational teams all over the world, they are building and testing equipment and software, participating in experiments and analysing data. The UK has a major role in the project and has scientists and engineers working on all the main experiments.

In the UK, engineers and scientists at 20 research sites are involved in designing and building equipment and analysing data. UK researchers are involved with all four of the main detectors and the computer GRID. British staff based at CERN has leading roles in managing and running the collider and detectors.

The total cost of building the LHC was approximately £3.74 billion, made up of three major components1:

- The Accelerator (£3 billion)
- The Experiments (£728 million)
- The Computers (£17 million)

The total cost was shared mainly by CERN's 20 Member States, with significant contributions from the six observer nations.



One hundred meters underground, beneath the border between France and Switzerland, there's a circular machine that might reveal to us the secrets of the universe. Or, according to some people, it could destroy all life on Earth instead. One way or another, it's the world's largest machine and it will examine the universe's tiniest particles. It's the Large Hardon Collider (LHC).

The LHC is part of a project helmed by the European Organization for Nuclear Research, also known as CERN. The LHC joins CERN's accelerator complex outside of Geneva, Switzerland. Once it's switched on, the LHC will hurl beams of protons and ions at a velocity approaching the speed of light. The LHC will cause the beams to collide with each other, and then record the resulting events caused by the collision. Scientists hope that these events will tell us more about how the universe began and what it's made of.

The LHC project involved 111 nations in designing, building and testing equipment and software, and now continues with them participating in experiments and analysing data. The degree of involvement varies between countries, with some able to contribute more financial and human resource than others.

The LHC is the most ambitious and powerful particle accelerator built to date. Thousands of scientists from hundreds of countries are working together -- and competing with one another -- to make new discoveries. Six sites along the LHC's circumference gather data for different experiments. Some of these experiments overlap, and scientists will be trying to be the first to uncover important new information.

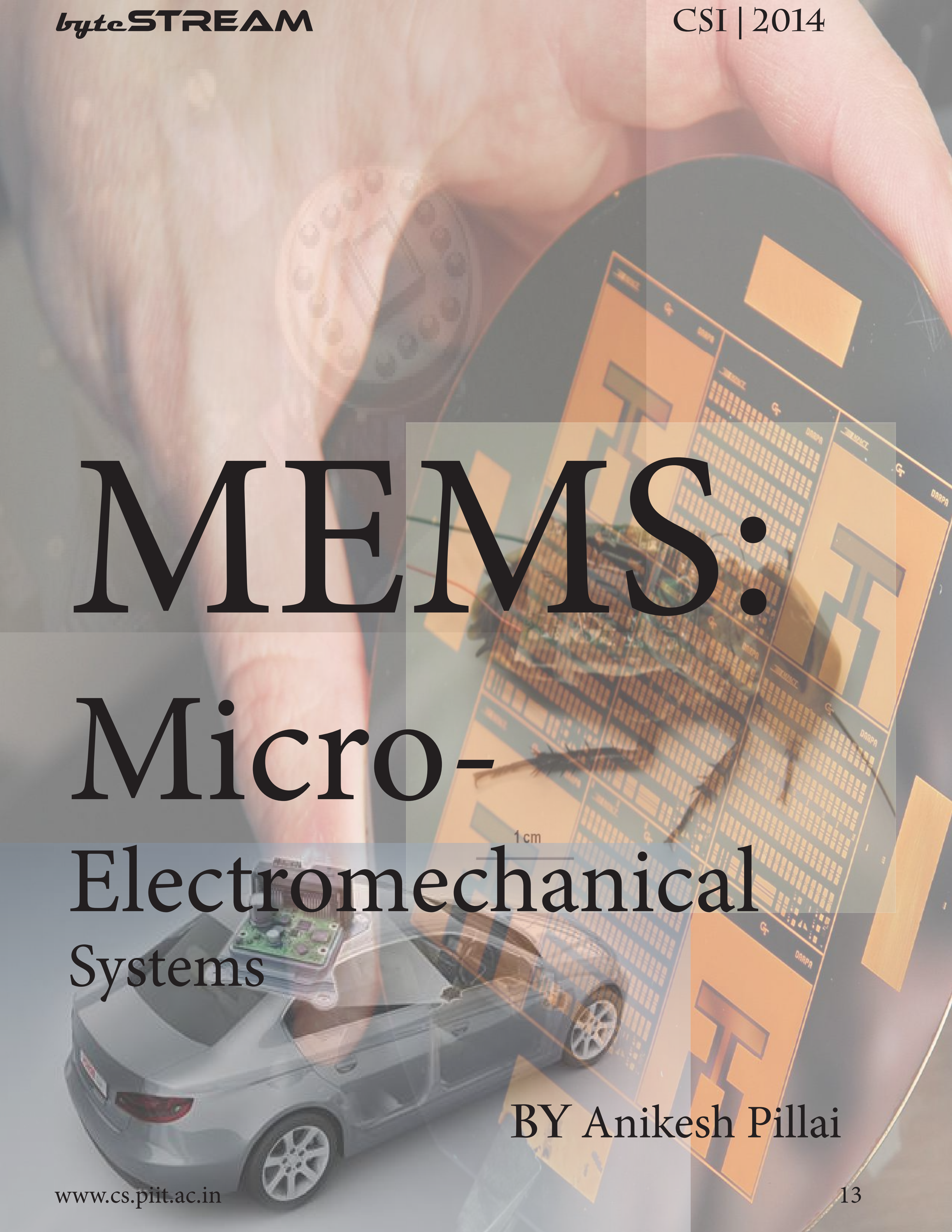
The purpose of the Large Hardon Collider is to increase our knowledge about the universe. While the discoveries scientists will make could lead to practical applications down the road, that's not the reason hundreds of scientists and engineers built the LHC. It's a machine built to further our understanding. Considering the LHC costs billions of dollars and requires the cooperation of numerous countries, the absence of a practical application may be surprising.

The experiments' complex detectors will eventually see up to 600 million collisions per second, as the energy of colliding protons transforms fleetingly into a plethora of exotic particles. In the data from these ultrahigh-energy collisions scientists from universities and laboratories around the world search for the tracks of particles whose existence could transform humankind's understanding of the universe we live in.

About the LHC

An international team has installed the Large Hadron Collider at CERN in a 27-kilometer ring buried deep below the countryside on the outskirts of Geneva, Switzerland. The LHC is the world's most powerful particle accelerate. Its very high energy proton collisions are yielding extraordinary discoveries about the nature of the physical un iverse. Beyond revealing a new world of unknown particles, the LHC experiments could explain why those particles exist and behave as they do. The LHC experiments could reveal the origins of mass, shed light on dark matter, uncover hidden symmetries of the universe, and possibly find extra dimensions.

Billions of protons in the LHC's two counter-rotating particle beams smash together at an energy of 8 trillion electron volts. After injection into the accelerator, the hair-thin proton beams accelerate to a whisker below the speed of light. They circulate inside for hours, guided around the LHC ring by thousands of powerful superconducting magnets. For most of their split-second journey around the ring, the beams travel in two separate vacuum pipes, but at four points they collide in the hearts of the main experiments, known by their acronyms: ALICE, ATLAS, CMS and LHCb.



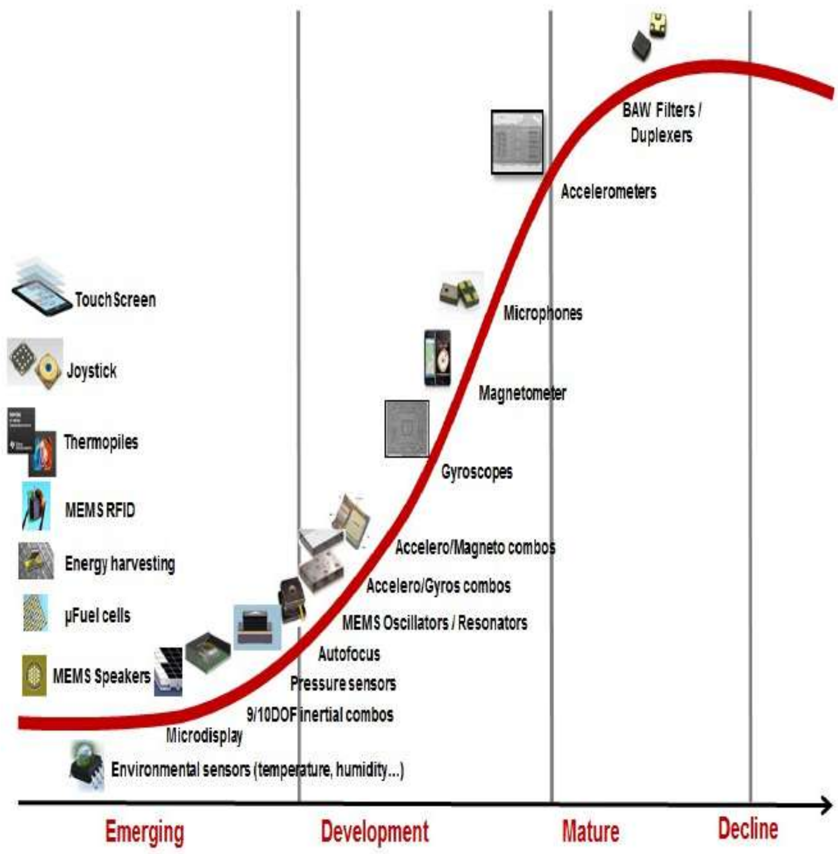
MEMS: Micro-Electromechanical Systems

BY Anikesh Pillai

MEMS: Micro-Electro Mechanical Systems

What is MEMS?

MEMS stands for Micro-ElectroMechanical Systems. MEMS techniques allow both electronic circuits and mechanical devices to be manufactured on a silicon chip, similar to the process used for integrated circuits. This allows the construction of items such as sensor chips with built-in electronics that are a fraction of the size that was previously possible.

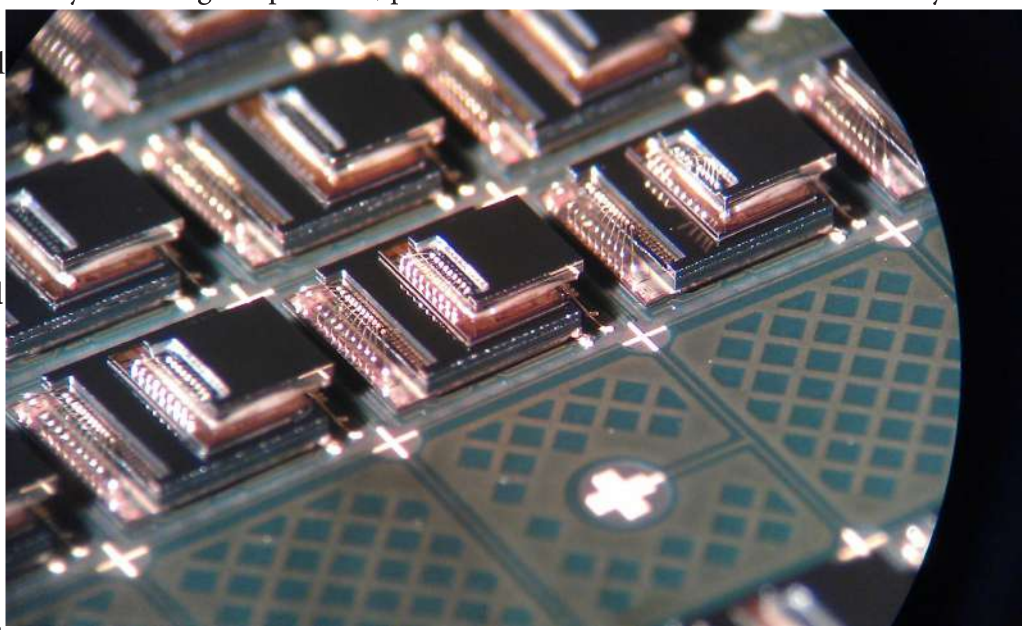


MEMS Products
Four devices using MEMS technology have been commercially successful for several years.
1. MEMS accelerometer chips used to trigger airbags
2. MEMS mirror chips for use in projection screen TVs
3. MEMS inkjet nozzles used in printers
4. MEMS pressure sensors for medical applications

What is MEMS Technology?

Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements i.e., devices and structures that are made using the techniques of microfabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move. The term used to define MEMS varies in different parts of the world. In the United States they are predominantly called MEMS, while in some other parts of the world they are called "Microsystems Technology" or "micromachined devices". While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable and perhaps most interesting elements are the microsensors and microactuators. Microsensors and microactuators are appropriately categorized as “transducers”, which are defined as devices that convert energy from one form to another. In the case of microsensors, the device typically converts a measured mechanical signal into an electrical signal

Over the past several decades MEMS researchers and developers have demonstrated an extremely large number of microsensors for almost every possible sensing modality including temperature, pressure, inertial forces, chemical species, magnetic fields, radiation, etc. Remarkably, many of these micromachined sensors have demonstrated performances exceeding those of their macroscale counterparts. That is, the micromachined version of, for example, a pressure transducer, usually outperforms a pressure sensor made using the most precise macroscale level machining techniques. Not only is the performance of MEMS devices exceptional, but their method of production leverages the same batch fabrication techniques used in the integrated circuit industry – which can translate into low per-device production costs, as well as many other benefits. Consequently, it is possible to not only achieve stellar device performance, but to do so at a relatively low cost level. Not surprisingly, silicon based discrete microsensors were quickly commercially exploited and the markets for these devices continue to grow at a rapid rate.



More recently, the MEMS research and development community has demonstrated a number of microactuators including: microvalves for control of gas and liquid flows; optical switches and mirrors to redirect or modulate light beams; independently controlled micromirror arrays for displays, microresonators for a number of different applications, micropumps to develop positive fluid pressures, microflaps to modulate airstreams on airfoils, as well as many others. Surprisingly, even though these microactuators are extremely small, they frequently can cause effects at the macroscale level; that is, these tiny actuators can perform mechanical feats far larger than their size would imply. For example, researchers have placed small microactuators on the leading edge of airfoils of an aircraft and have been able to steer the aircraft using only these microminiaturized devices.
This vision of MEMS whereby microsensors, microactuators and microelectronics and other technologies, can be integrated onto a single microchip is expected to be one of the most important technological breakthroughs of the future. This will enable the development of smart products by augmenting the computational ability of microelectronics with the perception and control capabilities of microsensors and microactuators. Microelectronic integrated circuits can be thought of as the “brains” of a system and MEMS augments this decision-making capability with “eyes” and “arms”, to allow microsystems to sense and control the environment. Sensors gather information from the environment through measuring mechanical, thermal, biological, chemical, optical, and magnetic phenomena. The electronics then process the information derived from the sensors and through some decision making capability direct the actuators to respond by moving, positioning, regulating, pumping, and filtering, thereby controlling the environment for some desired outcome or purpose. Furthermore, because MEMS devices are manufactured using batch fabrication techniques, similar to ICs, unprecedented levels of functionality, reliability, and sophistication can be placed on a small silicon chip at a relatively low cost. MEMS technology is extremely diverse and fertile, both in its expected application areas, as well as in how the

devices are designed and manufactured. Already, MEMS is revolutionizing many product categories by enabling complete systems-on-a-chip to be realized. Nanotechnology is the ability to manipulate matter at the atomic or molecular level to make something useful at the nano-dimensional scale. Basically, there are two approaches in implementation: the top-down and the bottom-up. In the top-down approach, devices and structures are made using many of the same techniques as used in MEMS except they are made smaller in size, usually by employing more advanced photolithography and etching methods. The bottom-up approach typically involves deposition, growing, or self-assembly technologies. The advantages of nano-dimensional devices over MEMS involve benefits mostly derived from the scaling laws, which can also present some challenges as well

Although MEMS and Nanotechnology are sometimes cited as separate and distinct technologies, in reality the distinction between the two is not so clear-cut. In fact, these two technologies are highly dependent on one another. The well-known scanning tunneling-tip microscope (STM) which is used to detect individual atoms and molecules on the nanometer scale is a MEMS device. Similarly the atomic force microscope (AFM) which is used to manipulate the placement and position of individual atoms and molecules on the surface of a substrate is a MEMS device as well. In fact, a variety of MEMS technologies are required in order to interface with the nano-scale domain.

Likewise, many MEMS technologies are becoming dependent on nanotechnologies for successful new products. For example, the crash airbag accelerometers that are manufactured using MEMS technology can have their long-term reliability degraded due to dynamic in-use stiction effects between the proof mass and the substrate. A nanotechnology called Self-Assembled Monolayers (SAM) coatings are now routinely used to treat the surfaces of the moving MEMS elements so as to prevent stiction effects from occurring over the product's life.

Fabrication Technologies

The three characteristic features of MEMS fabrication technologies are miniaturization, multiplicity, and microelectronics. Miniaturization enables the production of compact, quick-response devices. Multiplicity refers to the batch fabrication inherent in semiconductor processing, which allows thousands or millions of components to be easily and concurrently fabricated. Microelectronics provides the intelligence to MEMS and allows the monolithic merger of sensors, actuators, and logic to build closed-loop feedback components and systems. The successful miniaturization and multiplicity of traditional electronics systems would not have been possible without IC fabrication technology. Therefore, IC fabrication technology, or microfabrication, has so far been the primary enabling technology for the development of MEMS. Microfabrication provides a powerful tool for batch processing and miniaturization of mechanical systems into a dimensional domain not accessible by conventional (machining) techniques. Furthermore, microfabrication provides an opportunity for integration of mechanical systems with electronics to develop high-performance closed-loop-controlled MEMS.

Advances in IC technology in the last decade have brought about corresponding progress in MEMS fabrication processes. Manufacturing processes allow for the monolithic integration of microelectromechanical structures with driving, controlling, and signal-processing electronics. This integration promises to improve the performance of micromechanical devices as well as reduce the cost of manufacturing, packaging, and instrumenting these devices

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