
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.

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