**If you’re a regular watcher of vaguely scientific based YouTube channels like this one, then you’ll probably know only too well that we’re living in a rapidly changing world where some bright spark somewhere on the planet is coming up with a technology or device that gets hailed as a gamechanger, or revolutionary breakthrough. Most of don’t end up changing ANY games or starting any revolutions, but every now and then science hits the jackpot and the world takes another technological leap forward.**

**Way back in 1959 the American physicist Richard Feynman gave a talk in which he described his vision for one these winners. It was a process that would allow scientists to manipulate and control individual atoms and molecules. That might not sound earth shattering to our 21st century ears, but it was pure science fiction back then. Feynman’s dream became a reality in the eighties though with the advent of something called the scanning tunnelling microscope, for which it’s inventors, Gerd Binnig and Heinrich Rohrer receive the Nobel Prize for Physics in 1986. That invention allowed scientists to do precisely what Feynman had envisaged more than two decades earlier, and the world got a fancy new word to place in the dictionary…nanotechnology.**

**Since then, nanotechnology has genuinely revolutionised almost every aspect of our modern day lives, from pharmaceutical products, to construction materials and industrial processes, through to fuel efficiency and even the clothes we wear.**

**And now nanotechnology has reached the world of electric vehicle batteries. And needless to say, it’s “gonna be a gamechanger”!!**

**So, I thought it was about time I had a think about how it all works and why it’s so transformational.**

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

**So, we know that nanotechnology is to do with atomic and molecular scale stuff. Which means we’re talking small right? I mean really small. A nanometre is a billionth of a metre. A human hair is about a hundred thousand nanometres wide, so the ability to manipulate stuff at nano scale is pretty spectacularly smart science.**

**And it turns out when you get down to that kind of microscopic level, weird stuff happens. Atoms start reflecting light differently for example, so gold can become purple and silver can become yellow.**

**Perhaps more significantly, getting down to nanometre scale allows scientists to vastly increase the surface area of a material, which means more atoms can interact with atoms of other materials, and then all sorts of benefits start kicking in. You get materials that are stronger, more durable and even more electrically conductive as a result.**

**According to the US National Nanotechnology Initiative,**

**"Nanotechnology is not simply working at ever smaller dimensions. Rather, working at the nanoscale enables scientists to utilize the unique physical, chemical, mechanical, and optical properties of materials that naturally occur at that scale."**

**The potential of nanotechnology certainly hasn’t escaped the attention of the auto industry, and in particular the rapidly developing electric vehicle sector which has spent years and years looking for ways to reduce weight and improve the performance of vehicle batteries.**

**Much has been promised by so many, but as is so often the case these days, it is a Chinese company that is the first to launch an actual vehicle onto the actual market that actually contains nanotechnology in its actual battery.**

**They’re called GAC Group and at the back end of 2022 they will launch the latest version of their Aion V crossover SUV, featuring lithium-ion batteries enhanced with graphene, which is a nanomaterial that China is particularly obsessed with right now.**

**Specifically, GAC’s technology uses graphene instead of graphite as the anode material. Graphite is the usual choice for anode material because it easily transfers collected electrons into the metal wires of an electrical circuit. But graphite has its limitations. It takes six carbon atoms in graphite to hold on to a single lithium ion. That relative weakness limits how much lithium the electrode can hold onto, which in turn dictates how much potential energy the battery can store.**

**Studies over many years have shown that, unlike a lump of graphite, a graphene nanosheet can absorb lithium ions on both faces of the sheet, and along its edges and even in any defect sites. That gives it a theoretical capacity of seven hundred and forty-four milliamp hours per gram, compared with only three hundred and seventy-two milliamp hours per gram for graphite. That’s twice the capacity, which is really very significant indeed.**

**The main limiting factor until recently has been cost. At several hundred dollars per gram, graphene is a premium product and until we find a way to mass produce it in an economical way, it’ll probably be limited in its real-world applications.**

**But GAC Group have come up with a technology called 3DG or three-dimensional graphene, which they reckon reduces the graphene cost in their lithium-ion battery anode by a factor of ten, which brings graphene firmly into the realms of feasible production budgets.**

**GAC says its graphene-based battery has a 6C fast charge capability. In other words, the GAC battery is capable of receiving six times its total capacity in an hour, which is significantly higher than any existing EV on the market today.**

**Charge and discharge rates in batteries are often expressed using this C-rate figure. The higher the number the greater the charge the battery can accept for its given capacity. The downside with very high C rates is that they tend to generate high temperatures which can quickly degrade the materials inside the battery. And that’s really one of the main limitations holding back the development of super-fast charging for EVs. Graphene is much better at accepting those higher charges without degradation though, and although GAC haven’t provided specific technical details of how their 3DG tech works, it’s quite likely that it’s this property of graphene that has allowed them to achieve such high charge rates.**

**The result is the new Aion V can be recharged from zero to eighty percent in just 8 minutes. That’s getting much closer to the time it takes to fill up an internal combustion engine car with a tank of fuel.**

**GAC aren’t the only ones to have embraced a nanotechnology solution for their battery tech though. Mercedes Benz recently announced a joint partnership with the US company Sila Nanotechnologies to develop a battery for their G-Class SUV that replaces the graphite in the anode with silicon nanoparticles.**

**The principle is not dissimilar to the graphene that GAC have used. A silicon atom can bind to four lithium ions, which in principle means a silicon-based anode could store ten times as much energy as a graphite anode. Silicon is a very cheap and very abundant material, so there’s a big commercial advantage their over graphene. The trouble is, as the battery charges up, all those lovely lithium ions rush into to bind with the silicon and the anode swells up by as much as three hundred percent. And then it shrinks back down again as the battery discharges. That’s an awful lot of movement fatigue and it means most developmental silicon anodes quickly fracture and break down, making the battery useless.**

**But once again the weirdness of nanomaterials has come to the rescue. They have a much higher percentage of their atoms at the surface relative to the number of atoms in their interior, and because those surface atoms have fewer atomic neighbours locking them in place, they can move much more easily to respond to the stresses and strains of expansion and contraction. It’s a bit like why aluminium foil can be bent and scrunched up very easily compared to a thick lump of the same material.**

**Sila Nanotechnologies silicon anode technology is, they tell us, the result of more than ten years of chemical research, and more than fifty-five thousand iterations. The result of which is a battery with an energy density of more than eight-hundred watt hours per litre.**

**Now, I don’t know about you, but I’m more used to reading about battery energy in terms of watt hours per kilogram, so I had a quick look at Battery University online, and it explains that specific energy, or gravimetric energy density, defines battery capacity in weight, which is indeed watt hours per kilogram, but energy density, or volumetric energy density, reflects volume in litres. Whichever metric you chose to focus on though, the important thing is the relative performance between different battery chemistries. Silas website provides a development chart showing the limit of today’s lithium-ion batteries and how their technology will vastly improve that in the coming years.**

**So, Mercedes Benz are aiming to launch their new G-class range with as much as forty percent higher battery energy density as soon as twenty-twenty four, and I reckon we can expect to see a whole raft of other major automakers following suit very quickly.**

**And as an added bonus, Sila reckon the batteries will be manufactured using one hundred percent renewable energy at their brand-new Washington State facility.**

**I think it’s fair to say we’re still very much in the Wild West territory of the electric vehicle development cycle. New chemistries and concepts are popping up all the time, all claiming to be revolutionary gamechangers of course! Will you be charging your EV in under five minutes in ten years-time, or simply topping it up as you drive via inductive charging plates under the road surface. Or perhaps you’ll simply drive into a kiosk when your battery is dead and wait while a robot swaps it out for a fully charged one. Maybe we’ll end up filling our cars with hydrogen instead. And perhaps we won’t even own our own vehicle in the coming decades and instead we’ll simply tap on an app and wait two minutes for an autonomous vehicle to arrive and take us to our destination. All of these technologies already exist. It’s just a matter of which one gains market supremacy the fastest. For someone like me who is now well into middle age, it feels like the world has changed beyond recognition since I learnt to drive in a crappy Nissan Micra more than three decades ago, but based on what’s going on in the tech world right now, hold on to your hats folks, because you ain’t seen nothing yet!!**

**No doubt you’ve got views about these rapidly developing technologies. If you do, or if you work in the industry and you can share some insights with us, then why not jump down to the comments section below and leave your thoughts there.**

**That’s it for this week though.**

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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**