**All around the world from China to Europe and across to the United States, governments and commercial enterprises are all starting to get a bit giddy and excited about the prospect of electric vehicles displacing internal combustion engines in the coming years. The UK prime minister Boris Johnson announced last month that he’s banning the sale of the fossil fuel burners by 2030. Tesla’s opening giga factories all over the place, and all the major existing car manufacturers are emailing all their staff to find out if anyone knows anything about batteries. That last one might be a slight exaggeration, but it IS fair to say that it IS batteries that represent the biggest challenge to the green transport revolution. After all the rest of the car… is a car isn’t it. We’ve been building those for a hundred years.**

**Elon Musk’s company is a long way ahead of the game of course, having been focussed one hundred percent on electric vehicle development for well over a decade now. His latest battery day event revealed some pretty nifty advances including tab-less battery construction to speed up production, pure silicon anodes and greatly reduced quantities of cobalt. And he’s talking about fitting the batteries more tightly around the car’s body too, so that it can provide extra structural support.**

**Whichever way you look at it though, a whole bunch of heavy battery packs attached to your vehicle represents a very large proportion of the overall weight and a significant drain on energy efficiency. Batteries in a typical EV can account for as much as a third of the total mass of the vehicle. By stark contrast, the fuel in an internal combustion engine car only makes up about three percent of the mass.**

**But what if you didn’t need to bolt the batteries to any part of the bodywork at all? What if the bodywork itself provided all the energy the car needed?**

**Well that’s exactly what’s happening in the rapidly developing world of Structural Batteries**

**Hello and welcome to Just Have a Think**

**We all know how commonplace lithium ion batteries are nowadays, not just in electric vehicles, but in pretty much all electronic devices from your phone to your laptop, to power tools and kids toys.**

**Last week the folks over at Wired Magazine published a fascinating article highlighting a new renaissance in structural battery research that could pave the way for effectively weightless and invisible batteries powering everything around us.**

**The WIRED article interviewed Emile Greenhalgh, a materials scientist at Imperial College London. He and his team have been developing this technology for several years. Back in 2010 they collaborated with a materials scientist called Leif Asp, at the Chalmers University of Technology in Sweden, along with a team of European scientists, on an EU funded project called** [**Storage**](https://cordis.europa.eu/project/id/234236)**, that worked with Volvo to make structural batteries into some of the body parts of one of their hybrid prototypes to provide some secondary power for the air conditioning, sound system and lights.**

**Today’s rapid advances in composite materials, battery science and microscopic precision engineering mean that we’re now a whole lot closer to a world where structural batteries may provide all of the power for a vehicle or device, which would represent a really significant step change in size, weight and energy efficiency.**

**It’s not been an easy ride though. Convincing a battery to keep working when it’s been bent and stretched into all sorts of weird and wonderful shapes is a very difficult thing to do. We looked at how conventional lithium ion batteries work in a recent video. Essentially, you’ve got a cathode and anode, some sort of electrolyte and a separator to prevent short circuiting. They come in all sorts of shapes and sizes including pouches like these, and they can even be rolled up into a cylinder, which is what Tesla use for their vehicles. But all these designs share a common feature, which is that the anode and the cathode are precisely aligned so that electrons can flow between them. If you lose that alignment, you lose your circuit.**

**Jie Xiao, the chief scientist and manager of the Batteries & Materials System group at Pacific Northwest National Laboratory, explained the problem to the Wired team. She said**

**“From a design point of view, it’s very important that your positive and negative electrodes face each other, so even if we can take advantage of void spaces, if those electrodes are unaligned they are not participating in the chemical reaction. This limits the designs of irregular-shaped structural batteries.”**

**So how have the Imperial team got round that little wrinkle.**

**Well they started with good old carbon fibre, which is very light and extremely strong and already widely used for all sorts of applications including body panels in aircraft and high performance cars. It also has the distinct advantage of being very good at storing lithium ions, which means it’s a great candidate to replace the graphite anode in a lithium ion battery. But Greenhalgh and Asp needed the structural strength of carbon fibre across the whole area of the battery, which meant it needed to do the work of the cathode as well. To achieve that they infused the carbon fibre with iron phosphate, which is good and reactive, and also strong. They used a thin sheet of woven glass as a separator and then encased the whole thing in a conductive polymer resin which acts as a binder to keep everything aligned while also transferring load from one layer to another to give it that all important structural integrity, and of course keep the circuit flowing even when the panel is cut and shaped.**

**The result is a very strong and very thin sheet material that can moulded to any required panel shape.**

**That technology has been put to use in a more recent EU horizons project called** [**Sorcerer**](https://www.sorcerer.eu/index.html) **which developed structural lithium-ion batteries that could be used to build parts of an aircraft’s fuselage or wings. The relentless research and development that’s taken place during the decade since the original Storage project has resulted in vast improvements in the mechanical properties and energy density of the latest version of the battery material.**

**Asp told Wired Magazine**

**“Now we can make materials that have at least 20 to 30 percent of both energy storage capacity and the mechanical capacity of the systems we want to replace. It’s a huge progression”**

**And they’re not the only ones looking at structural batteries as a solution to electric flight.**

**MIT’s AeroAstro department have also been developing their own structural battery solution. This 2018 presentation by Kieran Strobel outlined the challenges that need to be overcome. Batteries present the same problem in planes as they do in cars – which is to say they are very heavy. That’s annoying if you’re in a car but it’s even more problematic if you want to actually get your vehicle off the ground. This is a Kitty Hawk CORA electric plane which has been designed as an air taxi of the not too distant future. It’s batteries represent 17% of the overall weight.**

**This chart shows where batteries currently sit in terms of Specific Energy, which is a measure of how much energy a battery contains relative to its weight.**

**You can see they’ve come quite a long way since 2010. The kittyhawks batteries can now deliver two hundred and twenty watt hours per kilogram. That does get it airborne but not for long. It’s generally reckoned that those batteries would need to pump out more like four hundred watt hours per kilo to make an air taxi service like this commercially viable. MITs approach is to flip that equation on its head. Rather than striving to increase battery energy to that new level, their goal is to bring that threshold back down to where it is today by making their structural batteries become components of the planes body. That brings the four hundred watt hours requirement right back down to about two hundred and ten watt hours, which is well within current capability. We won’t be flying across the Atlantic in one of these things anytime soon, but for urban hops and short haul flights they do look like a very promising solution.**

**The MIT team reckon there’s huge potential at the other end of the scale too with electronic devices like mobile phones, which today are basically a big battery surrounded by some tiny components. They’re making the phone HOUSING into a structural battery, and that reduces the thickness of an iPhone from just over seven millimetres today to just under 5 millimetres. And if it wasn’t for the onboard camera, the device could be even thinner.**

**Back at the Pacific Northwest National Laboratory, Jie Xiao and her team are also focussing on structural batteries for microelectronics, specifically for medical implants. Xiao told Wired that while conventional batteries can already be shrunk to the size of a grain of rice, that’s still very bulky in in really tiny devices. But a STRUCTURAL battery doesn’t take up any more space than the device itself.**

**Xiao and her team have worked on several niche scientific applications for micro structural batteries, like injectable tracking tags for salmon and bats. In the future they’re aiming for products like** [**electronic skin**](https://www.wired.com/2015/10/electronic-skin-will-change-the-way-we-interact-with-tech/) **for prosthetics which will be able to sense temperature, pressure and sound, just a like normal human skin.**

**That sort of thing is not too far away from the robotics industry, and sure enough, structural batteries are being looked at there too. A team at Michigan University led by chemical engineer Nicholas Kotov have created a zinc-air structural battery for their research machines. They don’t use carbon fibre like the Imperial College team. Instead they have a zinc anode, a manganese oxide coated carbon cloth cathode, and a semi-rigid electrolyte made from polymer-based nanofibers that they’ve engineered to behave like cartilage. That electrolyte also has the benefit of preventing dendrite growth from the zinc anode, which could otherwise cause a catastrophic short circuit in the battery. The energy is carried by hydroxide ions produced when oxygen in the air interacts with the zinc.**

**The team’s goal is to create machines with power sources that can integrate with their robotic skeletons, just like the fat and muscle in ANIMALS, and they’ve already got working examples of robotic scorpions, spiders, ants and caterpillars in their lab test area.**

**Kotov and his team published their** [**paper**](https://robotics.sciencemag.org/content/5/45/eaba1912) **earlier in 2020, showing that their structural batteries effectively have seventy two times the energy capacity of a conventional lithium-ion cell of the same volume. Their plan is to develop the technology for use in midsize robots and large hobby drones.**

**There’s still some way to go before these things become commonplace, but the proof of concept is definitely there in several research spaces. One of the best ways to save energy and reduce greenhouse gas emissions is to simply not use the energy in the first place, and these new structural batteries could play a major role in achieving that goal.**

**Leave your thoughts in the description box below, but that’s it for this week.**

**Just a quick note from my friends at Bubblr before I go – they tell me they’ve made some improvement sot the Just Have a Think app navigation buttons that should make it even easier for you to find new tabs. If you’ve already got the app, check that updates are set to automatic, and if you haven’t yet got the app, then you can download it from the pp store or Google play**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week**