n-tech Research Article

New and Future Markets for Thin-Film Batteries

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Over the past decade, the thin-film battery business has been little more than a niche at best and many “sure thing” applications for these batteries have led nowhere commercially. Specialist thin film battery firms have quietly disappeared as the whole sector has begun to look more and more like the usual story of an interesting technology chasing an unresponsive market.

n-tech believes that the advent of the Internet-of-Things (IoT) and wearable electronics is giving the film battery business a second chance. The IoT potentially needs billions of low-cost, small form factor batteries, which may be used in combination with energy harvesting to increase time between charges. Wearable electronics can support higher prices for batteries than IoT but flexible, small format batteries still seem to be the order of the day. In either case, thin-film batteries – at least provisionally – seem well suited to these needs.

The question then is if wearables and IoT prove to be the “killer app” for thin film batteries, what type of firms can benefit from recognizing this fact.

Thin Film Batteries: From Niche to Potential Mass Markets

n-tech Research has been covering new mobile battery technologies for almost a decade. For much of that time, these batteries were characterized primarily just by the fact that they were thin. In fact in many of our reports we specifically referred to these reports as “thin batteries.” These thin batteries could then be further divided into so-called printed batteries (never more than a market niche) and thin-film batteries (the core topic in this report and a growing market).

The implicit assumption behind most of our analysis in the past was that the primary selling feature of these novel types of batteries was essentially (1) form factor and (2) energy density. Energy density has been a competitive factor in all sectors of the battery industry since its inception, so the marketing messaging for the first generation of thin batteries was that they were suitable for applications where there was a need for small batteries that had – potentially at least -- a lot of capacity.

As a result, a list of conjectural applications for thin film batteries have grown up and become part of the lore of the thin film battery community. This list typically is taken to include RFID, sensor networks, smart cards, medical implants, medical disposables, computer clock and memory backups, etc. This list appears in some form on the Web sites of almost all the small firms that have been trying to make a business out of thin batteries. And although these applications are presented as if they are sure bets, a little digging shows the reality was somewhat different.

For example, in many cases the items on the thin film battery wish list proved somewhat ephemeral. As things turned out in many of the product areas where some of the thin film battery makers thought there would be considerable potential, the device makers were quite happy with existing power sources (active RFID and medical implants) or no power sources at all.

While there a few exceptions (e.g. Solicore, now BrightVolt), many of the companies in the thin battery space began to disappear or get themselves into financial difficulties starting around four or five years ago. And this was probably even truer in the printed battery sector than in the thin film battery sector. Increasingly, thin batteries began to look like an excellent example of a technology in search of an application.

What seems to have changed recently was the advent of the Internet of Things (IoT) and wearable electronics. These new applications seem well suited to what thin film batteries apparently have to offer (at least they do potentially) in terms of performance and functionality, while at the same time offering the first sizeable and serviceable market for thin-film batteries.

The point is that until now, most of the actual applications for thin batteries have been no more than niches (e.g. powered smart cards), while the "obvious" high volume market for thin batteries – that is cell phones – seemed unapproachable; volumes were to high and technologies were too entrenched.

For IoT and wearables, required volume production is much more modest, making it possible for thin film battery makers without huge factories to achieve the volumes achieved by customers. At the same time, thin film battery technology seems to be evolving in ways that make such technology superior to conventional mobile batteries for IoT and wearables. In Exhibit 1-1 we summarize the dimensions along which thin-film batteries are a fit for these newer applications.

Some future history of thin film battery technology may show that the first generation of thin-film battery applications, while still continuing to generate revenues, was mostly a practice run for thin film and similar batteries targeted to the IoT and wearable segment.

The Fit Between IoT/Wearables and Thin-Film Batteries

Source: n-tech Research

	R&D Directions	Internet-of-Things	Wearables
Energy density	Current thin-film batteries have low energy densities, but improvements are a major part of existing R&D programs	Despite low-energy densities IoT applications can be supported by existing thin-film battery technology because they can be used in combination with energy harvesting devices	High energy density is important since batteries can impair aesthetics and comfort. Today smart watches and other wearables make do with fairly conventional lithium ion batteries, so any trends at all towards small form factor, high capacity batteries may be regarded as an improvement
Flexibility	Foldable batteries seem close to commercialization, but extensive research is looking at fully flexible batteries	Many IoT applications do not seem to need flexible batteries – but batteries that conform to a surface may prove very useful. In the long run the potential for soft smart objects (e.g., smart tablecloths) is there and would require flexibility	While the current generation of wearables does not use any kind of flexible batteries, the advantage of a flexible battery in (say) a smart textile is obvious. That said, the question is open as to whether the wearables market will quickly adopt flexible batteries given the relatively low energy density and risk of adopting a new technology
Energy harvesting	Many efforts in this area with a focus on solar, vibration and radiation based energy harvesting	Energy harvesting (with or without a battery) is emerging as a core power source for IoT. However, for "serious" applications – e.g., in the Industrial IoT – reliability of energy sources becomes an issue	Certain kinds of energy harvesting seem to have a role to play in the wearable sector. These include energy harvesting that operate on the basis of motion and those that utilized body heat
Chargeability	Most thin-film batteries are rechargeable, but work is being done to increase times between charges and the speed at which these devices can be recharged	Batteries must be rechargeable perhaps with energy harvesting devices It is possible that some low end IoT devices would be disposable and would not use secondary cells. Where charging is automated, time to charge and time between charges may not be critical	Wearables would, much of the time, have the same chargeability and lifetime characteristics as mobile phones. That is batteries would need to last the life of the wearable itself; probably 2-5 years and be able to be quickly charged when necessary. Energy harvesting might help with recharging, but may not be sufficient. Times between charges also need to be maximized
Manufacturing and materials trends	Focus on new materials and manufacturing approaches to increase energy densities, improve flexibility and increase fit with existing manufac-turing in the battery industry	IoT is cost sensitive and batteries for this sector have to be manufactured at low cost. Materials must be environmentally friendly and for some applications – especially for the Industrial Internet of Things -- must be encapsulated in a manner that makes them extremely rugged	Cost may also play a role here, but perhaps less so than in the IoT market. But unlike the IoT, aesthetics is important and this will impact manufacturing in that integration into the wearable must be done in an aesthetically appealing way. In addition, materials being used must be appropriate in terms of biocompatablity, weight and flexibility.

Emerging Opportunities

Looked at in a particular way, Exhibit 1-1 establishes some key opportunities which are set out below and form the substance of most of what follows in our report. In fact, there is already a lot of R&D work going on both at industrial companies and at R&D institutions to plug the gaps in today's thin film battery products and to make the fit better between battery products and wearable and IoT products that much better.

If the work going on in these labs makes significant progress and can be patented, there is the potential to create considerable amounts of value. The markets to which improved thin-film batteries could be addressed in the wearable and IoT space are potentially very large.

Energy density: Thin film batteries often have a popular image of having high energy density, but this is not really the case at the moment; the thinness tends to work agains the potential for high energy density.

However, we expect this to improve and more than half of the R&D projects in this space seem to be directed towards making the energy density for thin film batteries better. We suspect that any improvement of this kind will pay off, but particularly in the wearables segment, where large batteries can be uncomfortable to the wearer and may also impair aesthetics. There is less of an opportunity in the IoT space where poor energy density can be offset through the use of energy harvesting. However, improved energy density is always a positive competitive factor

Flexibility: The development work that is currently being undertaken on developing flexible batteries is concentrated in a relatively places, but is often quite spectacular in its intent; for example batteries that can be completely folded up or stretched have been discussed and researched. This is, incidentally, largely a materials play since materials that do not change their electroactive characteristics when they are bent or flexed are quite hard to find.

What is unclear to us is just how big an opportunity flexible batteries really are. In the IoT, for example, all that might be needed from batteries is conformability; that is the batteries will have to fit curved surfaces which may not be too demanding, requiring only a one time flex for the battery. However, truly flexible batteries may be something of an investment for the future – there is already something of a fit for wearables (e.g., smart watchstraps) and smart clothing and some smart objects (such as smart tablecloths) may need flexible batteries in the not too distant future.

Chargeability and battery lifetimes: Most thin film batteries are already rechargeable, but improvements can always be made in terms of (1) how long it takes to charge a battery and (2) times between charges. This may not matter all that much in the IoT space where charging is automatic and people do not have to wait for it to occur. However, for wearables the need for rapid and infrequent re-charging is identical to that of today's mobile phones and would be as much of a selling feature.

Battery lifetimes are also important and in both the case of the IoT and wearable will have to match the lifetime of the smart object being powered. In the case of some disposables this may be less than a year, but in the case of wearables it is likely to be two to five years. These are not demanding requirements. However, some IoT sensor – especially in the case of sensors installed in the Industrial IoT – are going to be much longer than this; perhaps as much as 10 years. This could be more of a challenge.

Materials and opportunities for the specialty chemical industries: The opportunities outlined above are likely to be primarily available to the specialist thin film battery makers and the large consumer electronics firms that are getting into this space. (As an aside, mainstream battery makers have most stayed away from thin-film battery makers because of their unfamiliarity with the manufacturing technologies appropriate to thin film batteries.)

However, there is an opportunity here for specialty chemicals firms too. In fact, as we suggested at the beginning of this section energy density, flexibility, chargeability and lifetimes are all highly materials dependent. In addition, materials firms interested in the thin-film battery segment can look for competitive advantages in materials that are especially biocompatible and environmentally friendly.

See the n-tech Research report, "New and Future Markets for Thin-Film Batteries"