INSPIREEE

INSPIRATIONAL SCRIPTS, PERSONALITIES AND INNOVATIVE RESEARCH OF EEE

NEWS LETTER EEE/
VOLUME 9: ISSUE 2
-
FEBRUARY 2021

K.L.N. COLLEGE OF ENGINEERING

(An Autonomous Institution,
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai)
(Accredited by NAAC for 5 Years W.e.f November 2018) (Accredited by NBA for EEE)
(An ISO 9001:2015 Certified Institution)
Pottapalayam -630612,Sivagangai District,Tamilnadu

INSPIREEE

INspirational **S**cripts, **P**ersonalities and **I**nnovative **R**esearch of **EEE**

VISION

To become a high standard of excellence in Education, Training and Research in the field of Electrical and Electronics Engineering and allied applications

MISSION

To Produce excellent, innovative and Nationalistic Engineers with Ethical values and to advance in the field of Electrical and Electronics Engineering and Allied Areas

KNOWLEDGE FOR LEADERSHIP AND NOBILITY

K.L.N. COLLEGE OF ENGINEERING

K.L.N. College of Engineering
Pottapalayam – 630 612, Sivagangai District,
Tamil Nadu, India

INDEX

MESSAGE FROM HEAD OF THE DEPARTMENT

In this issue articles on the most recent topics presented by the student Electrical vehicles are desired of the future economic of our country.

A Briefly note on this presented opportunity are very high on this field.

Some of the articles guide lines for technical paper written in presentation. Once work will be appreciated only when it is presented well. As the paper will be presented in the National/International forum, special care should be taking before publishing in the articles. The recent fire accident hospitals and temples required more precaution measure to be taken to safe guards. Our loved only and properties and document protected for long period of time. Examination reforms and challenges will definitely improve the confidence of the student.

Best Wishes

EDITORIAL CREW

EDITOR IN-CHIEF:

Dr. S.M. KANNAN [Professor & Head]

EDITOR:

R.JEYAPANDI PRATHAP [Assistant Professor 2]

STUDENT IN-CHARGE:

SHYAM KISHORRE R (202906 / III YEAR /EEE / VI Sem)

R.YUVA PRASATH (202908/ III YEAR /EEE / VI Sem)

K.BHARATHIDASEN (202902/ III YEAR /EEE / VI Sem)

R.P.S.SRI BAVA (202020 / II Years /EEE/ III Sem)

S.AMIRTHA (202030 / II YEAR / EEE / III Sem)

POSTER CREATION:

M.D. KANAKARAJAN,M.A.,PGDCA [Lab Instructor]

THIN-FILM SOLAR CELL

R.SHYAM KISHORRE -202906

EEE III YEAR / VI SEM

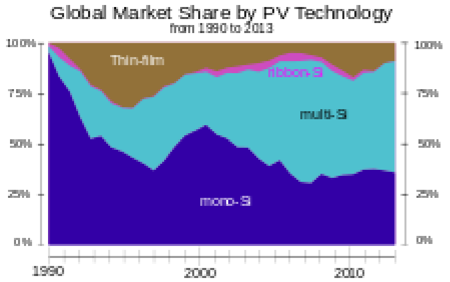
A thin-film solar cell is a second generation solar cell that is made by depositing one or more thin layers, or thin film (TF) of photovoltaic material on a substrate, such as glass, plastic or metal. Thin-film solar cells are commercially used in several technologies, including cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), and amorphous thin-film silicon (a-Si, TF-Si).

Film thickness varies from a few nanometers (nm) to tens of micrometers (µm), much thinner than thin-film's rival technology, the conventional, first-generation crystalline silicon solar cell (c-Si), that uses wafers of up to 200 µm thick. This allows thin film cells to be flexible, and lower in weight. It is used in building-integrated photovoltaics and as semi-transparent, photovoltaic glazing material that can be laminated onto windows. Other commercial applications use rigid thin film solar panels (interleaved between two panes of glass) in some of the world's largest photovoltaic power stations.

Thin-film technology has always been cheaper but less efficient than conventional c-Si technology. However, it has significantly improved over the years. The lab cell efficiency for CdTe and CIGS is now[when?] beyond 21 percent, outperforming multicrystalline silicon, the dominant material currently used in most solar PV systems.Accelerated life testing of thin film modules under laboratory conditions measured a somewhat faster degradation compared to conventional PV, while a lifetime of 20 years or more is generally expected.Despite these enhancements, the market-share of thin-film never reached more than 20 percent in the last two decades and has been declining in recent years to about 9 percent of worldwide photovoltaic installations in 2013.

Other thin-film technologies that are still in an early stage of ongoing research or with limited commercial availability are often classified as emerging or third generation photovoltaic cells and include organic, dye-sensitized, as well as quantum dot, copper zinc tin sulfide, nanocrystal, micromorph, and perovskite solar cells.

History



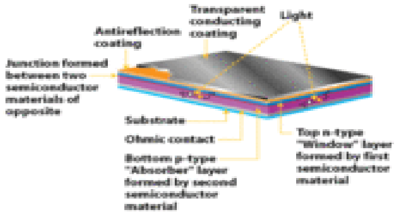
Market-share of thin-film technologies in terms of annual production since 1990

Thin film cells are well-known since the late 1970s, when solar calculators powered by a small strip of amorphous silicon appeared on the market.

They are now available in very large modules used in sophisticated building-integrated installations and vehicle charging systems.

Although thin-film technology was expected to make significant advances in the market and to surpass the dominating conventional crystalline silicon (c-Si) technology in the long-term,market-share has been declining for several years now. While in 2010, when there was a shortage of conventional PV modules, thin-film accounted for 15 percent of the overall market, it declined to 8 percent in 2014, and is expected to stabilize at 7 percent from 2015 onward, with amorphous silicon expected to lose half of its market-share by the end of the decade.

Material



Cross-section of a TF cell

Thin-film technologies reduce the amount of active material in a cell. Most sandwich active material between two panes of glass. Since silicon solar panels only use one pane of glass, thin film panels are approximately twice as heavy as crystalline silicon panels, although they have a smaller ecological impact (determined from life cycle analysis).[5] The majority of film panels have 2-3 percentage points lower conversion efficiencies than crystalline silicon.[6] Cadmium telluride (CdTe), copper indium gallium selenide (CIGS) and amorphous silicon (a-Si) are three thin-film technologies often used for outdoor applications.

Cadmium telluride

Main article: Cadmium telluride photovoltaics

Cadmium telluride (CdTe) is the predominant thin film technology. With about 5 percent of worldwide PV production, it accounts for more than half of the thin film market. The cell's lab efficiency has also increased significantly in recent years and is on a par with CIGS thin film and close to the efficiency of multi-crystalline silicon as of 2013.Also, CdTe has the lowest Energy payback time of all mass-produced PV technologies, and can be as short as eight months in favorable locations. A prominent manufacturer is the US-company First Solar based in Tempe, Arizona, that produces CdTe-panels with an efficiency of about 18 percent.

Although the toxicity of cadmium may not be that much of an issue and environmental concerns completely resolved with the recycling of CdTe modules at the end of their life time,there are still uncertainties and the public opinion is skeptical towards this technology.The usage of rare materials may also become a limiting factor to the industrial scalability of CdTe thin film technology. The rarity of tellurium—of which telluride is the anionic form—is comparable to that of platinum in the earth's crust and contributes significantly to the module's cost.

Copper indium gallium selenide

A copper indium gallium selenide solar cell or CIGS cell uses an absorber made of copper, indium, gallium, selenide (CIGS), while gallium-free variants of the semiconductor material are abbreviated CIS. It is one of three mainstream thin-film technologies, the other two being cadmium telluride and amorphous silicon, with a lab-efficiency above 20 percent and a share of 2 percent in the overall PV market in 2013.[13] A prominent manufacturer of cylindrical CIGS-panels was the now-bankrupt company Solyndra in Fremont, California. Traditional methods of fabrication involve vacuum processes including co-evaporation and sputtering. In 2008, IBM and Tokyo Ohka Kogyo Co., Ltd. (TOK) announced they had developed a new, non-vacuum, solution-based manufacturing process for CIGS cells and are aiming for efficiencies of 15% and beyond.[14]

Hyperspectral imaging has been used to characterize these cells. Researchers from IRDEP (Institute of Research and Development in Photovoltaic Energy) in collaboration with Photon etc., were able to determine the splitting of the quasi-Fermi level with photoluminescence mapping while the electroluminescence data were used to derive the external quantum efficiency (EQE).[15][16] Also, through a light beam induced current (LBIC) cartography experiment, the EQE of a microcrystalline CIGS solar cell could be determined at any point in the field of view.

As of April 2019, current conversion efficiency record for a laboratory CIGS cell stands at 22.9%.[18]

Silicon

Three major silicon-based module designs dominate:

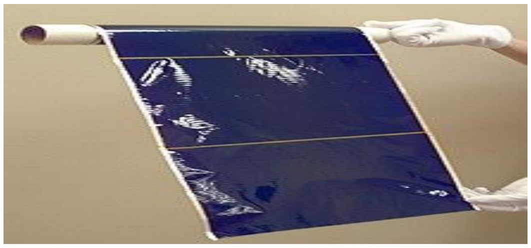
- amorphous silicon cells
- amorphous / microcrystalline tandem cells (micromorph)
- thin-film polycrystalline silicon on glass.[19]

Amorphous silicon

Main article: Amorphous silicon

United Solar Ovonic roll-to-roll solar photovoltaic production line with 30 MW annual capacity

Amorphous silicon (a-Si) is a non-crystalline, allotropic form of silicon and the most well-developed thin film technology to-date. Thin-film silicon is an alternative to conventional *wafer* (or *bulk*) crystalline silicon. While chalcogenide-based CdTe and CIS thin films cells have been developed in the lab with great success, there is still industry interest in silicon-based thin film cells. Silicon-based devices exhibit fewer problems than their CdTe and CIS counterparts such as toxicity and humidity issues with CdTe cells and low manufacturing yields of CIS due to material complexity. Additionally, due to political resistance to the use non-"green" materials in solar energy production, there is no stigma in the use of standard silicon.



Aerospace product with flexible thin-film solar PV from United Solar Ovonic

This type of thin-film cell is mostly fabricated by a technique called plasma-enhanced chemical vapor deposition. It uses a gaseous mixture of silane (SiH_4) and hydrogen to deposit a very thin layer of only 1 micrometre (µm) of silicon on a substrate, such as glass, plastic or metal, that has already been coated with a layer of transparent conducting oxide. Other methods used to deposit amorphous silicon on a substrate include sputtering and hot wire chemical vapor deposition techniques.

a-Si is attractive as a solar cell material because it's an abundant, non-toxic material. It requires a low processing temperature and enables a scalable production upon a flexible, low-cost substrate with little silicon material required. Due to its bandgap of 1.7 eV, amorphous silicon also absorbs a very broad range of the light spectrum, that includes infrared and even some ultraviolet and performs very well at weak light. This allows the cell to generate power in the early morning, or late afternoon and on cloudy and rainy days, contrary to crystalline silicon cells, that are significantly less efficient when exposed at diffuse and indirect daylight.

However, the efficiency of an a-Si cell suffers a significant drop of about 10 to 30 percent during the first six months of operation. This is called the Staebler-Wronski effect (SWE) – a typical loss in electrical output due to changes in photoconductivity and dark conductivity caused by prolonged exposure to sunlight. Although this degradation is perfectly reversible upon annealing at or above 150 °C, conventional c-Si solar cells do not exhibit this effect in the first place.

Its basic electronic structure is the p-i-n junction. The amorphous structure of a-Si implies high inherent disorder and dangling bonds, making it a bad conductor for charge carriers. These dangling bonds act as recombination centers that severely reduce carrier lifetime. A p-i-n structure is usually used, as opposed to an n-i-p structure. This is because the mobility of electrons in a-Si:H is roughly 1 or 2 orders of magnitude larger than that of holes, and thus the collection rate of electrons moving from the n- to p-type contact is better than holes moving from p- to n-type contact. Therefore, the p-type layer should be placed at the top where the light intensity is stronger, so that the majority of the charge carriers crossing the junction are electrons.

Tandem-cell using a-Si/μc-Si

A layer of amorphous silicon can be combined with layers of other allotropic forms of silicon to produce a multi-junction solar cell. When only two layers (two p-n junctions) are combined, it is called a *tandem-cell*. By stacking these layers on top of one other, a broader range of the light spectra is absorbed, improving the cell's overall efficiency.

In micromorphous silicon, a layer of microcrystalline silicon (μc-Si) is combined with amorphous silicon, creating a tandem cell. The top a-Si layer absorbs the visible light, leaving the infrared part to the bottom μc-Si layer. The micromorph stacked-cell concept was pioneered and patented at the Institute of Microtechnology (IMT) of the Neuchâtel University in Switzerland,and was licensed to TEL Solar. A new world record PV module based on the micromorph concept with 12.24% module efficiency was independently certified in July 2014.

Because all layers are made of silicon, they can be manufactured using PECVD. The band gap of a-Si is 1.7 eV and that of c-Si is 1.1 eV. The c-Si layer can absorb red and infrared light. The best efficiency can be achieved at transition between a-Si and c-Si. As nanocrystalline silicon (nc-Si) has about the same bandgap as c-Si, nc-Si can replace c-Si.

Tandem-cell using a-Si/pc-Si

Amorphous silicon can also be combined with protocrystalline silicon (pc-Si) into a tandem-cell. Protocrystalline silicon with a low volume fraction of nanocrystalline silicon is optimal for high open-circuit voltage.[25] These types of silicon present dangling and twisted bonds, which results in deep defects (energy levels in the bandgap) as well as deformation of the valence and conduction bands (band tails).

Polycrystalline silicon on glass

A new attempt to fuse the advantages of bulk silicon with those of thin-film devices is thin film polycrystalline silicon on glass. These modules are produced by depositing an antireflection coating and doped silicon onto textured glass substrates using plasma-enhanced chemical vapor deposition (PECVD). The texture in the glass enhances the efficiency of the cell by approximately 3% by reducing the amount of incident light reflecting from the solar cell and trapping light inside the solar cell. The silicon film is crystallized by an annealing step, temperatures of 400–600 Celsius, resulting in polycrystalline silicon.

These new devices show energy conversion efficiencies of 8% and high manufacturing yields of >90%. Crystalline silicon on glass (CSG), where the polycrystalline silicon is 1–2 micrometres, is noted for its stability and durability; the use of thin film techniques also contributes to a cost savings over bulk photovoltaics. These modules do not require the presence of a transparent conducting oxide layer. This simplifies the production process twofold; not only can this step be skipped, but the absence of this layer makes the process of constructing a contact scheme much simpler. Both of these simplifications further reduce the cost of production. Despite the numerous advantages over alternative design, production cost estimations on a per unit area basis show that these devices are comparable in cost to single-junction amorphous thin film cells.

Gallium arsenide

Gallium arsenide (GaAs) is a III-V direct bandgap semiconductor and is a very common material used for single-crystalline thin-film solar cells. GaAs solar cells have continued to be one of the highest performing thin-film solar cells due to their exceptional heat resistant properties and high efficiencies.As of 2019, single-crystalline GaAs cells have shown the highest solar cell efficiency of any single-junction solar cell with an efficiency of 29.1%.This record-holding cell achieved this high efficiency by implementing a back mirror on the rear surface to increase photon absorption which allowed the cell to attain an impressive short-circuit current density and an open-circuit voltage value near the Shockley–Queisser limit.As a result, GaAs solar cells have nearly reached their maximum efficiency although improvements can still be made by employing light trapping strategies.

GaAs thin-films are most commonly fabricated using epitaxial growth of the semiconductor on a substrate material. The epitaxial lift-off (ELO) technique, first demonstrated in 1978, has proven to be the most promising and effective. In this method, the thin film layer is peeled off of the substrate by selectively etching a sacrificial layer that was placed between the epitaxial film and substrate. The GaAs film and the substrate remain minimally damaged through the separation process, allowing for the reuse of the host substrate.]With reuse of the substrate the fabrication costs can be reduced, but not completely forgone, since the substrate can only be reused a limited number of times. This process is still relatively costly and research is still being done to find more cost-effective ways of growing the epitaxial film layer onto a substrate.

Despite the high performance of GaAs thin-film cells, the expensive material costs hinder their ability for wide-scale adoption in the solar cell industry. GaAs is more commonly used in multi-junction solar cells for solar panels on spacecraft, as the larger power to weight ratio lowers the launch costs in space-based solar power (InGaP/(In)GaAs/Ge cells). They are also used in concentrator photovoltaics, an emerging technology best suited for locations that receive much sunlight, using lenses to focus sunlight on a much smaller, thus less expensive GaAs concentrator solar cell.

Emerging photovoltaics

Main article: Third-generation photovoltaic cell

An experimental silicon based solar cell developed at the Sandia National Laboratories

The National Renewable Energy Laboratory (NREL) classifies a number of thin-film technologies as emerging photovoltaics—most of them have not yet been commercially applied and are still in the research or development phase. Many use organic materials, often organometallic compounds as well as inorganic substances. Despite the fact that their efficiencies had been low and the stability of the absorber material was often too short for commercial applications, there is a lot of research invested into these technologies as they promise to achieve the goal of producing low-cost, high-efficient solar cells.

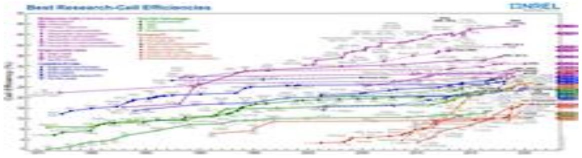
Emerging photovoltaics, often called third generation photovoltaic cells, include:

- Copper zinc tin sulfide solar cell (CZTS), and derivates CZTSe and CZTSSe
- Dye-sensitized solar cell, also known as "Grätzel cell"
- Organic solar cell
- Perovskite solar cell
- Quantum dot solar cell

Especially the achievements in the research of perovskite cells have received tremendous attention in the public, as their research efficiencies recently soared above 20 percent. They also offer a wide spectrum of low-cost applications.In addition, another emerging technology, concentrator photovoltaics (CPV), uses high-efficient, multi-junction solar cells in combination with optical lenses and a tracking system.

Efficiencies

Main article: Solar cell efficiency



Solar cell efficiencies of various cell technologies (including both single-crystal and thin film technologies) as tracked by NREL

The achievable efficiency of thin-film solar cells is extremely dependent on the semiconductor chosen and the growth technology. Incremental improvements in efficiency began with the invention of the first modern silicon solar cell in 1954. By 2010 these steady improvements had resulted in modules capable of converting 12 to 18 percent of solar radiation into electricity.The improvements to efficiency have continued to accelerate in the years since 2010, as shown in the accompanying chart.

Cells made from newer materials tend to be less efficient than bulk silicon, but are less expensive to produce. Their quantum efficiency is also lower due to reduced number of collected charge carriers per incident photon.

The performance and potential of thin-film materials are high, reaching cell efficiencies of 12–20%; prototype module efficiencies of 7–13%; and production modules in the range of 9%.The thin film cell prototype with the best efficiency yields 20.4% (First Solar), comparable to the best conventional solar cell prototype efficiency of 25.6% from Panasonic.

NREL once predicted that costs would drop below $100/m^2 in volume production, and could later fall below $50/m^2.

A new record for thin film solar cell efficiency of 22.3% has been achieved by Solar Frontier, the world's largest CIS (copper indium selenium) solar energy provider. In joint research with the New Energy and Industrial Technology Development Organization (NEDO) of Japan, Solar Frontier achieved 22.3% conversion efficiency on a 0.5 cm^2 cell using its CIS technology. This is an increase of 0.6 percentage points over the industry's previous thin-film record of 21.7%.

Absorption

Multiple techniques have been employed to increase the amount of light that enters the cell and reduce the amount that escapes without absorption. The most obvious technique is to minimize the top contact coverage of the cell surface, reducing the area that blocks light from reaching the cell.

The weakly absorbed long wavelength light can be obliquely coupled into silicon and traverses the film several times to enhance absorption.

Multiple methods have been developed to increase absorption by reducing the number of incident photons being reflected away from the cell surface. An additional anti-reflective coating can cause destructive interference within the cell by modulating the refractive index of the surface coating. Destructive interference eliminates the reflective wave, causing all incident light to enter the cell.

Surface texturing is another option for increasing absorption, but increases costs. By applying a texture to the active material's surface, the reflected light can be refracted into striking the surface again, thus reducing reflectance. For example, black silicon texturing by reactive ion etching(RIE) is an effective and economic approach to increase the absorption of thin-film silicon solar cells.A textured backreflector can prevent light from escaping through the rear of the cell.

In addition to surface texturing, the plasmonic light-trapping scheme attracted a lot of attention to aid photocurrent enhancement in thin film solar cells. This method makes use of collective oscillation of excited free electrons in noble metal nanoparticles, which are influenced by particle shape, size and dielectric properties of the surrounding medium.

In addition to minimizing reflective loss, the solar cell material itself can be optimized to have higher chance of absorbing a photon that reaches it.

Thermal processing techniques can significantly enhance the crystal quality of silicon cells and thereby increase efficiency. Layering thin-film cells to create a multi-junction solar cell can also be done. Each layer's band gap can be designed to best absorb a different range of wavelengths, such that together they can absorb a greater spectrum of light.

Further advancement into geometric considerations can exploit nanomaterial dimensionality. Large, parallel nanowire arrays enable long absorption lengths along the length of the wire while maintaining short minority carrier diffusion lengths along the radial direction. Adding nanoparticles between the nanowires allows conduction. The natural geometry of these arrays forms a textured surface that traps more light.

Production, cost and market

multi-Si (54.9%) mono-Si (36.0%) CdTe (5.1%) a-Si (2.0%) CIGS (2.0%)

With the advances in conventional crystalline silicon (c-Si) technology in recent years, and the falling cost of the polysilicon feedstock, that followed after a period of severe global shortage, pressure increased on manufacturers of commercial thin-film technologies, including amorphous thin-film silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS), leading to the bankruptcy of several companies.As of 2013, thin-film manufacturers continue to face price competition from Chinese refiners of silicon and manufacturers of conventional c-Si solar panels. Some companies together with their patents were sold to Chinese firms below cost.

LASER WEAPON SYSTEM

R.YUVA PRASATH - 202908

EEE / III YEAR / VI SEM

A **laser weapon**[2] is a directed-energy weapon based on lasers. After decades of R&D, as of January 2020 directed-energy weapons including lasers are still at the experimental stage and it remains to be seen if or when they will be deployed as practical, high-performance military weapons.[3][4] Atmospheric thermal blooming has been a major problem, still mostly unsolved, and worsened if fog, smoke, dust, rain, snow, smog, foam, or purposely dispersed obscurant chemicals are present. Essentially, a laser generates a beam of light which needs clear air, or a vacuum, to work[5] without thermal blooming.

Many types of laser can potentially be used as incapacitating weapons, through their ability to produce temporary or permanent vision loss when aimed at the eyes. The degree, character, and duration of vision impairment caused by eye exposure to laser light varies with the power of the laser, the wavelength(s), the collimation of the beam, the exact orientation of the beam, and the duration of exposure. Lasers of even a fraction of a watt in power can produce immediate, permanent vision loss under certain conditions, making such lasers potential non-lethal but incapacitating weapons. The extreme handicap that laser-induced blindness represents makes the use of lasers even as non-lethal weapons morally controversial, and weapons designed to cause permanent blindness have been banned by the Protocol on Blinding Laser Weapons.

Weapons designed to cause temporary blindness, known as dazzlers, are used by military and sometimes law enforcement organizations. Incidents of pilots being exposed to lasers while flying have prompted aviation authorities to implement special procedures to deal with such hazards.[6] See Lasers and aviation safety for more on this topic. Laser weapons capable of directly damaging or destroying a target in combat are still in the experimental stage. The general idea of laser-beam weaponry is to hit a target with a train of brief pulses of light. The power needed to project a high-powered laser beam of this kind is beyond the limit of current mobile power technology, thus favoring chemically powered gas dynamic lasers. Example experimental systems included MIRACL and the Tactical High Energy Laser, which are now discontinued. The United States Navy has tested the very short range (1 mile), 30-kW Laser Weapon System or LaWS to be used against targets like small UAVs, rocket-propelled grenades, and visible motorboat or helicopter engines.[7][8] It has been defined as "six welding lasers strapped together." A 60 kW system, HELIOS, is being developed for destroyer class ships as of 2020.

Electro laser

An electro laser first ionizes its target path, and then sends an electric current down the conducting track of ionized plasma, somewhat like lightning. It functions as a giant, high-energy, long-distance version of the Taser or stun gun

HOW DO HIGH-ENERGY LASERS WORK?

How do high-energy lasers work, anyway? At the simplest level, electrical power is used to generate a laser beam, getting rid of the waste heat from that process. You also need a system that knows where to point the laser beam and can hold it precisely on the target for long enough to kill it. Of course, this description oversimplifies what is a sophisticated series of steps.

It all starts with a radar somewhere – typically on the platform itself or in an adjacent platform – that sends a message to say: ‘there is something out there that might be a threat.’ The laser system slews and points in the direction of the threat. A camera looks at the threat, often providing a better, higher resolution picture than the radar could provide. The decision-maker then determines whether the object is a threat that must be engaged.

Once that decision is made, the beam control system engages sensors to ensure that the target is precisely tracked despite motion of both the platform and the target. Based on prior knowledge of the identified target, the most vulnerable point is selected – either manually or via automation. The beam control system ensures that the high energy laser continues to hit the same point on the target with high precision until the target is neutralized.

To further understand how the system works, it helps to look at the four subsystems that make up the HEL.

First, there is the power subsystem, which reconditions electrical power to whatever voltage is needed to drive the laser. The power can come from the platform that the laser is mounted on, such as a destroyer ship, or from lithium-ion batteries, like those in the Polaris MRZR ATV that was adapted.

Then there is the thermal subsystem. It removes the large amount of waste heat generated by the laser system and disposes of it in a way that doesn't degrade the performance of the laser.

The third subsystem is the laser beam itself, one of the most complicated parts of the whole system. In the first step, arrays of thousands of low power semiconductor diode lasers, each similar to a laser pointer, convert the electrical power into divergent beams of laser light. In the next step, each fiber laser acts as a brightness converter, efficiently converting the divergent diode light beams into highly directional fiber laser beams. A range of different techniques are used to efficiently combine the multiple beams from multiple fiber lasers into a single, high-power, low-divergence beam.

Two of the main beam-combining techniques are spectral and coherent beam combining. With coherent beam combining, sensors measure a distorted probe laser beam at, or near, the target, then use algorithms to provide phase corrections and compensate for the distortions. Matching phase corrections can then be applied to individual fiber laser beams comprising the high-energy laser beam, correcting for the distortions in that high-power laser beam.

Spectral beam combining provides a simpler technique for generating low to moderate power level laser beams (up to ~50 kW-class). But for higher power lasers in the presence of atmospheric distortion, a separate adaptive optics system is required, including components that are unproven for long term operation in field environments. Both techniques are still being developed and refined across the industry. RI&S believes that each solution has a mission set that is better-suited to address.

The fourth subsystem, beam control, serves a critical role: pointing the beam precisely at the chosen aim point on the target with sufficient intensity to neutralize it. Any jitter in the position of impact on the target is equivalent to a lower laser power that will take longer to kill the target.

TARGETING AND OPTICS

RI&S's high-energy laser weapon system uses a modified version of our Multi-Spectral Targeting System, or MTS, to hold the laser beam on a target with ultra-high precision. The MTS, an electro-optical and infrared sensor commonly seen on manned and unmanned aircraft, makes for a near-ideal effective beam control system. A highly integrated design philosophy makes our HEL system more robust, providing lower jitter than other beam control systems.

In addition to the four subsystems, future laser systems may also need adaptive optics. To understand adaptive optics, imagine being outside on a hot day. As you look at the horizon, the image becomes blurry or distorted. The same distortion effect happens to a laser beam as it moves towards its target – it becomes distorted and can start to break up. If you are close to the ground, dealing with threats at a similar altitude, adaptive optics becomes important. To solve this challenge, there are different adaptive optical techniques that can be used with the two, previously mentioned beam combining techniques.

There will be more challenges to overcome as lasers move to the field and towards volume manufacturing. Since the timing of a strong demand signal from the government has been uncertain, the defense industry hasn't yet invested in largescale manufacturing infrastructure for laser weapons. At RI&S, we are drawing on existing manufactured components as much as possible – leveraging our MTS production facility, as well as readily-available fiber lasers from established commercial manufacturers. In this way, we can lower the additional investment needed to reach volume production.

The next few years will help determine whether high-energy lasers become a staple of the battlefield. The upcoming field deployment, as well as further development of the technology, will provide important milestones in the future of laser weapon systems.

RAIL-MAGLEV HYBRID-MAGKLEV (from magnatic levaitation)
K.BHARATHIDASAN -202902
EEE / III YEAR / VI SEM

This article is about transportation. For the phenomenon, see Magnetic levitation. For other uses, see Maglev (disambiguation).

L0 Series on SCMaglev test track in Yamanashi Prefecture, Japan

Transrapid 09 at the Emsland test facility in Lower Saxony, Germany

A full trip on the Shanghai Transrapid maglev train

Maglev

(from magnetic levitation) is a system of train transportation that uses two sets of magnets: one set to repel and push the train up off the track, and another set to move the elevated train ahead, taking advantage of the lack of friction. Along certain "medium-range" routes (usually 320 to 640 km (200 to 400 mi)), maglev can compete favourably with high-speed rail and airplanes.

With maglev technology, the train travels along a guideway of magnets which control the train's stability and speed. While the propulsion and levitation require no moving parts, the bogies can move in relation to the main body of the vehicle and some technologies require support by retractable wheels at speeds under 150 kilometres per hour (93 mph). This compares with electric multiple units that may have several dozen parts per bogie. Maglev trains can therefore in some cases be quieter and smoother than conventional trains and have the potential for much higher speeds.

Maglev vehicles have set several speed records, and maglev trains can accelerate and decelerate much faster than conventional trains; the only practical limitation is the safety and comfort of the passengers, although wind resistance at very high speeds can cause running costs that are four to five times that of conventional high-speed rail (such as the Tokaido Shinkansen).The power needed for levitation is typically not a large percentage of the overall energy consumption of a high-speed maglev system.Overcoming drag, which makes all land transport more energy intensive at higher speeds, takes the most energy. Vactrain technology has been proposed as a means to overcome this limitation. Maglev systems have been much more expensive to construct than conventional train systems, although the simpler construction of maglev vehicles makes them cheaper to manufacture and maintain.

The Shanghai maglev train, also known as the Shanghai Transrapid, has a top speed of 430 km/h (270 mph). The line is the fastest operational high-speed maglev train, designed to connect Shanghai Pudong International Airport and the outskirts of central Pudong, Shanghai. It covers a distance of 30.5 km (19 mi) in just over 8 minutes. For the first time, the launch generated wide public interest and media attention, propelling the popularity of the mode of transportation.Despite over a century of research and development, maglev transport systems are now operational in just three countries (Japan, South Korea and China).The incremental benefits of maglev technology have often been considered hard to justify against cost and risk, especially where there is an existing or proposed conventional high-speed train line with spare passenger carrying capacity, as in high-speed rail in Europe, the High Speed 2 in the UK and Shinkansen in Japan.

Development

In the late 1940s, the British electrical engineer Eric Laithwaite, a professor at Imperial College London, developed the first full-size working model of the linear induction motor. He became professor of heavy electrical engineering at Imperial College in 1964, where he continued his successful development of the linear motor. Since linear motors do not require physical contact between the vehicle and guideway, they became a common fixture on advanced transportation systems in the 1960s and '70s. Laithwaite joined one such project, the Tracked Hovercraft, although the project was cancelled in 1973.

The linear motor was naturally suited to use with maglev systems as well. In the early 1970s, Laithwaite discovered a new arrangement of magnets, the magnetic river, that allowed a single linear motor to produce both lift and forward thrust, allowing a maglev system to be built with a single set of magnets. Working at the British Rail Research Division in Derby, along with teams at several civil engineering firms, the "transverse-flux" system was developed into a working system.

The first commercial maglev people mover was simply called

"MAGLEV" and officially opened in 1984 near Birmingham, England. It operated on an elevated 600 m (2,000 ft) section of monorail track between Birmingham Airport and Birmingham International railway station, running at speeds up to 42 km/h (26 mph). The system was closed in 1995 due to reliability problems.

First maglev patent

High-speed transportation patents were granted to various inventors throughout the world.The first relevant patent, U.S. Patent 714,851 (2 December 1902), issued to Albert C. Albertson, used magnetic levitation to take part of the weight off of the wheels while using conventional propulsion.

Early United States patents for a linear motor propelled train were awarded to German inventor Alfred Zehden. The inventor was awarded U.S. Patent 782,312 (14 February 1905) and U.S. Patent RE12700 (21 August 1907). In 1907, another early electromagnetic transportation system was developed by F. S. Smith.In 1908, Cleveland mayor Tom L. Johnson filed a patent for a wheel-less "high-speed railway" levitated by an induced magnetic field.Jokingly known as "Greased Lightning," the suspended car operated on a 90-foot test track in Johnson's basement "absolutely noiseless[ly] and without the least vibration. A series of German patents for magnetic levitation trains propelled by linear motors were awarded to Hermann Kemper between 1937 and 1941. An early maglev train was described in U.S. Patent 3,158,765, "Magnetic system of transportation", by G. R. Polgreen (25 August 1959). The first use of "maglev" in a United States patent was in "Magnetic levitation guidance system by Canadian Patents and Development Limited.

New York, United States, 1968

In 1959, while delayed in traffic on the Throgs Neck Bridge, James Powell, a researcher at Brookhaven National Laboratory (BNL), thought of using magnetically levitated transportation.Powell and BNL colleague Gordon Danby worked out a maglev concept using static magnets mounted on a moving vehicle to induce electrodynamic lifting and stabilizing forces in specially shaped loops, such as figure-of-8 coils on a guideway. These were patented in 1968–1969.

Japan, 1969–present

See also: Chūō Shinkansen

Japan operates two independently developed maglev trains. One is HSST (and its descendant, the Linimo line) by Japan Airlines and the other, which is more well known, is SCMaglev by the Central Japan Railway Company.

The development of the latter started in 1969. Maglev trains on the Miyazaki test track regularly hit 517 km/h (321 mph) by 1979. After an accident which destroyed the train, a new design was selected. In Okazaki, Japan (1987), the SCMaglev was used for test rides at the Okazaki exhibition. Tests in Miyazaki continued throughout the 1980s, before transferring to a far longer test track, 20 km (12 mi) long, in Yamanashi in 1997. The track has since been extended to almost 43 km (27 mi). The current 603 km/h (375 mph) world speed record for manned trains was set there in 2015.

Development of HSST started in 1974. In Tsukuba, Japan (1985), the HSST-03 (Linimo) became popular at the Tsukuba World Exposition, in spite of its low 30 km/h (19 mph) top speed. In Saitama, Japan (1988), the HSST-04-1 was revealed at the Saitama exhibition in Kumagaya. Its fastest recorded speed was 300 km/h (190 mph).

Construction of a new high-speed maglev line, the Chuo Shinkansen, started in 2014. It is being built by extending the SCMaglev test track in Yamanashi in both directions. The completion date is currently unknown, with the most recent estimate of 2027 no longer possible following a local governmental rejection of a construction permit.

Hamburg, Germany, 1979

Transrapid 05 was the first maglev train with longstator propulsion licensed for passenger transportation. In 1979, a 908 m (2,979 ft) track was opened in Hamburg for the first International Transportation Exhibition (IVA 79). Interest was sufficient that operations were extended three months after the exhibition finished, having carried more than 50,000 passengers. It was reassembled in Kassel in 1980.

Ramenskoye, Moscow, USSR, 1979

Experimental car TP-01 (ТП-01) in Ramenskoye built in 1979

Experimental car TP-05 (ТП-05) in Ramenskoye built in 1986

In 1979 the USSR town of Ramenskoye (Moscow oblast) built an experimental test site for running experiments with cars on magnetic suspension. The test site consisted of a 60-metre ramp which was later extended to 980 metres.From the late 1970s to the 1980s five prototypes of cars were built that received designations from TP-01 (ТП-01) to TP-05 (ТП-05).The early cars were supposed to reach the speed up to 100 km/h.

The construction of a maglev track using the technology from Ramenskoye started in Armenian SSR in 1987 and was planned to be completed in 1991. The track was supposed to connect the cities of Yerevan and Sevan via the city of Abovyan. The original design speed was 250 km/h which was later lowered to 180 km/h.However, the Spitak earthquake in 1988 and the First Nagorno-Karabakh War caused the project to freeze. In the end the overpass was only partially constructed.

In the early 1990s, the maglev theme was continued by the Engineering Research Center this time by the order from the Moscow government. The project was named V250 (В250).

The idea was to build a high-speed maglev train to connect Moscow to the Sheremetyevo airport. The train would consist of 64-seater cars and run at speeds up to 250 km/h. In 1993, due to the financial crisis, the project was abandoned. However, from 1999 the "TEMP" research center had been participating as a co-developer in the creation of the linear motors for the Moscow Monorail system.

Technology

See also: SCMaglev § Technology, Transrapid § Technology, and Magnetic levitation

In the public imagination, "maglev" often evokes the concept of an elevated monorail track with a linear motor. Maglev systems may be monorail or dual rail—the SCMaglev MLX01 for instance uses a trench-like track—and not all monorail trains are maglevs. Some railway transport systems incorporate linear motors but use electromagnetism only for propulsion, without levitating the vehicle. Such trains have wheels and are not maglevs.Maglev tracks, monorail or not, can also be constructed at grade or underground in tunnels. Conversely, non-maglev tracks, monorail or not, can be elevated or underground too. Some maglev trains do incorporate wheels and function like linear motor-propelled wheeled vehicles at slower speeds but levitate at higher speeds. This is typically the case with electrodynamic suspension maglev trains. Aerodynamic factors may also play a role in the levitation of such trains.

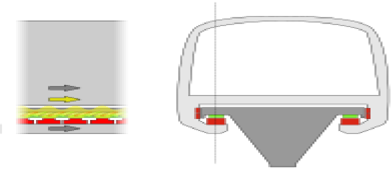
MLX01 Maglev train Superconducting magnet bogie

The two main types of maglev technology are:

- Electromagnetic suspension (EMS), electronically controlled electromagnets in the train attract it to a magnetically conductive (usually steel) track.
- Electrodynamic suspension (EDS) uses superconducting electromagnets or strong permanent magnets that create a magnetic field, which induces currents in nearby metallic conductors when there is relative movement, which pushes and pulls the train towards the designed levitation position on the guide way.

Electromagnetic suspension (EMS)

Main article: Electromagnetic suspension



Electromagnetic suspension (EMS) is used to levitate the Transrapid on the track, so that the train can be faster than wheeled mass transit systems[59][60]

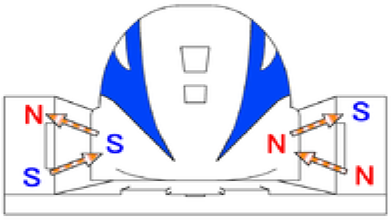
In electromagnetic suspension (EMS) systems, the train levitates above a steel rail while electromagnets, attached to the train, are oriented toward the rail from below. The system is typically arranged on a series of C-shaped arms, with the upper portion of the arm attached to the vehicle, and the lower inside edge containing the magnets. The rail is situated inside the C, between the upper and lower edges.

Magnetic attraction varies inversely with the square of distance, so minor changes in distance between the magnets and the rail produce greatly varying forces. These changes in force are dynamically unstable—a slight divergence from the optimum position tends to grow, requiring sophisticated feedback systems to maintain a constant distance from the track, (approximately 15 mm [0.59 in]).

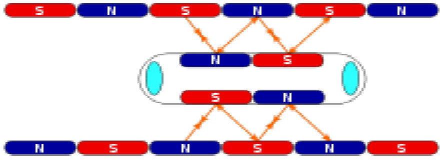
The major advantage to suspended maglev systems is that they work at all speeds, unlike electrodynamic systems, which only work at a minimum speed of about 30 km/h (19 mph). This eliminates the need for a separate low-speed suspension system, and can simplify track layout. On the downside, the dynamic instability demands fine track tolerances, which can offset this advantage. Eric Laithwaite was concerned that to meet required tolerances, the gap between magnets and rail would have to be increased to the point where the magnets would be unreasonably large.In practice, this problem was addressed through improved feedback systems, which support the required tolerances.

Electrodynamic suspension (EDS)

Main article: Electrodynamic suspension



The Japanese SCMaglev's EDS suspension is powered by the magnetic fields induced either side of the vehicle by the passage of the vehicle's superconducting magnets.



EDS Maglev propulsion via propulsion coils

In electrodynamic suspension (EDS), both the guideway and the train exert a magnetic field, and the train is levitated by the repulsive and attractive force between these magnetic fields.In some configurations, the train can be levitated only by repulsive force. In the early stages of maglev development at the Miyazaki test track, a purely repulsive system was used instead of the later repulsive and attractive EDS system.The magnetic field is produced either by superconducting magnets (as in JR–Maglev) or by an array of permanent magnets (as in Inductrack). The repulsive and attractive force in the track is created by an induced magnetic field in wires or other conducting strips in the track.

A major advantage of EDS maglev systems is that they are dynamically stable—changes in distance between the track and the magnets creates strong forces to return the system to its original position.In addition, the attractive force varies in the opposite manner, providing the same adjustment effects. No active feedback control is needed.

However, at slow speeds, the current induced in these coils and the resultant magnetic flux is not large enough to levitate the train. For this reason, the train must have wheels or some other form of landing gear to support the train until it reaches take-off speed. Since a train may stop at any location, due to equipment problems for instance, the entire track must be able to support both low- and high-speed operation.

Another downside is that the EDS system naturally creates a field in the track in front and to the rear of the lift magnets, which acts against the magnets and creates magnetic drag. This is generally only a concern at low speeds, and is one of the reasons why JR abandoned a purely repulsive system and adopted the sidewall levitation system.At higher speeds other modes of drag dominate.

The drag force can be used to the electrodynamic system's advantage, however, as it creates a varying force in the rails that can be used as a reactionary system to drive the train, without the need for a separate reaction plate, as in most linear motor systems. Laithwaite led development of such "traverse-flux" systems at his Imperial College laboratory. Alternatively, propulsion coils on the guideway are used to exert a force on the magnets in the train and make the train move forward. The propulsion coils that exert a force on the train are effectively a linear motor: an alternating current through the coils generates a continuously varying magnetic field that moves forward along the track. The frequency of the alternating current is synchronized to match the speed of the train. The offset between the field exerted by magnets on the train and the applied field creates a force moving the train forward.

Tracks

The term "maglev" refers not only to the vehicles, but to the railway system as well, specifically designed for magnetic levitation and propulsion. All operational implementations of maglev technology make minimal use of wheeled train technology and are not compatible with conventional rail tracks. Because they cannot share existing infrastructure, maglev systems must be designed as standalone systems. The SPM maglev system is inter-operable with steel rail tracks and would permit maglev vehicles and conventional trains to operate on the same tracks.MAN in Germany also designed a maglev system that worked with conventional rails, but it was never fully developed.

Evaluation[edit]

Each implementation of the magnetic levitation principle for train-type travel involves advantages and disadvantages.

Technology	Pros	Cons
EMS (Electromagnetic suspension)	Magnetic fields inside and outside the vehicle are less than EDS; proven, commercially available technology; high speeds (500 km/h or 310 mph); no wheels or secondary propulsion system needed.	The separation between the vehicle and the guideway must be constantly monitored and corrected due to the unstable nature of electromagnetic attraction; the system's inherent instability and the required constant corrections by outside systems may induce vibration.
EDS (Electrodynamic suspension)	Onboard magnets and large margin between rail and train enable highest-recorded speeds (603 km/h or 375 mph) and heavy load capacity; demonstrated successful operations using high-temperature superconductors in its onboard magnets, cooled with inexpensive liquid nitrogen.	Strong magnetic fields on the train would make the train unsafe for passengers with pacemakers or magnetic data storage media such as hard drives and credit cards, necessitating the use of magnetic shielding; limitations on guideway inductivity limit maximum speed; vehicle must be wheeled for travel at low speeds.
Induct rack System (Permanent Magnet Passive Suspension)	Failsafe Suspension—no power required to activate magnets; Magnetic field is localized below the car; can generate enough force at low speeds (around 5 km/h or 3.1 mph) for levitation; given power failure cars stop safely; Halbach arrays of permanent magnets may prove more cost-effective than electromagnets.	Requires either wheels or track segments that move for when the vehicle is stopped. Under development as of 2008; no commercial version or full-scale prototype.

Proposed technology enhancements

Evacuated tubes

Main article: Vactrain

Some systems (notably the Swissmetro system) propose the use of vactrains—maglev train technology used in evacuated (airless) tubes, which removes air drag. This has the potential to increase speed and efficiency greatly, as most of the energy for conventional maglev trains is lost to aerodynamic drag.

One potential risk for passengers of trains operating in evacuated tubes is that they could be exposed to the risk of cabin depressurization unless tunnel safety monitoring systems can repressurize the tube in the event of a train malfunction or accident though since trains are likely to operate at or near the Earth's surface, emergency restoration of ambient pressure should be straightforward. The RAND Corporation has depicted a vacuum tube train that could, in theory, cross the Atlantic or the USA in around 21 minutes.

Rail-Maglev Hybrid

The Polish startup Nevomo (previously Hyper Poland) is developing a system for modifying existing railway tracks into a maglev system, on which conventional wheel-rail trains, as well maglev vehicles can travel. Vehicles on this so-called 'magrail' system will be able to reach speeds of up to 300 km/h at significantly lower infrastructure costs than stand-alone maglev lines. Similar to proposed Vactrain systems, magrail is designed to allow a later-stage upgrade with a vacuum cover which will enable vehicles to reach speeds of up to 600 km/h due to reduced air pressure, making the system similar to a hyperloop, but without the necessity for dedicated infrastructure corridors.

Energy use

Energy for maglev trains is used to accelerate the train. Energy may be regained when the train slows down via regenerative braking. It also levitates and stabilises the train's movement. Most of the energy is needed to overcome air drag. Some energy is used for air conditioning, heating, lighting and other miscellany.

At low speeds the percentage of power used for levitation can be significant, consuming up to 15% more power than a subway or light rail service.For short distances the energy used for acceleration might be considerable.

The force used to overcome air drag increases with the square of the velocity and hence dominates at high speed. The energy needed per unit distance increases by the square of the velocity and the time decreases linearly. However power increases by the cube of the velocity. For example, 2.37 times as much power is needed to travel at 400 km/h (250 mph) than 300 km/h (190 mph), while drag increases by 1.77 times the original force.

Aircraft take advantage of lower air pressure and lower temperatures by cruising at altitude to reduce energy consumption but unlike trains need to carry fuel on board. This has led to the suggestion of conveying maglev vehicles through partially evacuated tubes.

Comparison with conventional trains

Maglev transport is non-contact and electric powered. It relies less or not at all on the wheels, bearings and axles common to wheeled rail systems.

- **Speed:** Maglev allows higher top speeds than conventional rail, but experimental wheel-based high-speed trains have demonstrated similar speeds.
- **Maintenance**: Maglev trains currently in operation have demonstrated the need for minimal guideway maintenance. Vehicle maintenance is also minimal (based on hours of operation, rather than on speed or distance traveled). Traditional rail is subject to mechanical wear and tear that increases rapidly with speed, also increasing maintenance.For example: the wearing down of brakes and overhead wire wear have caused problems for the Fastech 360 rail Shinkansen. Maglev would eliminate these issues.
- **Weather**: Maglev trains are little affected by snow, ice, severe cold, rain or high winds. However, they have not operated in the wide range of conditions that traditional friction-based rail systems have operated. Maglev vehicles accelerate and decelerate faster than mechanical systems regardless of the slickness of the guideway or the slope of the grade because they are non-contact systems.
- **Track**: Maglev trains are not compatible with conventional track, and therefore require custom infrastructure for their entire route. By contrast conventional high-speed trains such as the TGV are able to run, albeit at reduced speeds, on existing rail infrastructure, thus reducing expenditure where new infrastructure would be particularly expensive (such as the final approaches to city terminals), or on extensions where traffic does not justify new infrastructure. John Harding, former chief maglev scientist at the Federal Railroad Administration, claimed that separate maglev infrastructure more than pays for itself with higher levels of all-weather operational availability and nominal maintenance costs. These claims have yet to be proven in an intense operational setting and they do not consider the increased maglev construction costs.
- **Efficiency**: Conventional rail is probably more efficient at lower speeds. But due to the lack of physical contact between the track and the vehicle, maglev trains experience no rolling resistance, leaving only air resistance and electromagnetic drag, potentially improving power efficiencySome systems, however, such as the Central Japan Railway Company SCMaglev use rubber tires at low speeds, reducing efficiency gains.
- **Weight**: The electromagnets in many EMS and EDS designs require between 1 and 2 kilowatts per ton.The use of superconductor magnets can reduce the electromagnets' energy consumption. A 50-ton Transrapid maglev vehicle can lift an additional 20 tons, for a total of 70 tons, which consumes 70–140 kW (94–188 hp).Most energy use for the TRI is for propulsion and overcoming air resistance at speeds over 100 mph (160 km/h).
- **Weight loading**: High-speed rail requires more support and construction for its concentrated wheel loading. Maglev cars are lighter and distribute weight more evenly.
- **Noise**: Because the major source of noise of a maglev train comes from displaced air rather than from wheels touching rails, maglev trains produce less noise than a conventional train at equivalent speeds. However, the psychoacoustic profile of the maglev may reduce this benefit: a study concluded that maglev noise should be rated like road traffic, while conventional trains experience a 5–10 dB "bonus", as they are found less annoying at the same loudness level.
- **Magnet reliability:** Superconducting magnets are generally used to generate the powerful magnetic fields to levitate and propel the trains. These magnets must be kept below their critical temperatures (this ranges from 4.2 K to 77 K, depending on the material). New alloys and manufacturing techniques in superconductors and cooling systems have helped address this issue.
- **Control systems**: No signalling systems are needed for high-speed rail, because such systems are computer controlled.

Human operators cannot react fast enough to manage high-speed trains. High-speed systems require dedicated rights of way and are usually elevated. Two maglev system microwave towers are in constant contact with trains. There is no need for train whistles or horns, either.

- **Terrain**: Maglevs are able to ascend higher grades, offering more routing flexibility and reduced tunneling.However, their high speed and greater need for control make it difficult for a maglev to merge with complex terrain, such as a curved hill. Traditional trains, on the other hand, are able to curve alongside a mountain top or meander through a forest.

Comparison with aircraft

Differences between airplane and maglev travel:

- **Efficiency**: For maglev systems the lift-to-drag ratio can exceed that of aircraft (for example Inductrack can approach 200:1 at high speed, far higher than any aircraft). This can make maglevs more efficient per kilometer. However, at high cruising speeds, aerodynamic drag is much larger than lift-induced drag. Jets take advantage of low air density at high altitudes to significantly reduce air drag. Hence despite their lift-to-drag ratio disadvantage, they can travel more efficiently at high speeds than maglev trains that operate at sea level.
- **Routing**: Maglevs offer competitive journey times for distances of 800 km (500 mi) or less. Additionally, maglevs can easily serve intermediate destinations.
- **Availability**: Maglevs are little affected by weather.
- **Travel time**: Maglevs do not face the extended security protocols faced by air travelers nor is time consumed for taxiing, or for queuing for take-off and landing.

Proposed maglev systems

Germany

On 25 September 2007, Bavaria announced a high-speed maglev-rail service from Munich to its airport. The Bavarian government signed contracts with Deutsche Bahn and Transrapid with Siemens and ThyssenKrupp for the €1.85 billion project.

On 27 March 2008, the German Transport minister announced the project had been cancelled due to rising costs associated with constructing the track. A new estimate put the project between €3.2–3.4 billion.

Hong Kong

In March 2021 a government official said Hong Kong would be included in a planned maglev network across China, planned to operate at 600 km/h (370 mph) and begin opening by 2030.

Hong Kong is already connected to the Chinese high speed rail network by the Guangzhou–Shenzhen–Hong Kong Express Rail Link, which opened on Sunday 23 September 2018.

Mumbai – Delhi

A project was presented to then Indian railway minister (Mamata Banerjee) by an American company to connect Mumbai and Delhi. Then Prime Minister Manmohan Singh said that if the line project was successful the Indian government would build lines between other cities and also between Mumbai Central and Chhatrapati Shivaji International Airport.

Mumbai – Nagpur

The State of Maharashtra approved a feasibility study for a maglev train between Mumbai and Nagpur, some 1,000 km (620 mi) apart.

Chennai – Bangalore – Mysore

A detailed report was to be prepared and submitted by December 2012 for a line to connect Chennai to Mysore via Bangalore at a cost $26 million per kilometre, reaching speeds of 350 km/h.

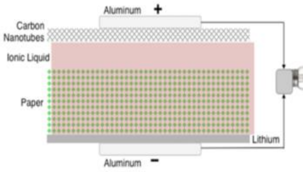
PAPER BATTERY

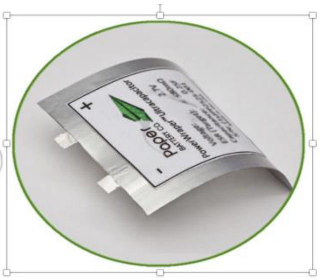
R.P.S. SRI BAVA – 202020

EEE / II YEAR / III Sem

The continuously advancing technology of portable electronic devices requires more flexible batteries to power them. Batteries power a wide range of electronic devices including phones, laptop computers and medical devices such as cardiac pacemakers and defibrillators. With the ever increasing demand for efficiency and design, there is a need for ultrathin, safe and flexible energy storage options. A paper battery is a flexible, ultra- thin energy storage and production device formed by combining carbon nanotubes with a conventional sheet of cellulose based paper. A paper battery acts as both a high energy battery and supercapacitor, combining two components that are separate in traditional electronics.

This combination allows the battery to provide long term, steady power production and bursts of energy. Through the use of super capacitors, batteries can be made that will deliver renewable energy from bodily fluids such as blood or sweat. This technology can be greatly utilized by medical devices. It combines two essential materials, cellulose and carbon nanotubes (CNTs), that fit the characteristics of spacer and electrode and provide inherent flexibility as well as porosity to the system. Cellulose, the main constituent of paper and an inexpensive insulating separator structure with excellent biocompatibility, can be made with adjustable porosity. CNTs, a structure with extreme flexibility, have already been widely used as electrodes in electrochemical devices.





Need for Paper Battery:

The ordinary Electro-Chemical battery faces many problems like:

1. **Limited life time**: The primary batteries can't be recharged like secondary batteries. They irreversibly convert chemical energy into the electrical energy. Although the secondary batteries may be rechargeable, the life time may be very short and also they are very costlier than the primary ones. The paper battery provides a better advantage of all these problems.
2. **Environmental Influence**: The extensive use of batteries can generate environmental pollutions like toxic metal pollutions etc. But the Paper batteries are environmentally friendly and can decompose very easily without any abuse.
3. **Leakage**: If by chance any leakage of batteries occurred, the chemical released may be very dangerous to the environment and also to the nearby metals which are in contact with the batteries. But there is no toxic chemical in the paper batteries.

Carbon nanotubes:

Carbon is accomplished with many allotropes. Some renowned form of carbon allotropes are diamonds, graphite etc. Currently different forms of allotropes of carbon have been ascertained and researched like carbon nano tubes. In Carbon nanotubes, each carbon atom is amalgamating with all other three carbon atoms in order to form a nanosize cylindrical structure. The nanosize cylindrical structure along with its novel properties makes the carbon nanotube conceivably beneficial in wide range of applications in materials science, electronics, nanotechnology and optics. The carbon nanotube unveils outstanding strength along with its distinctive electrical properties also the carbon nanotube is an effective heat conductor too.

Three ways to construct the paper batteries:

1. **First Method:** First fabricate the cathode and anode with Zinc and manganese dioxide respectively. With the help of a standard silk screen printing press, these batteries are printed on to the surface of a paper. After that this printed paper is infused with the carbon nanotubes (electrode). Now let this printed paper to dip into the electrolyte (Ionic liquid solution).

- Cathode – Zinc
- Anode - Manganese dioxide
- Electrode - Carbon nanotubes
- Electrolyte - Ionic liquid solution

2. **The second method:** This method is little complex than the first method. Here silicon is used as the substrate. And the nanotube grows on this substrate. Cellulose is used to fill the gaps in the matrix substrate and also to form a combination with the nanotubes. When the matrix dried, the amalgamated nanotubes and cellulose is striped off. Thus we can create paper sheets having layers of Carbon nanotubes. By combining these two sheets together, we can construct a super capacitor with an ionic solution like urine, sweat or human blood as an electrolyte.

3. **The Third Method**: This method is comparatively simple and can be fabricate in the laboratory.

- First take a rectangular shaped Xerox paper.
- Now made a coating of ionic solution in to this paper surface.
- Then spread the specially prepared carbon nanotubes ink over this ionic coated Xerox paper.
- The other side of the Xerox paper is laminated with a thin film or layer of lithium.
- Aluminum rods are used to transfer current between the 2 electrodes.

Working Principle of Paper Battery

The internal performance of paper batteries is identical to that of a traditional battery by generating a voltage about 1.5V. We can recall the working principles of a traditional batteries where ions (+ ve charged particles) and electrons (- ve charged particles) moves between the electrodes, anode (+ve electrode) and cathode (-ve electrode). Due to the flow of electrons from cathode to anode, current start flowing from anode to cathode along the conductor.

- Cathode: Carbon Nanotube
- Anode: Lithium metal (Li+)
- Electrolyte: bio electrolytes like urine, blood and sweat. (All electrolytes can be used)
- Separator: Cellulose or Paper

Similarly in Paper Batteries, the metal (Lithium) is used as the anode and carbon nanotubes as cathode and also the paper or cellulose is used as the separator. Due to the chemical reaction between the electrolyte and carbon, electrons are generated. Similarly due to the chemical reaction between electrolyte and metal, ions are generated. These generated electrons starts flow through the external circuit from cathode to the anode.

Where can Paper Batteries be used

- Paper Battery can be now implemented in wearable technology like **Google Glass**, **Wearable Biosensors**, and **Wearable computer** etc.
- Used in entertainment devices.
- Used in tags and smart cards.
- For medical applications like disposable medical diagnostic devices and also can be used in pacemakers due to the paper batteries nontoxic and biodegradable nature.
- Ideal for aircraft, automobiles, remote controllers etc.

Advantages of Paper Battery

- Paper battery can be used as both super capacitor and battery.
- Paper batteries are very flexible, ultrathin, nontoxic and biodegradable battery
- Long life.
- Provides a steady power.
- Can be available in different shapes and sizes.
- They offer high energy efficiency.
- Paper Batteries are low cost and can be easily disposed.
- They can be used to produce 1.5V energy and also paper batteries are rechargeable.

SILENT SOUND TECHNOLOGY

S.AMIRTHA- 202030

EEE / II YEAR / III Sem

Everybody has the experience of talking aloud in the cell phone in the midst of the disturbance while travelling in trains or buses. There is no need of shouting anymore for this purpose. ‘Silent sound technology’ is the answer for this problem.

The Silent sound technology is an amazing solution for those who had lost their voice but wish to speak over phone. It is developed at the Karlsruhe Institute of Technology and you can expect to see it in the near future. When demonstrated, it seems to detect every lip movement and internally converts the electrical pulses into sounds signals and sends them neglecting all other surrounding noise. It is definitely going to be a good solution for those feeling annoyed when other speak loud over phone.

‘Silent Sound’ technology aims to notice every movements of the lips and transform them into sounds, which could help people who lose voices to speak, and allow people to make silent calls without bothering others. Rather than making any sounds, your handset would decipher the movements your mouth makes by measuring muscle activity, then convert this into speech that the person on the other end of the call can hear. So, basically, it reads your lips. This new technology will be very helpful whenever a person looses his voice while speaking or allow people to make silent calls without disturbing others, even we can tell our PIN number to a trusted friend or relative without eavesdropping . At the other end, the listener can hear a clear voice. the awesome feature added to this technology is that "it is an instant polyglot" I.E, movements can be immediately transformed into the language of the user's choice. This translation works for languages like English, French & German. But, for the languages like Chinese, different tones can hold many different meanings. This poses Problem said Wand. he also said that in five or may be in ten years this will Be used in everyday's technology.

Methods

Silent Sound Technology is processed through some ways or methods. They are:

1. Electromyography (EMG)
2. Image Processing

Electromyography

- The Silent Sound Technology uses electromyography, monitoring tiny muscular movements that occur when we speak.
- Monitored signals are converted into electrical pulses that can then be turned into speech, without a sound uttered.
- Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles.
- An electromyography detects the electrical potential generated by muscle cells, when these cells are electrically or neurologically activated.
- Electromyographic sensors attached to the face records the electric signals produced by the facial muscles, compare them with pre recorded signal pattern of spoken words
- When there is a match that sound is transmitted on to the other end of the line and person at the other end listen to the spoken words .

Image Processing

- The simplest form of digital image processing converts the digital data tape into a film image with minimal corrections and calibrations.
- Then large mainframe computers are employed for sophisticated interactive manipulation of the data.
- In the present context, overhead prospective are employed to analyze the picture.
- In electrical engineering and computer science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Application of Silent Sound Technology

It will help people who have lost their voice as a result of accident or cannot speak loudly again as result of old age

ii. It can be use a military for communication of secrete or sensitive information.

iii. It is applicable if you want to make a call in conference meeting or library without disturbing the others

iv. Speaker can speak his native language like German and listener can listen to it in his native language like English

v. It is applicable for those who want to make a call in nosily environment e.g. people working in train station, Movies Theater, market etc.

vi. As we know in space there is no medium for sound to travel therefore this technology can be best utilized by astronauts.

VISION

TO BECOME A HIGH STANDARD OF EXCELLENCE IN EDUCATION,
TRAINING AND RESEARCH IN THE FIELD OF
ELECTRICAL AND ELECTRONICS ENGINEERING
AND ALLIED APPLICATIONS

MISSION

TO PRODUCE EXCELLENT, INNOVATIVE AND NATIONALISTIC ENGINEERS
WITH ETHICALVALUES AND TO ADVANCE IN
THE FIELD OF ELECTRICAL AND ELECTRONICS ENGINEERING
AND ALLIED AREAS