**Back in nineteen ninety-one, Sony introduced us all to the first commercial lithium-ion battery when they used it to provide power for one of their new-fangled camcorders. The technology caught on rather well, as I’m sure you know, and nowadays lithium-ion batteries are in just about every conceivable electronic device, from calculators to electric vehicles, and they’ve even carved out a niche in very large grid scale energy storage.**

**But according to most industry commentators, lithium-ion batteries are not the final answer to the energy storage question. Next generation batteries will need to find a way of improving energy density, reduce charging time and lengthen battery life, while also eliminating the slightly inconvenient potential hazard of spontaneous combustion that existing lithium-ion batteries can suffer from.**

**The answer to that conundrum, according to most industry experts, will be solid state batteries. But it’s a technology that’s not generally expected to come to market until the latter part of this decade at the earliest.**

**At least that was the accepted wisdom until recently.**

**Now though, a large and very well-established Japanese battery and supercapacitor maker called Murata has announced it will begin mass producing a market-ready, all-solid-state battery by the Autumn of 2021.**

**So, have they really stolen a march on the competition, or will this be yet another empty battery promise?**

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

**There’s an awful lot of industry and media excitement around solid state batteries at the moment. Well, to be more accurate there’s been an awful lot of industry and media excitement around solid state batteries for about the last decade or so.**

**But it seems that every time a major manufacturer announces they’re on the cusp of a breakthrough, with promises of real-world production runs within months, their optimism turns out to have been unfounded and their plans for solid state technology are quietly put on a back burner. It happened with Fisker, who originally promised a supercar powered by a solid state battery by twenty twenty, then said it would be delayed until twenty twenty-two, and have now dropped the idea completely. It happened with Dyson, who bought a Michigan based solid state battery company called Satki 3 in twenty fifteen and spent billions developing its own electric vehicle before canning the project altogether, writing off all that investment capital and parting ways with Satki3’s founder, Marie Sastry, in twenty seventeen. The list of companies vying to be the first to market with a workable solid-state battery is lengthy, but none of them look like getting anything into real world production until twenty-twenty five at the very earliest.**

**Why is that? Well, it turns out that solid state batteries are proving to be devilishly difficult things to develop.**

**The basic principle seems straightforward enough, and looks very attractive when compared directly to a traditional lithium-ion battery.**

**Lithium-ion technology makes use of an electrochemical reaction. Inside each battery there are two electrodes, a negatively charged anode, typically made of graphite, and a positively charged cathode made of some combination of lithium and other elements. The two electrodes are separated by a liquid electrolyte solution with a semi permeable membrane in the centre acting as a separator between negative and positive. As the battery charges up, electrons flow from the cathode, out across the external power source and back to the anode. That causes the cathode to release its lithium ions which move to the anode by flowing across the electrolyte and passing through the semi permeable membrane.**

**When a fully charged lithium-ion battery is connected up to a device, electrons flow out from the anode, through the connected device and back to the cathode, causing the lithium ions to flow back across the electrolyte. Once all the ions have made that journey, electrons stop flowing and the battery is flat.**

**Lithium-ion batteries are an attractive option because lithium is the most electropositive element, which means it very easily gives up its negative electrons to produce positive ions. Lithium is also the lightest of all the metals, so lithium-ion batteries are much lighter than lead acid batteries and have a much higher energy density. Those are extremely useful qualities, whether you’re making a mobile phone or an electric vehicle.**

**But the useful reactivity of lithium also has its downside. No doubt you’ve heard of the dreaded dendrite issue for example. Over time deposits of lithium ions can build up on the face of the anode forming spikes that can eventually puncture the separator. If they manage to get all the way across to the cathode then you get a short circuit – an instant discharge of a very reactive material into a volatile and highly flammable liquid electrolyte – which is something you definitely don’t want! The result could be a nasty swollen battery pouch that has to be replaced, or if you’re really unlucky, you could find you’ve got a small incendiary device going off in your trouser pocket.**

**Solid state batteries remove that problem by using a solid electrolyte instead of liquid, hence the name. That makes the whole battery much safer. It also makes it much more compact, with a much higher energy density, perhaps as much as three times that of a standard lithium-ion battery. Solid-state batteries can work at very high rates of power as well. Research suggests that they may be capable of recharging up to six times faster than current technologies and achieve far more charging cycles during their useful working life – something that electric vehicle makers are particularly interested in for obvious reasons.  And because they don’t have that volatile and highly flammable liquid electrolyte, they no longer need the cumbersome battery management systems that add weight and cost to existing lithium-ion batteries.**

**They’ve actually been in existence for longer than you might think. They first got used in pacemakers for heart patients way back in the nineteen seventies. A sheet of Lithium metal is placed in direct contact with solid iodine. That effectively causes a short circuit and forms a new layer of lithium iodide between them. Once that layer has formed, a tiny, but constant, current can still flow from the lithium anode to the iodine cathode for several years, making it ideal to keep a dodgy ticker beating reliably.**

**In twenty eleven, Toyota made a breakthrough with a solid sulphide-based material that had the same ionic conductivity as a liquid electrolyte, and ever since then the race has been on to perfect the technology. It’s proving to be a technically very difficult challenge though. Studies on sulphides for electric vehicle batteries have suggested that if the battery packs were breached and the sulphide escaped, it might produce a very unhealthy gas when exposed to air. Getting them wet is apparently another problem too, as one Toyota engineer recently pointed out**

 **"Materials for all-solid-state batteries don't go well with water," he said. "It is difficult to maintain a dry state in a plant and other facilities."**

**Murata’s battery doesn’t use sulphides in its chemistry, and it’s not aimed at the electric vehicle market. Instead, it’ll sit in the space somewhere between the tiny devices like pacemakers and mobile devices like smartphones. That space is currently occupied by wearable technology like earphones and other ‘Internet of Things’, or IoT devices that are rapidly being developed.**

**In 2017 the company acquired Sony’s battery division, and since then they’ve managed to combine Sony’s sophisticated lithium-ion battery technology with laminating techniques that they’d already developed to make their own multi-layered ceramic capacitors.**

**The result is a battery with a non-combustible and highly heat resistant solid oxide ceramic electrolyte which Murata claim has a substantially larger capacity than any previously developed technology.**

**The Japanese firm will establish a production line for the batteries at its Yasu Division, in Shiga Prefecture and commence production in the Autumn of 2021, starting with relatively small batches and eventually building to a capacity of a hundred thousand batteries a month.**

**This is a pretty bold move for Murata. They’re sinking a huge amount of upfront capital into the project, and will almost certainly make no profit on the product for some time, but they see it as an essential step forward to try and stay ahead of the pack in what is rapidly becoming an extremely competitive playing field with huge industry players in China, South Korea, the United States and Europe all desperately trying to gain market supremacy.**

**The real holy grail though, the tantalisingly elusive megabucks goal that keeps all major R&D departments furiously working away all over the world, is of course a truly affordable, mass produced solid state battery for electric vehicles. If such a thing ever comes to market, it’ll be so disruptive to the auto industry that it’ll most likely accelerate the demise of internal combustion engines and really kick start the revolution of fossil free global transport. It’s not difficult to see why it’s such an enticing prize, but putting the corporate head above a well targeted public parapet has so far proven to be a dangerous and costly gamble, and not just for Fiskar and Dyson either.**

**The US battery maker QuantumScape has also fallen foul of its own ambition. The company has been widely touted as the most likely contender in the pioneering world of solid-state batteries. In November 2020 the business was floated on the New York Stock exchange to great acclaim. They announced that they had created fire-resistant test batteries that were good for eighty percent capacity even after eleven hundred cycles. That translates to a three hundred mile battery pack with an operational lifetime of three hundred thousand miles, or a five hundred mile battery pack that’s good for half a million miles. It all sounded absolutely splendid and the stock price leapt up by two hundred and fifty six percent in just one month. Bill Gates invested, and the word on the street was that Quantamscape was poised to become one of the most valuable stocks in the auto industry, even rivalling Tesla.**

**But then an independent report was published on a crowd sourced financial information platform called Seeking Alpha. It suggested that QuantumScape’s batteries were actually smaller than an iWatch battery and had never been tested outside a lab. The report concluded that the batteries were unlikely to ever achieve the performance they claimed.**

**That news didn’t sit well with investors, and the stock price promptly dropped off a cliff.**

**Despite insisting that the Seeking Alpha story had no merit, Quantumscape did have to concede that their batteries are still in the development stage, with results so far coming only from tests on small prototypes, not full packs.**

**They’re now facing a class action lawsuit from a New York law firm on behalf of very disgruntled investors who’ve watched their shares drop seventy percent in value in recent months.**

**Toyota have been at the forefront of solid-state battery development ever since that twenty eleven sulphide breakthrough that I mentioned earlier. They’ve got over a thousand patents involving solid-state batteries, and right now they’re looking like they might just be the first to market in the EV sector. The Japanese government has been encouraging the domestic development of solid-state batteries as part of a nineteen billion-dollar state fund designed to fast track decarbonization technologies. Toyota are planning to launch a prototype solid state battery powered electric vehicle before the end of 2021, and a full production model, with a ten-minute charge time and five hundred-mile range, just a couple of years later.**

**The likes of Nissan, VW and Hyundai are all fairly close behind as well, and even behemoths like Ford and General Motors are now diving into the technology, partnering with existing battery tech companies in a desperate attempt to catch up.**

**There’s an old cliché used somewhat cynically about another potentially world changing technology - Nuclear Fusion. They say it’s only thirty years way from reality, and always will be.**

**Let’s hope the same satire won’t be directed at solid state batteries, because if someone does actually nail it, then the road to global decarbonisation will suddenly look a lot less long and winding.**

**So what’s your view? Do you think solid state batteries are a realistic prospect, or just more media hype from the big auto-makers. Why not dive down to the comments section below, and let me know your thoughts there.**

**That’s it for this week though.**

**A big thank you, as always, to the folks who make these videos possible by supporting my work via Patreon. They allow me to remain completely independent, and they enable me to keep all my videos totally ad free. And I must just give a quick shout out to those people who joined recently with pledges of ten dollars or more a month. They are**

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**And of course, a big thank you to everyone else whose joined since last time too.**

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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.**