**The last time we looked at Sodium-ion batteries here on the Just Have a Think channel, there was quite a lot going in in what looked like an increasingly busy and competitive sector.**

**Since then, we’ve had news of a US bankruptcy filing by Swedish battery maker Northvolt, amid stories about how tricky it’s proving to make a commercially viable sodium-ion battery that can genuinely compete with the overwhelmingly dominant lithium-ion technology that is now so ubiquitous in just about every electrical device on the planet.**

**We’ve examined the technical difficulties with sodium-ion chemistry in some detail in previous videos. None of them are insurmountable, but they’re not simple to overcome and they make it much more challenging to reach the holy grail of commercially viable and profitable mass production.**

**Now a team at the Argonne National Laboratory, in the USA, say they’ve cracked on of the most fundamental of all the constraints on sodium-ion cell longevity, and they’ve published a paper to explain they’re findings.**

**And you know me folks – I do like a nice peer -reviewed research paper!**

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

**Apparently, a couple of months before Northvolt’s bankruptcy filing, China’s so-called ‘battery king’ – a guy called Robin Zeng – was asked why Western battery makers were struggling to make good quality products.**

**He said. “They have a wrong design . . . they have a wrong process, and they have the wrong equipment. So almost all mistakes together.”**

**Not exactly a glowing review, was it? And of course, Zeng speaks from a position of considerable strength, given his position as the founder and chairman of China’s CATL, who in combination with the other Chinese behemoth BYD, and South Korea’s LG Energy and SK On, now control more than seventy percent of the global battery market.**

**So, finding some sort of breakthrough or USP to achieve a foothold in that market, and put a dent into what most European and American manufacturers see as a rather unhealthy state of affairs, is becoming an increasingly urgent priority for western governments. Which brings us to this latest paper from the folks at Argonne.**

**The main issue this research addresses is the slightly annoying tendency of cathode materials to develop structural cracks during operation that can lead to a rapid reduction in cell performance over repeated charge and discharge cycles. That issue appears to be exacerbated in sodium chemistry because sodium ions have a larger radius than lithium ions and therefore have a tendency to make more of a nuisance of themselves as they move in and out of the cathode structure.**

**But up until recently no-one has really been quite sure about precisely what was fundamentally causing the cracking phenomenon. And of course, if you can’t find a problem, you can’t fix it can you?**

**To address that challenge, the Argonne team created sodium-ion cells using what they call sodium layered oxide cathodes that included transition metals like nickel, cobalt, or manganese, and then they used some very high-powered machinery to analyse what was actually happening inside the cathode right down at the molecular level.**

**So, first of all, why do battery makers seem to keep defaulting to these metals, some of which have significant environmental and supply issues?**

**Well, it’s because they each perform different but very useful functions inside the cathode material.**

**For example, manganese on the surface of a particle provides external structural stability, while a nickel rich core surrounded by a layer of cobalt offers very high energy density. Cobalt also stabilizes the internal layered structure of each particle, and it tends to reduce the risk of thermal runaway which means the overall cell can potentially operate safely at higher temperatures.**

**The performance limitation of a configuration like this was thought to be caused entirely by the stresses and strains that build up between the different materials as ions move in and out during charge and discharge, and it’s these stresses and strains that were thought to propagate cracks in the material, starting at the outer surface and moving downwards towards the core.**

**To assess the problem more forensically and hopefully come up with some solutions, the Argonne team constructed two versions of a sodium hydroxide compound that could be used to make the cathode.**

**One version had the additional metals distributed in a gradient, similar to the layers I just described, and the other version had the three metals evenly distributed throughout the material.**

**Then they heated the materials right up to six-hundred degrees Celsius at different heating rates and for various lengths of time, before cooling them back down to room temperature.**

**While all that was going on they used some very fancy Department of Energy facilities to watch was what happening. The first bit of machinery was the Advanced Photon Source at the Argonne lab itself, and the second was something called the National Synchotron Light Source II, which is housed at the DoE’s Brookhaven National Laboratory.**

**They also used Argonne’s Center for Nanoscale Materials and the Polaris supercomputer to reconstruct X-ray data into 3D images.**

**The tests results confirmed a somewhat counterintuitive finding.**

**In the sample with the gradient metal configuration, cracks were forming at around two hundred and fifty degrees Celsius. But instead of starting at the surface and spreading inwards towards the core, which is what generally happens during the electrochemical process of charging and discharging a battery cell, those cracks were actually starting deep inside and spreading outwards. By contrast, in the sample with evenly distributed metal, cracking was barely observed at all. The strong inference was that the distinct boundaries between different metals in the traditional gradient configuration were setting up their own so-called microstrains.**

**In other words, it looked very much like the problem was in large part being created by the manufacturing process itself rather than the charge and discharge cycles that occurred during the cells operation.**

**And that was a fairly important piece of insight.**

**But it turned out there was another variable at play too. And that was the rate of heating during the manufacturing process.**

**The test rig was run twice with both cathode material configurations and with exactly the same start and end temperatures. The first run was heated at a rate of five degrees Celsius per minute and the second was heated at a rate of only one degree Celsius per minute. While the faster heating sample showed particle cracking, no such problem appeared to be occurring with the more slowly heated samples.**

**Now I’ve greatly simplified the scientific language here, as I’m sure you’ve already spotted, partly to keep this video to a watchable length, and partly to avoid frazzling my own somewhat limited brainbox.**

**If you’re a proper science type though, and you really want the details of Rietveld refinement results, temperature dependent O3 stacking, heterogeneous microstrain propagation and phase transformation induced stresses, then I’ve left a link in the description section to the original paper. You will need to be pretty committed though I’m afraid, because, as is so often the case nowadays, the full text of the paper is protected behind a paywall.**

**Anyway, the bottom line, according to the Argonne team, is that there’s a pretty simple and almost zero cost solution here to significantly improving the performance and longevity of future battery cells by applying relatively minor changes to the construction of the cathode material.**

**The paper’s authors argue that their finding have filled a long-standing knowledge gap in that process, and that their test results provide valuable guidance for future development of more sustainable battery materials with high capacity, long cycling life and good thermal stability.**

**That could apply just as well to Lithium-ion cells or Sodium-ion cells and perhaps even to Potassium-ion cells, which are already in development and may start creeping into the tech media headlines in the next few years.**

**So, there we are then folks. It doesn’t always have to be complex rocket science, does it. Sometimes it’s the simple solutions that prove to be the most effective!**

**Feel free to leave your thoughts and feedback in the comments section below, but that’s it for this week. Thanks, as always to the folks who support my work via the online Patreon platform, which means I can make these videos without having to bother you with annoying ads and sponsorship messages. And I must just give a quick shout out to some folks who joined recently with pledges of ten dollars or more a month. They are Stephen Chamberlain, Philip Strong, Tim Mitchell, Adrian Dawson, William Bain, Howard, Sharon Knuth, Matthew Peel, Marvine Hamner, and Nicholas Sale.**

**Don’t forget to jump over to Patreon dot com forward slash just have a think to find out how you can join them and have a look at all the exclusive perks you can get there, including free membership. And if you enjoyed this video then you’d be hugely supporting me if you could hit the subscribe button on YouTube and click on all notifications. It really does help get us noticed by the all-powerful YouTube algorithm. It doesn’t cost you a penny to subscribe, you won’t get any annoying spam nonsense from me or YouTube, and it’s just a simple click away, either down there or on that icon there.**

**Most importantly though, thanks very much for watching! Have a great week, and remember to just have a think.**

**See you next week.**