Battery chemistry is getting in the way of Apple's vision
Eric Savitz

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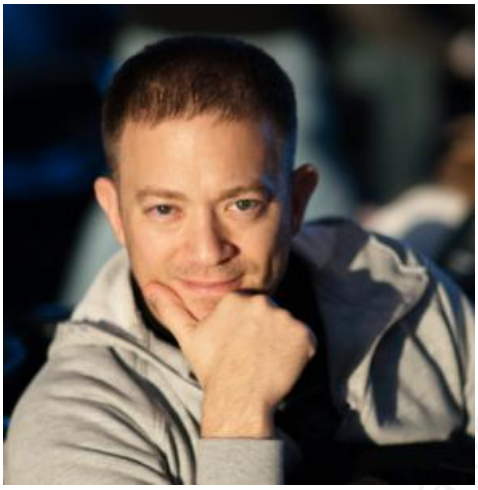

Noam Kedem: iPads are hot

The new Apple iPad is a hot product in more ways than one. A small firestorm has blown up in user forums as consumers report the device getting unusually warm, or even shutting down when exposed to hotter than normal conditions. Apple's response so far is that the device is "operating well within our thermal specifications."

Speculation about the cause has focused on the power-hungry LED-backlit Retina display, the new A5X processor with its quad core graphics, the 4G LTE chipset present in some of the flavors offered and the new, larger battery pack.

The uproar has overshadowed another aspect of the new iPad that's really more interesting: the fact that for the first time, a flagship mobile product from Apple is thicker and heavier than its predecessor. Not a lot – 0.6 mm and 51 grams – but significant enough for a company that lives on the cutting edge of design and has always been known for pushing the envelope on sleekness. Thinner and lighter was the mantra until now. What's going on? Has Apple blinked? Is this Apple's "New Coke"?

Hardly. The reality is much simpler: bleeding-edge features impose bleeding-edge power requirements. More power means a bigger battery and more heat generated during operation. For instance, the "resolutionary" Retina display has double the LEDs, which some experts estimate means 2.5 times the power. The 4G LTE feature appears to contribute to the problem too, as users have noted less heat with it turned off. Most important, bleeding-edge features mean more consumer engagement with graphically-mesmerizing applications, so there's less time to cool down. In a way, the heat complaints are a testimony to Apple's ability to create products that consumers can't put down.

The fundamental driver of both heat and bulk – and not just in the New iPad – is the fact that Moore's Law only works for electronics, not for the batteries that power them. The lithium-ion (Li-ion) batteries that power the iPad and virtually all other mobile devices are still based on a chemistry from the early 1990s. Since then, Li-ion batteries have barely tripled their volumetric energy density, while processor transistor count has zoomed more than a thousand-fold.

When Apple's engineers summed up the power requirements for the new iPad they hit lithium-ion's chemistry ceiling. They needed to increase battery capacity by 70 percent, but there was no magic wand available, so the new battery pack is just over a millimeter thicker and roughly

80 grams heavier than that of the iPad 2 – both about at 60% increase. The rest of the capacity increase comes from the kind of efficiencies Apple is well known for. But even with Apple's brilliant engineering, the end result had to be a thicker and heavier iPad. Not by much… but with Apple, one can assume this didn't go down well.

Worse, there's a vicious cycle involved. Li-ion batteries don't like elevated temperatures. Without going into details, suffice it to say that a hotter battery means shorter cycle and calendar life. What this means is that every time you charge and discharge a Li-ion battery, it loses some run-time and finally can't run the device long enough between charges to satisfy the user. Plus, even if a battery isn't cycling, heat shortens its life. This degradation is due to irreversible chemical changes that double in speed with every 10° C increase in temperature; according to Consumer Reports, the New iPad runs 6-7° C (12-13° degrees F) hotter than the old one.

But wait, there's more! Batteries – especially the high energy-density batteries required by devices like the iPad – generate more heat the faster they discharge (which is what higher power consumption means) and, equally important, the faster they recharge. Some Web postings indicate it takes as much as 4 hours to charge the new iPad from a 31 percent to a 65 percent state of charge, which may reflect the impact of this fundamental physical limitation on recharge speed, despite how unhappy it makes users.

Only time will tell what impact these realities will have on the New iPad, but since battery replacement for the iPad means giving up that can't-put-it-down experience (and all your personal data) until Apple gets it back to you, any perceived shortfall in battery life is going to mean unhappy customers.

What the kerfuffle over the New iPad really illustrates, then, is that in the race to make mobile devices both thinner and more powerful, which are pretty much opposing vectors from a battery design standpoint, manufacturers are pushing the limits of existing Li-ion battery chemistry to the point of failure. There's a lot of promising research into new battery chemistries out there, and some new solutions are already on the market, including one that eliminates hydrofluoric acid – the most corrosive of all chemicals – from Li-ion chemistry to deliver dramatic improvement in thermal stability, cycle life and calendar life.

In the meantime, Apple has a huge reservoir of goodwill with consumers to draw on, and rightfully so – its world-class product design and interest in supplying their customers with the latest and greatest has long been a core principle. That will buy the company time to address the battery problems. What we're seeing in the short term is simply the problem of any company that pushes the envelope as aggressively as Apple does: as the old saying goes, it's the pioneers who get the arrows in the back.

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