
BATTERY
TECHNOLOGY
for the
FUTURE

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Frankly Speaking

Imagining new technologies is easy, figuring out how to bring them into the real world is much harder.

If you're trying to design something futuristic, challenge are, you're waiting on the materials available to catch up with your idea.

But there are some exciting solutions that can help us to reimagine what mobility will look like in the future.

Poor logic makes a solid-state battery, the battery in your phone is also lithium based.

But it uses the liquid to move energy around.

This means they get hot, they're more flammable and they can explode.

Remember the note seven solid-state batteries, you solid electrodes and electrolytes making it much more stable.

There are a few reasons why we think solid-state batteries are gonna be the next big thing.

Well they're much smaller and cheaper than current liquid based batteries.

They can potentially charge faster or last longer and just have better overall performance.

Today's batteries have short lifespans and the constant charging and discharging slowly erodes their performance.

Solid-state batteries are projected to have life cycles longer than the current.

Two to three years that we're getting in batteries today, there are several categories of solid-state batteries each of.

Which uses a different material for the electrolyte as we're still dealing with an emerging technology.

Researchers are still coming to grips with what type of solid-state electrolyte is best used for different product categories.

Pro-law geom uses fl cb this is the only lithium chemical battery that adopts a flexible printed circuit.

This makes it suitable for wearables or anything else that requires flexibility or a unique battery shape.

Since it can be cut while charging it, makes it safe for people to wear.

Researchers released another video of their battery being cut in half and charging a phone for 24 hours.

The more battery you cut away the lower the battery's capacity.

So we're still waiting for this technology to find at home.

It seemed very simple, the wearable market was going to grow and it is.

But we have yet to see pro-law gm appear in mainstream products.

Frustratingly the area of our electronics is the one component that has yet to see a significant improvement processors.

Displays and foreign factors have all taken dramatic leaps forward but the battery only improves a few percent a year.

And the improvements to daily battery life come primarily from the cpu and display improving their power consumption not from the battery itself.

We're hoping that this will be the year that solid-state batteries finally find a home in wearables.

But they're not the only game in town and maybe that's why they haven't caught on hydrogen fuel.

Cells are the electric-vehicle battery of choice in japan.

There's only a few countries in the world that are all in our hydrogen power and japan is one of them.

Meanwhile aqua batteries blue battery stores electricity using only water and table salt.

This is a radically new way to store energy and it's environmentally friendly.

Nanowires are hoping to be the base of a battery that never dies.

Now why is a thousands of times thinner than a human hair and made of gold.

For suspended and electrolyte gel to avoid snapping while charging.

Copper foam substrate is another version of the solid-state battery though.

Its 3d structure allows for a more efficient and less than linear transfer of energy over the air charging is also possible.

Beam it uses ultrasound to transmit electricity power is turned into sound waves.

Inaudible to humans and animals and then transmitted and converted back.

Upon reaching the device but graphene is truly one of those technologies to get excited about.

It's 200 times stronger than steel, it's the thinnest material on earth, it's extremely conductive transparent, and it's even won a nobel prize.

Samsung in november 2017 revealed that it had developed the technology based on a graphene ball.

This could potentially boost its better capacity by 45% an increased charging speed fivefold.

Their goal is to have a graphene based power unit charge in only 12 minutes.

We've actually tested out a graphene battery pack, it went from zero to five thousand milliamperes in only twelve point five minutes.

Graphene also has the ability to be transparent.

So we could see a truly transparent smartphone in the future.

Graphene has the potential to change the way speakers are made.

They contend seawater into drinking water revolutionized.

Stem-cell research changed low-light photography, prevent building collapse by being built into structures.

To show structural defects and electric vehicles aren't discounting this technology either.

Lithium-ion batteries aren't going anywhere, they're gonna be the battery found in our smartphone, laptop for at least the next five years.

But the key to new form factors is being able to power them from new sources.

We're gonna be tracking battery technology quite closely.

Because we see it as an integral part of how we change our mobility

Futuristic Battery Technology

Batteries are everywhere in today's hyper connected electrically propelled society.

I bet a battery is powering the device you're watching this video on right now.

Do you have low battery status?.

What if you didn't have to charge your phone again for another month?.

Today pretty much every electric vehicle utilizes lithium particle batteries. .

To add insult to injury, the energy density of decomposed organisms destructively drilled from the earth still achieve more than 100 times the energy density of the batteries used in most electric cars.

1 kilogram of gasoline contains about 48 megajoule's of energy, and lithium ion battery packs only contain about .3 megajoules of energy per kilogram.

What's more, lithium batteries degrade with each charging cycle, gradually losing capacity over the battery's lifetime. Researchers often compare batteries by the number of full cycles until the battery has only 80% of its original energy capacity remaining.

As indicated by Elon Musk, battery modules are the primary restricting element in electric vehicle life.

In 2019 he said the Tesla Model 3 drive unit is evaluated for 1 million miles, however the battery just goes on for 300,000 - 500,000 miles or around 1,500 charge cycles.

While energy density and lifetime improvements to batteries appear to be the most crucial issues, there are environmental and geopolitical problems associated with current lithium ion batteries which are equally, if not more pressing to solve to reach the battery of tomorrow.

The mining industry of the world's largest producer is often made up of competing rebel militias that use child labor.

Much is illegally exported and directly funds armed conflict in the region.

Additionally the camps often create conditions which drive deforestation and an array of human rights abuses.

To deal with the anticipated interest blast for electric vehicles throughout the next few decades, we'll need to create better batteries that are cheaper, longer lasting, more durable, and more efficient.

We must also address the issues of political and environmental sustainability electric future.

Many questions were answered after Tesla's long awaited battery day took place on September The Palo Alto automaker announced a larger The king sized cells make use of an improved design that eliminates the tabs normally found in Lithium Ion batteries that transfer the cell's energy to an external source.

Laser powdered them, and enabled dozens of connections into the active material through this shingled spiral" This more efficient cell design alleviates thermal issues, and simplifies the manufacturing process.

Tesla also introduced high-nickel cathodes that eliminate the need for cobalt, and improved silicon battery chemistry in which they stabilize the surface with an elastic ion-conducting polymer coating that allows for a higher percentage of cheap commodified silicon to be used in cell manufacture.

All together these changes create an expected and the new 4680 cells expect to achieve a increase in range, and a 6 time increase in power.

Tesla hopes the improved cell design will allow them to achieve an eventual production target of 3 terawatt-hours per year by 2030, and help scale the world's transition to ubiquitous long distance electric vehicles.

After Tesla's recent battery day, the world's attention is now more focused on batteries In the following video, we're going to explore change everything.

Realistic battery packs would probably be closer to 1000 Wh/kg initially, but this is still three to five times higher than lithium ion batteries can achieve.

As usual, this technology is not without its drawbacks.

Current electrodes of lithium air batteries tend to clog with lithium salts after only a few tens of cycles – most researchers are using porous forms of carbon to transmit air to the liquid electrolytes.

Feeding pure oxygen to the batteries is one solution but is a potential safety hazard in the automotive environment.

Researchers at the University of Illinois found that they could prevent this clogging by using molybdenum disulphide nanoflakes to catalyze the formation of a thin coating of lithium peroxide (Li_2O_2) on the electrodes.

Their test battery ran for an equivalent with uncoated electrodes. While this isn't enough lifetime for a car, it's a promising hint of things to come.

More on nanotechnology later.

They believe that once their research cell is optimized, they should be looking at around high power requirements of takeoff.

But they too are struggling with low battery life.

For them, the solutions will boil down to improvements in the electrolyte.

Nanomaterials make use of particles and structures 1-100 nanometers The magic is that they behave in unusual ways because this small size bridges the gap between that which operates under the rules of quantum physics and those of our familiar macro world.

As we've seen, one of the challenges in battery design is the physical expansion of lithium electrodes as they charge.

Researchers at Purdue University made use of antimony 'nanochain' electrodes last year to enable this material to replace graphite or carbon-metal composite electrodes.

By structuring this metalloid element in this 'nanochain' net shape, extreme expansion can be accommodated within the electrode since it leaves a web of empty pores.

The battery appears to charge rapidly and showed no deterioration over the Carbon nanostructures also show great promise.

Graphene is one of the most exciting of these.

Graphene is made up of a single atomic thickness sheet of graphite, and it turns out that this material has very interesting electrical properties, being a very thin semiconductor with high carrier mobility, meaning that electrons are transmitted along it rapidly in the presence of an electric field, as inside a battery.

It is also thermally conductive and has exceptional mechanical strength, about 200 times stronger than steel.

Grabat, a Spanish nanotechnology company are pursuing graphene polymer cathodes with metallic lithium anodes – a highly potent combination if their electrolyte can adequately protect the metallic anode and prevent dendrite growth.

This battery promises to be lighter and more robust than current technology while charging and discharging faster and with greater energy capacity.

Samsung have patented a technology they call 'graphene balls'.

These are silicon oxide nanoparticles which are coated with graphene sheets that resemble popcorn.

These are used as the cathode as well as being applied in a protective layer on the anode.

The researchers found increases in the volumetric density of a full cell of 27.6% compared to an uncoated equivalent and the experimental cell retains almost 80% capacity after 500 cycles.

Additionally, charging is accelerated and temperature control is improved.

NanoGraf, meanwhile, are using graphene sheets to produce carbon-silicon batteries to increase stored energy by 30%.

The silicon nanowires are attached to a thin foil by vapor deposition in a continuous, roll-to-roll production process – helping keep manufacturing costs down.

The clever part is that these finger-like projections are porous on a micro and macro scale, allowing them to swell freely without significant expansion of the whole electrode.

Just as trees swell with leaves in spring but the forest remains the same size.

Some internet sleuths concluded that the company was recently acquired by Tesla because Amprius recently moved their headquarters right next to a Tesla facility, but Elon Musk debunked these claims on twitter.

The University of California Irvine have even produced electrodes good for 200,000 cycles using gold nanowires and manganese dioxide with a polymer gel electrolyte and many other research efforts are ongoing with other diverse materials.

One thing that seems to be sure though is that as soon as it's possible to mass produce suitable nanotechnology, we will be seeing it in our batteries in some form and quite possibly in conjunction with silicon.

This is a huge improvement: a lithium sulphur battery could be up to seven and a half times lighter than its current equivalent.

Right now, lithium sulphur batteries are nowhere near their theoretical limit, but the ALISE, a pan-European collaboration are working towards attaining a stable automotive battery of 500 Wh/kg based on this technology.

In terms of economics, sulphur is much cheaper than the cobalt and manganese it would replace, and can be extracted as a by-product of fossil fuel refinement or mined from abundant natural deposits.

Existing lithium ion batteries are made up of an anode and cathode between which a liquid electrolyte allows dissolved lithium ions to travel.

Lithium sulphur batteries are constructed similarly, except that the active element in the cathode is sulphur, while the anode remains lithium based.

Researchers are facing a few challenges in bringing this technology to market.

Firstly, sulphur is a poor conductor of electricity.

Typically the sulphur atoms are embedded within the matrix of carbon atoms in graphite, an excellent electrical conductor.

This arrangement is vulnerable to a process known as shuttling, which causes batteries to drain when not in use, while also corroding metallic lithium anodes, reducing capacity as the battery is cycled.

Next and most significantly, the electrodes physically swell up as lithium ions bond to them.

This is more dramatic with lithium sulphur than existing chemistries, the sulphur cathode expanding and contracting by as much as 78% as the battery cycles, or eight times more than cathodes typically used in lithium ion batteries.

As might be expected from this kind of repeated strain, polymer or carbon based supports and binders fragment and can disintegrate as the battery cycles, reducing capacity and performance.

One approach to solving this is to bind the cathodes with different polymers and to reduce there thickness so that the absolute change in dimension is not so extreme.

Many lithium-based batteries also must deal with dendritic growth, thin fingers of metal which grow away from the surface and can eventually reach across to the cathode, creating a short circuit and rapid discharge.

This is the same thermal runaway malfunction which has caused lithium ion battery fires in the past, so research for coping with this effect can be carried over to lithium sulphur technology, including exciting uses of graphene and other nanostructures to act as scaffolds for the deposition of lithium.

Solid state electrolytes could also offer solutions to these issues.

Lithium sulphur batteries are not just ivory tower ideas.

Airbus Defense and Space flew a 350 Wh/kg battery made by Sion Energy back in 2014 powering their Zephyr High Altitude Pseudo Satellite.

Researchers at Monash university in Australia announced in 2020 that they anticipate having a product ready for commercialization in 2-4 years which could provide electric cars with a 621 mile range.

Additionally battery safety improves in vehicle crashes, and becomes more resistant to overheating and short circuiting, in part due to physical blocking of the dendritic growth of lithium and other electrode materials which currently plague lithium batteries.

Apart from its theoretical promise, we can be confident that we will see solid state batteries powering us along the road in the near future because carmakers as diverse as Volkswagen, Toyota, BMW, and Hyundai have all been investing in the technology.

Volkswagen, for example, put $300 million into QuantumScape, a Stanford University spin-off.

QuantumScape has been holding its cards close to its vest as the website offers no information on their product, only a long list of new job openings – implying company expansion and confidence in their product.

It is notable that they hold patents on sulphide-based lithium ion technology and seem to be interested in thin, sintered ceramic films and lithium impregnated garnet.

One of the difficulties in solid state electrolyte design is dealing with the expansion of electrodes which is more difficult to manage in solid materials.

A solid electrolyte must be sufficiently flexible to permit this, yet also tough enough to resist dendrite penetration.

QuantumScape hold a patent for ‘Composite Electrolytes’ to allow them to customize and adjust the physical properties of their electrolytes for such conflicting requirements.

Samsung too are working on solid state batteries, and in May 2020 described their technology based on a silver and carbon anode, claiming this could give a generic electric car a 500 mile range and survive over 1000 charging cycles.

This is probably good news for your phone and laptop too given their current commercial interests.

It may be just a matter of time before solid state electrolytes are in your pocket and in your car.

Two carbon electrodes and a non-toxic electrolyte: what’s not to like? PJPEye, an offshoot of Japan Power Plus have developed this technology with the National Kyushu University in Fukuoka and are currently supplying their ‘Cambr ian’ batteries to an electric bicycle company, Maruishi Cycle.

Currently these are single carbon electrode batteries, and details of their exact makeup are hard to find, but they are simultaneously working on a fully dual carbon battery with two carbon electrodes, eventually to be manufactured from natural, agriculturally grown products. They anticipate achieving a performance similar to graphene based batteries.

Although their Cambrian batteries have a lower specific energy and lower energy density than lithium ion – meaning that their batteries are both heavier and bulkier than their equivalents – they boast higher specific power.

For the same mass of battery as a lithium ion based alternative, it's possible to extract the energy much faster, translating into faster vehicle accelerations.

In addition to this, unlike lithium-ion, these carbon-based batteries can be discharged fully.

The maker claims that this changes the equation for actual usable energy density, boasting a 40% improvement in range over lithium ion batteries of the same capacity.

Moreover, they say that the battery runs cool and does not require the heavy cooling systems of current electric vehicles. Their claim that a proof-of-concept battery degraded only 10% after 8000 cycles is very promising.

They plan to gradually upscale from low volume applications, such as medical devices and satellites, towards mass market aerospace and automotive customers with a battery made from carbonized cotton fibers rather than exotic, toxic metals.

With fast charging and exceptionally low battery degradation over thousands of charging cycles, maybe these will provide long term, sustainable solutions for commercial vehicles in the coming decades.

So much diverse research is underway in battery technology that it is almost impossible just to pick five selections.

Lithium batteries are found in almost any modern battery powered product: cars, computers, cameras and phones.

Quadcopters and drones have come about because of advances in battery technology as well as and uses for these machines are mostly held back by current battery life limitations.

Consumers, technology companies and industry are all clamouring for safer, lighter, more energy dense solutions – and concern is also mounting worldwide at the environmental impact of this growing demand for batteries.

With all of these exciting new battery technologies on the horizon, it's clear the future will be electric.

A great first step to prepare for the coming electric revolution is to learn the fundamentals of electricity and magnetism.

Brilliant does a great job of taking complicated science and breaking it down into bite sized pieces with fun and challenging interactive explorations.

Master concepts, and build a base of knowledge so you can develop your intuition to better understand how the world is changing.

I've taken brilliant courses on electricity & magnetism and solar energy, and was really impressed with how well they structure their lessons with clever analogies, examples, and quizzes to test your knowledge.

It almost makes learning feel like a game and I found myself eager to advance through the course.

Brilliant offers a wide range of other content in topics from mathematical fundamentals to quantitative finance, from scientific thinking to special relativity, from programming with python to machine learning.

Electric Cars vs Gas Cars - Which One is Better?

When you take something that people have as much passion for as the automobile, you're not just looking at a transportation tool to get from point A to point B.

When you step into the drivers seat, your car become an extension of yourself, and in a way, your car is a public expression of your identity.

The industry has experienced countless engineering breakthroughs and created a plethora of undeniable mechanical masterpieces.

From the distinct high pitched growl of a Lamborghini, to the teeth chattering rumble of a hemi v8, these cars are exciting and iconic, Its no wonder there's such a large community of passionate automotive enthusiasts.

When we have meaningful objects with such personal significance as the car, humans tend to retreat to more emotional thinking and logic falls by the wayside.

but facts are facts, and by almost every objective measure, battery electric vehicles are better than internal combustion engine vehicles.

The recent EV revolution has even created some conflict between early adopters of electric car's and traditionalists born with gasoline flowing through their veins.

In the following video we're going to tell you exactly why electric vehicles are better than ICE vehicles.

It's crazy to think that when a 5000 lb Tesla Model S accelerates to 60 MPH in 2.3 seconds, all that horsepower is transmitted through a 1mm "air gap" inside its electric motor with no physical contact.

In combustion powered vehicles, up to 15% of the engine's power can be lost through mechanical inefficiency as it travels through the drivetrain.

Electric automakers are capitalizing on the high efficiency of electric propulsion, and creating a new generation of hypercars with mind bottling acceleration, such as the Rimac Concept Two which claims a 1,914 HP electric Tesla Roadster, with it's comparably grandma slow takeoff to 60 in 1.9 seconds.

It's not just electric supercars that are redefining the driving experience, take for example the sensible Tesla Model 3 that's capable of going for a grocery run, and racing back home with a 0 to 60 of 3.2 seconds.

These are acceleration figures you'd expect to sedan.

A common misconception you'll hear from EV naysayers sounds something like, Hey Buddy, you're charging your electric car with power generated by fossil fuel powered stations, so you're still creating the same amount of pollution, whether it comes out of your tailpipe, or the 500 foot smoke stack of a coal fired powered station.

While coal is still the most dominant energy source globally, the use of cleaner and more renewable sources are rapidly expanding, and charging electric vehicles is is becoming less carbon intensive every year.

In the US, an estimated 43% of new electricity generation came from renewable sources in 2018, and there are many global initiatives to reach a 100% renewable energy transition in the coming decades.

The state of Washington recently enacted a historic clean energy legislation requiring that 100% of the state's electricity come from clean sources by 2045, and in the beautiful nation of Costa Rica, renewable energy has has supplied nearly 100% of the electrical energy output since 2016.

According to the 2019 Impact report from Tesla the average lifecycle emissions from a Tesla Model 3 are less than half those of a equivalent mid sized ICE car, and if you install a solar power system on your home, and charge your EV with that, your carbon footprint can be reduced to almost nothing.

We're not just talking about emissions from driving though, even when taking into consideration the entire EV lifecycle: from raw materials, to production, usage, and disposal electric cars still have a lower environmental impact.

Is that lithium ion batteries are recyclable at the end of their lifecycle, while once fossil fuels are burned their harmful emissions are released into the atmosphere for good.

The novelty of high voltage vehicles seems to make some people forget that the C in I.C.E.

Electric car pros when it comes to safety: they have no bulky engine under the hood.

This means that there's a larger potential crumple zone and in case of a crash the force of the impact will be distributed across the entire structure of the car and away from the occupants.

Besides these lifesaving design elements, electric car manufacturers such as Tesla are pioneering new active safety features, including intelligent autopilot, lane assist functions, proximity sensors and collision avoidance sensors that help mitigate the fallibility of human operation and provide a buffer against driver error.

EV's won't just save your life, they can save your bank account too.

The United states office of energy efficiency and renewable energy has an online tool called eGallon, that compares the cost of fueling a vehicle with electricity, compared to a similar vehicle that runs on gasoline.

The price is calculated using the most recently available state electricity and gas prices, and on average, they find the average cost of the eGallon, is less than half that of regular gasoline.

Now that's just driving costs, but taking into consideration maintenance costs, electric parts and a more efficient design.

Because of this, EV's are immune to the top 10 most common car repairs such as replacing an oxygen sensor, replacing an ignition coil, or replacing a catalytic converter.

As a matter of fact an EV drivetrain has only about 20 moving parts, compared to over 2000 for comparable combustion cars. Many local governments also offer enticing tax credits and incentives for EV buyers that further reduce costs.

So you miss the rumble of your V8? Well I prefer to accelerate in half the time, with double the efficiency, and do it all without waking up my neighbors.

Noise pollution is actually a big deal, even though some people are still sentimental about the loud rumble of a V8, it's better for humanity to have silent transportation.

If you're anything like me and enjoy listening to podcasts and audiobooks on the road, it's a massive benefit to have a quiet cabin that becomes your very own classroom.

Also With the rise of delivery, the pervasive pulse of massive idling diesel trucks has become a common soundtrack in every neighborhood across the world, and it will be great to have these replaced with fleets of silent electric trucks.

As the saying goes: less is more, or less, maintenance that is.

With the simplified and more efficient drivetrains of Electric vehicle's, there are fewer moving parts and components to be replaced or maintained.

An internal combustion engine vehicle requires a crankshaft to convert the reciprocating motion of the pistons into rotational motion, a flywheel to smooth power output, and a ton of other mechanical and electrical components electric cars don't need.

Even the underbody of an electric car is an ode to simplicity, made up of only a few metal plates welded together at the seems, there's not much to be seen when you take a look under an electric car.

Maybe it doesn't spring to mind instantly, but yet another great thing about electric cars is the fact that there's no annual or bi-annual oil change required.

No matter how many miles you put under your electric car's virtual belt, the low oil indicator will never light up on your dashboard.

On top of all this, there are no spark plugs to be replaced and even the disk brakes last longer thanks to regenerative braking that takes a great deal of friction away and instead turns the slowing down of the car into energy.

Yes, modern combustion powered cars are jam packed with sensors, computers and dashboard tablets but electric cars are on top of the mountain of intelligent technology: being constantly improved via over the air updates to make them even smarter and safer.

Tesla is especially known for periodically updating their cars software, utilizing driver data to improve safety, make improvements, and max out the overall experience with clever add-ons like games and easter eggs.

Subjectively, Electric cars are just more civilized.

The world is heading towards a sustainable future, so driving an EV is a good way to show you're on team planet earth, or Team Mars if you'r a big Elon Musk fan.

If you've ever eaten outside at a crowded street café and had a noisy smoky diesel truck pull up to unload deliveries, you know how offensive that is, and for all of the technological advancements our society has made, that experience is just plain uncivilized.

If the fact that electric cars have a bigger brain than conventional vehicles wasn't enough, it appears that they can actually make smarter too.

No, seriously Air pollution exposure has been proven to damage children's cognitive abilities, increase adults' risk.

And if saving your brain, wallet and the planet hasn't yet convinced you that electric cars are better, you have one pedal driving, you can warm your car while it's in the garage without risking carbon monoxide poisoning, you benefit from privileged parking spots, there's free charging available at some public stations, and in California, you can drive your electric car in the restricted high occupancy vehicle lane without a second passenger.

We look forward to the vehicles currently being produced by other electric automakers such as Rivian, Nikola, and traditional manufacturers like BMW, Nissan, Ford and more.

Can't wait to see what they come up in the coming years when internal combustion engine vehicles are obsolete and all cars are electric.

Know Better Solid State Battery

We take a lot of the technology around us today for granted.

Like many computers for phones that last the entire day which was unheard of.

Not too long ago, but what if your phone lasted three to four days on a charge.

Or a laptop that can be pushed to the limits for an entire day without needing to be plugged in at all.

Or an eevee that can go 5 to 600 miles and charge in minutes and cost less than an internal-combustion engine car state batteries for years now.

But where do things stand today and how much start seeing solid state batteries in the technologies that we use every single day.

Excitement around solid state batteries is understandable with companies like Toyota teasing a solid state battery.

Vehicle around the time of the winter olympics.

The buzz continues to grow the lithium-ion batteries that we use today.

As great as they are, have some drawbacks that solid state is trying to solve and to understand those drawbacks.

We need to look at the basic components of a battery there's a positive electrode or cathode.

Which is usually something like a nickel cobalt aluminum formula.

And there's a perforated separator to keep it isolated from the negative side or anode which is usually a compound of a carbon material like graphite.

Finally all of this will be filled with a liquid electrolyte that allows the free flow of ions back and forth between the anode and cathode during charging and discharging.

You can substitute many chemical formulations for the cathode and the anode.

But the liquid or gel electrolytes and most of the batteries that we use today are highly combustible.

This can happen because of manufacturing defects or damage to the cell.

But it's also a problem because of something called dendrites metal can build up in the anode and slowly create stalactite.

Like growths and those can extend and puncture the separator between the anode and the cathode and that's when you get exploding batteries.

So how does a solid-state battery solve that problem.

They replaced the liquid electrolyte with you probably guessed it that's most often a ceramic or glassy electrolyte.

Now these salad electrolytes aren't flammable.

Which means a big improvement with safety but a bigger benefit of solid electrolytes is.

The ability to use other anode materials like lithium metal which has the highest theoretical storage capacity.

In fact lithium metal was used in some of the first lithium-ion battery research in 1979.

However one of the reasons we haven't used lithium metal and batteries up until this point is because they suffer from dendrite growth.

Which is as I mentioned before kind of a bad thing there's been a lot of really interesting research in recent years that may have solutions to that problem though.

Mit researchers have developed something called mixed ionic electronic conductors or miec.

An electron and lithium ion insulators or li now that's a mouthful.

It's a three dimensional honeycomb architecture with nanoscale tubes made from miec and the tubes are infused with lithium metal.

Which forms the anode the fascinating part of this breakthrough.

Is that the honeycomb pattern gives the lithium metal room to expand and contract during charging and discharging.

Giving the battery room to breathe avoids cracking and that li coating the tubes acts as a barrier protecting them from the solid electrolyte.

Now all of this means having a true solid-state battery without the need for any liquid or gel mixed in and no dendrite growth.

A company called ion storage systems has developed a super thin ceramic electrolyte that's about 10 micrometers thick.

Which is about the same thickness as today's plastic separators used in liquid electrolytes.

Now each side of the ceramic electrolyte is covered in a super thin layer of aluminum oxide.

That helps to reduce resistance the company's prototype battery had a specific energy of 300 watt hours per kilogram and is capable of charging in five to ten minutes.

For a point of comparison today's commercial lithium ion batteries can do about 250 watt hours per kilogram.

Ibm and daimler announced a breakthrough cells day battery that used ibm's quantum computing on a battery chemistry that uses no heavy metals such as nickel or cobalt.

And that aren't extracted in damaging ways but unlike other big breakthrough announcements they provide no details that can be explained or corroborate.

All we know is what they've told us and it's very vague like that it can supposedly charge to 80% in five minutes and match the energy density of state-of-the-art lithium batteries.

This skepticism due to the lack of details but one announcement which is the biggest of them all.

It's back to the legendary rock star of the battery technologies himself and nobel prize winner John B Goodenough together with his co-author Maria Elena Braga.

They announced a glass battery at 97 years old John Goodenough is still researching battery chemistry is to replace lithium-ion batteries with something better faster safer and ecologically.

Sound something that would be cheaper than gas.

And would push humanity off the need to use fossil fuels.

Both Maria Braga and John Goodenough think they've unlocked that potential with their discovery.

At some point as you probably guessed from the nickname it's using a glass electrolyte.

They can last for more than 23,000 charge and discharge cycles which is more than a minor improvement over several thousand.

For a typical lithium-ion cell now there's still some debate from battery researchers around good enough and broca's findings but goodness.

Credentials as one of the inventors of the lithium-ion battery add a lot of credibility to the findings.

Now this all leads me to the giant question of win when will we finally see the solid state batteries hit the market.

We've heard of promises of solid state battery breakthroughs for years.

But have yet to see them in a while and that's part of why I selected some of the examples that I did like the ibm example when it comes to news reports and public perception.

There's a disconnect between research and breakthroughs in the lab versus when it becomes commercialized.

In the marketplace there's often the perception that'll be a product within a year or two.

Which is actually something ibm stated in their announcement they partnered with mercedes-benz r&d north america, a japanese chemical company called central glass, and a battery startup called sidess to test the battery.

A direct quote from an interview with oee spectrum said ibm has built prototype pouch battery cells in the lab.

Example, portable power tools within one to two years.

One to two years that's exciting unless you pay attention to the specifics of limited applications like portable power tools.

This isn't something that's going to be an evs anytime soon.

Sadly some companies perpetuate this misperception on purpose to appear as though they're relevant and competitive in the marketplace.

At ces this year mercedes showed off their avatar concept car which is made of environmentally friendly materials and a cutting-edge battery pack.

That's fully recyclable that got a lot of headlines.

But in an interview with mercedes senior manager of battery research he stated that the battery technology is currently in lab testing and about 10 to 15 years away.

I just recently had a video about catl and their prismatic cell 2-pack technology that tesla may be using soon.

Well catl also produce a solid-state battery sample.

But said it wouldn't be commercialized until after 2030.

Now I don't bring all of this up to squash the excitement around the research.

Breakthroughs with solid-state batteries it's important to keep things in context and understand.

That it's incredibly difficult to go from lab to manufacturing at scale cost-effectively.

Remember that it was over a decade between the original lithium-ion battery research and sony producing the first commercially available version.

And even John Goodenough thinks it's going to be five to ten years before solid-state batteries will become commercially successful.

Even Toyota's planned solid state vehicle announcement around the time of the olympics is another good indicator.

Toyota's r&d chief has said "We will produce a car with solid state batteries and unveil it to you in 2020.

But mass production with cells state batteries will be a little later, and by a little later he means mid 2020s at the earliest.

We're a giant middle step of solid state research, which is trying to apply what has been learned in the lab to real-world".

Production in limited situations, John Goodenough is doing that with hydro-quebec.

The university of texas at austin owns the patents to the glass battery.

But is working with hydro-quebec to try to commercialize the technology.

Will know whether a product can be manufactured and how such a product might perform compared to existing lithium-ion battery cells.

We're most likely going to see solid-state battery technology hit the market in small batches in very limited ways.

The difficulty in manufacturing yields and costs will mean it's most likely going to be used at small form factors.

Like consumer electronics think smart phones and smart watches as the processing chemistry's get perfected.

We'll start to see it in larger scale products.

I wouldn't be surprised if John Goodenough prediction is accurate and that we'll see the first batteries in five years or so.

But we're most likely a decade away before it starts to make significant inroads.

Once it does it's gonna change everything again everything.

We know and expect out of consumer electronics health technology and ev's will shift.

We'll be able to charge phones and cars in minutes instead of hours.

I'm really excited to see where solid-state batteries can take us in the future for the time being.

We'll just need to be a little bit patient.

What is Inside a Solid State Battery?

Good old days when mercury was considered medicine wireless electricity to power.

Airplanes was a thing and the first let acid batteries ruled the world.

Which funny enough had an energy density of less than 40 watt hour per liter.

Since its invention in 1859 batteries were never a big hit.

They even tried to use it with electric cars at the time but these batteries weren't powerful enough to do anything with it.

It would take 120 years for batteries to get somewhere.

When during the 1970s and 80s lithium-ion technology was in the works by john goodenough, stainle whittingham, rashida asami, and akira yoshino.

But the early lithium batteries were famous for a few problems.

Ranging from losing capacity with a short period of time to bursting into flames.

Let me put it this way, they weren't as reliable as they are today.

In 1991 later lithium-ion batteries started to be commercialized by sony have this technology.

And at this point in time the energy density increased only a little or from about 40 watt hour per liter to about 190.

30 years later and samsung is close to finalizing its research towards an all solid-state battery.

Which delivers an unprecedented 900 watt per liter and a minimum lifetime of a thousand cycles.

Hold on to your lunches my dear viewers because things are about to get interesting.

Lithium is by far the best candidate for high energy density batteries not only is abundant in nature but in theory.

Its energy density of 6,389 watt hours per liter can surpass that off gasoline.

Just to give you an idea the energy density provided by gasoline is at current about 15.8 times more energy dense than batteries or 9500 watt hour per liter.

Compared to living in lithium-ion batteries ranging from 250 to 600.

Of course if you take into account that gasoline combustion cycle, is less efficient.

Such that for every liter you burn, you get at most 40% of that energy.

And then the difference drops to about 6.3 times but let's go with that.

Assuming efficiency to be around 40%, side by side we can easily see why interest in batteries increased so much that if we could reach the full potential of lithium-ion batteries.

The range per charge for model 3 for instance would be multiplied by almost 10 or from 518 kilometers to 5,000 kilometers in one charge.

What it also means is that instead of having 6 to 8,000 batteries.

We could have cars with only 1 to 2,000 batteries with a range of a thousand kilometers.

If not more not only that, but decreasing the number of batteries makes it safer, charge is faster, and is more environmentally friendly.

But that is only possible with solid-state batteries.

And we all know that there are mainly two problems with them.

The first one is dendrites which causes volume expansion ultimately.

Causing the battery to fail or even burst.

Then samsung came with have the local ohmic efficiency, which causes the battery to degrade faster, having a lower life cycle, and let's not even enter the discussion of how complicated it is to work with lithium.

Represents a 50% improvement in terms of energy density, while more than 200% of battery life cycle.

How they achieved this, is fascinating.

Samsung research for an all solid-state battery, their goal was to eliminate dendrites formation and increase columbic efficiency.

To do that they send which layers of lithium nickel cobalt aluminium oxide mixed with a sulfide solid electrolyte on top of a nano composite layer of silver carbon.

All of this is located in between a foil of aluminum and stainless steel as the current collectors.

The idea behind this nmc or the ss this approach diminishes the cost of the overall battery manufacturing.

Since handling lithium usually needs an oxygen-free environment due to its higher reactivity.

This is important for a few reasons in conventional lithium batteries, the anode comprised of lithium moves freely.

Towards the positive electrode during discharge dendrites are formed during the charging process.

This is the main limiting factor of how much energy can be stored in these batteries.

Since to control this, the amount of lithium available in the system has to be kept limiting.

The energy density the sulfide solid electrolyte approach.

Leave him back and forth with a little help from silver in a uniform manner.

Allowing the atom to be deposited in flat layers with little to no chance of dendrites forming nice right.

But samsung took this idea a step further most solid-state battery technologies proposed to date have some sort of nano matrix layer compound like silica for instance.

That is used to absorb lithium ions by removing this layer and having only silver atoms.

Playing the part of the matrix to guide the ions, you can effectively introduce more cathode into the mix.

Increasing the overall energy density of the battery or 900 watt hours per liter.

This approach also increases battery lifetime efficiency by 200%.

In this scenario all lithium in this system is allocated within the nmc molecules.

Comprising the cathode of the system here, there is no anode and the stingless still.

Sheet works as the current collector to drive the reaction.

So the battery is initially in a discharged state.

When the battery is being charged, lithium ions pass through the carbon layer attaching themselves to silver atoms.

This in turn, promotes a better connection of the lithium layer onto the stainless steel current collector.

What you get in the end is a clean sheet of lithium silver free of dendrites.

This cycle can be repeated more than a thousand times flawlessly.

Samsung solved many problems here but one of them stands out and that is the construction of the battery.

By having only the nmc cathode embedded into a solid electrolyte and separated by the nano layer of silver carbon.

It eliminates the need for oxygen free environment.

Necessary for the construction of the battery, ultimately reducing cost.

Although this is a huge gain the impact on price for these new batteries.

Is yet to be seen but we know for sure that at least 35% of the final cost is due to manufacturing overhead.

Which includes energy costs research and development production sales.

And so on then we have the remaining costs attributed to materials alone.

Cobalt and nico are to blame since prices are increasing due to the high demand for these elements.

Why most companies are trying to move away from these elements?.

But it's safe to assume the samsung may have used nmc here just to test the concept and acquire real-world numbers.

From this first prototype at this point is still unclear where samsung intends to use these batteries.

But one thing is for sure they still need more research and development.

So they can get rid of the nickel and cobalt.

If they achieve this then they will have the triple crown breakthrough cheap elements high energy density and a long life time cycle.

That is when we'll finally have a dramatic drop in battery prices.

Overall this is a huge step forward for solid-state batteries and we can safely say that we are closer and closer to an electric future.

Does a Graphene Battery Really Exist?

Graphene was discovered in 2004, most of you have probably heard the story but for any of you that haven't it's worth sharing.

At the time scientists knew that the one atom thick two-dimensional crystal graphene existed.

But no one had worked out how to extract it from graphite two scientists andre gaia and konstantin novoselov would hold friday night experiments.

Where they would test new science not linked to their day jobs one friday.

They removed some flakes from a lump of bulk graphite while polishing it with scotch tape.

They noticed some flakes were thinner than others and so they continued to separate the graphite fragments repeatedly.

Which is how they ended up creating flakes that were just one atom thick.

They then dissolved the tape away resulting in graphene being isolated for the very first time.

Constantine and andre went on to win the 2010 nobel physics prize for their discovery.

As scientists have theorized about graphene for decades, and yes had any of us playfully put tape on our graphite pencils in elementary school we could have discovered graphene.

Graphene is an allotrope in the form of a single layer of atoms one atom thick arranged in a 2-dimensional hexagonal lattice.

An allotrope is just a structural modification of an element with the atoms bonded together differently.

In this case the arrangement of atoms was modified from three dimensions to two.

Graphene is composed of carbon atoms in which each atom forms of vertex just a single layer of atoms is perfectly visible to the naked eye.

It has a unique property of expanding when cooled and shrinking.

When warm graphene is literally one of the most mind-boggling discoveries known to man.

It is the thinnest material ever discovered while also being the strongest material ever tested.

And it can stretch up to 25% of its length it's 200 times stronger than steel and 40 times stronger than diamonds.

While being one atom thick it's bulletproof when folded to two atoms.

It's the most efficient conductor known to man it could hold energy densities six times higher than copper.

It has the best thermal conductivity and is the most imperiled ever discovered.

While being bendable and very flexible, it's lightweight and can be added to almost any cell without affecting the cell attributes.

This means we may see a world with graphene enhanced batteries.

First I've simply adding one layer could result in significant performance enhancements.

Graphene could cover both the cathode and the anode resulting in charge times five times faster than currently.

Possible graphene suppresses damaging reactions from continuous charging.

Normal batteries would degrade quickly at these quick charging speeds as lithium doesn't like a lot of energy in or out.

Clearly the hype around graphene is warranted, it has truly mind-blowing potential in the battery world.

Even more use cases in a shocking number of other industries it's quite possibly the most amazing material known to man.

All this being said it's been joked about the graphene can do everything.

But leave the lab so where are we today, there are many companies falsely advertising graphine products.

They're actually using graphite the 3d cousin without the main benefits of graphene.

However there are true graphene enhanced products on the market.

Before mentioning them that should be noted that the industry is very convoluted with marketing fluff and hyperbole.

As there are literally billions of dollars at stake for the first companies to commercialize this incredible material.

Graphene can revolutionize a shocking number of industries rust-free ships and cars, computers, phones, and foldable screens, aircrafts, aviation, sporting equipment like tennis racquets and skis night-vision, contacts, clean, drinking water, and many more currently you can check at website https://www.jbbatterychina.com .

Graphene enhanced wireless headphones applied graphene materials supplied graphene for use in fishing rods and colmar.

A high-end sportswear company sells ski jackets with graphene to enable the body and the environment ensuring ideal temperatures.

This only scratches the surface of graphene enhanced products.

But let's get back to the battery world and tusla there are a handful of startup companies.

Claiming to have created power banks enhanced with graphene apollo traveler.

Real graphene charge asap and ultron to name a few one of the main issues that has held.

Graphene products back then has been very high costs since one sheet of graphene one millimetre thick or 1/32 of an inch.

Requires three million layers of atoms graphene has been cost prohibitive to produce in large amounts.

In 2013 it was reported that one micrometer of graphene which is 1,000 times smaller than 1 millimeter cost a thousand dollars making graphene one of the most expensive materials on earth.

Scientists have been on a frantic search for the holy grail of a scalable production process ever since and they've made significant strides.

It's been reported that in the last three years the cost of graphene is down to 10 cents per gram in some cases.

So now the billion dollar question what does this mean for Tesla.

For starters we need to talk about the indiegogo campaign hosted by charge asap.

That is raising money for their power bank called flash, it makes them bold and super exciting claims.

But the most interesting and controversial is that this power bank is powered by Tesla graphene batteries.

They claim to be using four of the 2170 Tesla lithium polymer graphene composite battery cells.

Which have been specially designed in partnership with panasonic who has been making the cells.

Which they claim are the highest energy density batteries in the world.

But here's a potential glaring red flag among others.

Not only is this an incredibly generic statement, but we have not heard anything from Tesla about a 2170 graphene composite cell already being used in their cars.

Speaking of red flags the company charged asap is reportedly headquartered in los angeles.

But when you go to their indiegogo business page it says they are in sydney australia.

They set a fixed goal of $5,000 which is wildly small for a technology like this.

If it were real and they have apparently raised $663,000 for a project that's only in the prototype stage.

There were numerous errors throughout the sales funnel paired with vague wording which can often scream scam alert.

The question needs to be asked would we really see a seismic shift in battery tech from an indiegogo crowdfunding campaign.

With no mention of this from Tesla or panasonic.

If you're not familiar with indiegogo this could just as easily be a front for a money laundering scheme.

However they have delivered on five of their seven total crowdfunding projects.

What value you choose to give that I'll leave up to you.

Of course I would love nothing more than for Tesla and panasonic to be working together.

To be producing and testing graphene composite batteries.

While I can't argue that it's likely, that this is what they're doing.

It's certainly possible you never know who knows who at these companies.

And it would in theory be a good way for Tesla to dabble with graphene in the real world.

Begin testing the reliability performance enhancements and cost efficiencies that could be available before then implementing on a larger scale in their ev's cells.

I wish there was a stronger link between Tesla and graphene technologies to report.

But there is zero percent chance that Tesla has not been experimenting and paying attention to the graphene advancements.

It's been the wonder material of the 21st century and Tesla being the world leader in evey battery tech and production.

Will be ready and waiting in the wings, if and when graphene is ready to be mass-produced.

Implemented in evey batteries in a cost-effective fashion.

If Elon does not mention graphene in april that battery investor day.

We need to get a shareholder to ask him directly about Tesla's plans and thoughts on graphene.

Closing Statement

Breakthroughs that would allow our spec table smartphones to last for days, our cars to drive 500 miles in a charge, and our houses to store enough energy.

Derived from solar panels or other sources to last days on end without resorting to the grid.

The closest to maturity cheapest and easiest to achieve of the next gen battery technologies it offers current lithium-ion batteries and requires.

Cheaper production materials rapid deterioration was a problem but researchers have now achieved more than 2000 - charge cycles.

With degradation on par with the best - lithium-ion units probably the biggest advantage of lithium sulfur.

However is that, it can practice superior density into a much smaller and lighter battery pack which bodes well.

For our ever thinning smartphones moreover it is also more durable than the lithium ion models.

Using microscopic for silicon spheres, for the anil usc, researchers managed to achieve fast and release on the chip the result three times more storage.

Than the conventional battery in your smartphone and 10 minute charging times once the charge discharge cycles numbers.

Increased the technology will be good to go into batteries.

Gives way to magnesium we can expect eight to 12 times higher energy density than a lithium battery and five times higher charge discharge efficiency.

This is because the magnesium ions in the electrolyte carry a double positive charge elevating the overall energy density amount.

There's two obstacles to be overcome but plenty of research is heading in that direction.

With pretty encouraging results already enough with the swanky battery material breakthroughs.

How about the good old oxygen we breathe ibm in collaboration with researchers government labs and industry leaders.

Who's working on project 500 a lithium air battery undertaking that is supposed to give electric cars.

As much range as a typical gas tank and since lithium air batteries are suitable for any application.

Where weight is important, phones are a perfect candidate this one is too far out in the future.

But recent developments have made it viable again besides increasing energy density and decreasing charging times.

New materials can also optimized mobile batteries form to feeling everywhere while looking on the inside of our ever thinning smartphones with juicing capacity both.