Printable Battery Markets: 2009 and Beyond

Chapter One

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About the Report:

This report provides a market and technology analysis of the worldwide market for printed batteries and a forecast of printed battery revenues from 2009 to 2016.

After years of development several firms are finding real world applications for their printed batteries. This report analyzes the opportunities for these products, the strategies of the firms that are manufacturing them, and the printing approaches that they are using. It discusses how the market will evolve in the current worldwide recessionary environment with its lower expectations for the growth of the RFID; a key driver for printed batteries in the past. The report also pinpoints where printed batteries could ultimately offer a cost or manufacturing advantage over today's coin or button batteries. The report also provides profiles of firms that are competing in this sector, the products that they are offering and the markets they are targeting.

Printed batteries are the natural power source for smart packaging, active RFID, powered smartcards, sensor arrays, medical and cosmetic patches and smart bandages; even certain kinds of displays. Not only do printed batteries bring low-cost manufacturing to battery manufacture, but they also enable integrated manufacturing plants to be created in which an entire electronic device including processors, memory and power sources can be created in a single process. And printing batteries is also the obvious way to fabricate power sources on flexible substrates, especially paper. This report provides an in depth discussion of the printed batteries market in 2009 and a forecast of where this exciting new business is headed.

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1.1 Background to this Report

A variety of small, low-cost batteries have powered electronics for generations and with considerable success. These batteries come in an assortment of chemistries and are used for different applications. For example, primary batteries using carbon zinc are inexpensive power sources for flashlights and toys. Single-use alkaline chemistries last longer, but are a bit more expensive. Uses include calculators, smoke detectors and other consumer goods. Secondary batteries include lead-acid chemistries used in automobiles and lithium-ion batteries used in portable devices.

All of these established battery technologies are widely used for large area/flexible/disposable electronics applications. However, these traditional battery types have major disadvantages in such applications. While very small by the standards of (say) a car battery, they are still quite large and bulky compared to what is needed for the large area/flexible/disposable electronics sector. For example, imagine fitting a smartcard powered by a hearing aid battery into a wallet. There is also a potential health and safety issue in that more conventional batteries often use hazardous chemicals, including lead, mercury, and cadmium. These are not materials that anyone wants in smart packaging that contains food or even pharmaceuticals.

The business proposition of the makers of thin-film and printable batteries is that their products can move beyond such issues. While it is fairly easy to demonstrate that this is the case, the manufacturers of these newer kinds of batteries face some fairly formidable challenges. One of these is that many of the applications at which their new technologies are aimed are themselves new technologies that have generally not done well in the current recession. Most notable among these is RFID. Not so long ago this was seen as a "killer app" for thin-film batteries, but the recession is not likely to be a good time for retail and wholesale firms and others to implement what is, in effect, major new IT systems. In addition, RFID is not coming down in price fast enough to really make significant penetrations at the item level; at least not as fast as hoped and, of course, most RFID tags derive their power inductively and don't need batteries anyway.

With all this in mind, makers of thin-film/printed batteries have turned elsewhere for first revenues. Powered smartcards are seen as one good prospect, because they can potentially provide very high security at a time when ID theft and other forms of abuse cost credit card companies billions of dollars. This seems to NanoMarkets a better bet than RFID at this point in time, but it remains an opportunity that is only just beginning to open up. (Smartcards have been around for many years, but they have been of a type that has relatively low functionality and therefore do not need batteries.)

The bottom line is that the thin-film/printable batteries have a whiff of a technology chasing an application about them. However, a much more serious problem for these batteries is cost. Not that any thin-film battery firm would want to compete on price alone and many of them clearly do not have the resources to do so. However, the facts are that conventional batteries are extremely inexpensive and because of this it is impossible for thin-film/printable batteries to compete with them in many markets at this point in time. This means that the addressable market for these kinds of new battery technologies is quite small; the powered smartcard is a good example of where one might today choose a thin-film/printable battery. But it is hard to think of any other right now.

There have really been three ways to address this price problem, and they are not mutually exclusive. One approach is to essentially route around the pricing problem with the battery company creating its own high-value-added products in which the batteries are used. Cosmetic patches are the main example here. The other approach is to predict and rely on future major economies of scale that will make the price points for thin-film/printable batteries much more comparable with conventional batteries. Every firm in the thin film/printed battery space believes this to some extent, but it is important to realize that this hope is predicated on some kind of "take-off" application.

Finally, there is the strategy that consists in searching for lower cost methods for manufacturing batteries. Usually—but not always—these new production modes involve printing. The argument for printing is mostly the one that is always used for printable electronics, namely that printing machinery is relatively inexpensive and printing processes are well understood. In addition, it is hoped that the printed battery manufacturing can be integrated on the same manufacturing line with the device being powered and on the same substrate, then fixed production costs can be allocated to both battery and device. The thinking here is best exemplified in the concept of printed packaging, where batteries are just another printed layer.

1.1.1 Printed Batteries vs. Thin-film Batteries

Printed batteries—the main topic of this report—are really a subclass of thin-film batteries and they have many things in common with them. These include small footprint, of course, as well as the difficulty in getting the price point right. Also important—at least potentially—is the fact that these batteries can be formed to fit in almost any shape, depending on the application, and can be manufactured in-line with the final product. As well, these new battery technologies are solid-state and therefore do not pose safety issues. Printed batteries basically combine the advantages associated with thin-film technologies—lightweight, flexible, can be integrated into smartcards, etc—with the low manufacturing cost typically associated with printing.

For the purposes of this report, we define printed batteries as any battery that uses printing technology in its manufacture. For example, many printed batteries today use printing only for the electrodes and then laminate the electrolyte in between these electrodes. These batteries typically involve liquid electrolytes, which so far have not provided an effective electrolyte layer via printing. There are several chemistries currently being used by companies that have developed printable battery technology, but they are usually zinc manganese dioxide or carbon zinc. These are relatively low-cost materials when compared with the various lithium chemistries used in many of the thin-film and conventional batteries. These materials can be formulated into inks, which are then printed via screen printing onto a variety of substrates.

However, in addition to the issues that beset thin-film batteries as a whole, printed batteries have their own challenges. Where they are not entirely printed, the manufacture of these batteries will obviously not get all the cost benefits associated with printing. In addition, there is a major technical issue that must be resolved before printed batteries can realize their potential. This is the issue of the liquid electrolyte. Many in the battery industry believe that only a fully printed battery will be able to compete with conventional batteries. Today's printable batteries rely on a liquid electrolyte, which cannot be printed. (Liquid electrolytes have a viscosity similar to water and therefore need a solid in which to contain them; they are typically absorbed into a "separator" material.)

1.1.2 Current Prospects for Printed Batteries in RFID

The RFID market holds out the potential as a very high-volume application for printable batteries and until very recently was seen by the printed battery sector as being where its first large revenues would come from. As we have already mentioned, this looks a little less likely now in recession, but the longer-term prospects are still seen as vital to the future of the printable battery sector by many participants.

While the vast majority of RFID tags on the market today are considered passive, and therefore do not rely on batteries, there is increasing demand for active, as well as semi-passive tags, which do take advantage of batteries. The value proposition being offered by printable batteries for RFID tags is the ability to lower the cost by printing the battery in-line with the rest of the RFID tag, ultimately reducing its cost—a key requirement for the mainstream acceptance of RFID technology. The ultimate goal—still a long way away—by general consensus would be a completely printed device that would replace barcodes. Many of these "barcodes of the future" would be passive, but some would be printed with batteries as part of the complete package.

With advances in materials—better OTFTs and printed silicon especially—RFID tags have the potential to take advantage of low-cost printing technology. The evolution of printed RFID has been steady but slow. PolyIC, the firm most closely associated with this area has moved into the sampling phase, but still seems to be some way from large-scale production. OrganicID seems to be back in the business, after a year or two of under-the-radar development activity. There are also broader development projects underway. One example is the German Federal Ministry of Education and Research (BMBF)-sponsored alliance project called MaDriX that was launched in February 2008 to advance the development of high-performance printable RFID tags. PolyIC is leading the project; other partners include BASF, Evonik Industries, Elantas Beck, and Siemens.

All that being said, we are in a very different economic environment today—recessionary economics, which do not favor emerging technologies. There is much more intrinsic risk in any venture at the present time. This means that the focus is likely to be on the tried and true both in terms of applications that receive funding and materials adopted for bringing these applications to market. As such, we do not expect the RFID market to grow over the next few years at the same pace as we might have expected a few years ago.

1.1.3 Other (and Better?) Growth Markets for Printed Batteries

Other applications that printed battery producers are targeting include: smartcards, medical devices, sensors, displays, and consumer devices. Many of these applications lend themselves to thin-film batteries in general, and do not necessarily need printed thin-film batteries. The reasons for using a printed battery (as opposed to a non-printed thin-film battery) would generally be to either lower the cost or to enable some design feature that only printing can provide.

Smartcards: A smartcard, also called a chip card or integrated circuit card (ICC), is any pocket-sized card that is embedded with integrated circuits to process information. It can receive input, process the information and deliver output. There are two categories of smartcards: contact and contactless. For the purposes of this report, we will focus on the contactless cards, which unlike the contact cards, rely on on-board batteries. There is increasing demand for contactless smartcards in the financial sector, primarily because they can provide enhanced security in a dangerous world.

The smartcard is already a product that uses printing in its manufacturing and so would be well suited to a printed battery solution. Also, printed batteries would survive in the relatively high temperature (130°C to 150°C) and high pressure (~200 N/cm^2) lamination process that is used in the manufacture of smartcards. Conventional batteries, such as coin or button cells, would not survive such temperatures, at least not in a charged state. Given that RFIDs are not taking off as fast as was once hoped, smartcards represent a tremendous opportunity for printable batteries. The number of cards, produced by only one of the major credit card companies would number in the range of 150 million to 300 million cards a year. That is a lot of batteries.

Medical devices: The medical and cosmetic device market has enormous potential for the kinds of batteries that we are discussing in this report. What is usually mentioned in this context is patches, which may already have some printing in their manufacturing process and would be quite amenable to using printed batteries. Another similar area would be “smart bandages,” an area that is getting a lot of attention from the U.S. military at the present time. In general, there is probably a wide and growing need for implants and patches that have therapeutic, diagnostic, or cosmetic functionality. Batteries serving this market vary in their requirements, but key factors are often flexibility, long periods between charges, and a small form factor.

The good news about this segment is that it is also fairly cost insensitive; certainly this is the case when compared with item-level RFIDs and smart packaging. However, most medical devices must undergo government regulated trials, which means that there is a period of hiatus before any volume production can be undertaken. One way around this problem is to focus on cosmetic (and hence unregulated) products. This would include patches that enhance the delivery of active ingredients to the skin. The patches are designed for treatment of conditions such as skin damage, aging, wrinkles, hyper-pigmentation and photo-damage. Patches can be customized to any shape and size, conforming to body contours and to varying temperature and humidity. Some of these patches are already using printable batteries because of the cost factor.

Sensors: It may well make good economic sense to print the batteries used with printed sensors, but printed batteries can be also used with non-printed sensors and most printed sensors are not powered by printed—or even thin-film—batteries.

That said, many of the trends in the sensor industry would seem to favor the use of small, thin (and possibly printable) batteries of the kind we are covering here. In particular, there is a need to produce distributed sensing devices on large substrates for atmospheric and national security/military applications and these could certainly benefit from the use of printed batteries. In some cases these distributed sensing systems might be (screen or transfer) printed on a textile substrate to create smart fabrics. In addition, these kinds of applications, suggest that government might have a strong interest in this area both as a customer and a funder of R&D.

There are also broader trends that are worth noting that may well drive the printed and thin-film battery business. Medical diagnosis is moving more to a point-of-care model, using small portable/handheld diagnostic devices or implants. Many of the latest wireless sensor networks and environmental sensing devices are often located in areas where other forms of electricity are not widely available and batteries are the obvious choice of power source. However, in some cases energy harvesting and photovoltaics may prove a better way to power both remote and implantable sensors.

Displays and consumer devices: RFIDs are not the only information revolution that is beginning to take off in the retail sector. Another comes in the form of electronic shelf labels (ESLs, also known as smart shelving). These are small low-cost displays (usually passive matrix LCDs, but potentially e-paper) that provide updatable pricing information. They save the cost of updating pricing labels on a regular basis with the theory also being that by more regular updating of prices in some cases, higher profitability can be achieved. It is also possible to imagine that ESLs would eventually link into larger retail networks that might also include input from RFIDs.

Generally speaking, ESLs have to be powered by batteries and they are usually not displays that use much power so this is not a hard thing to do. The batteries used need not be thin-film or printable. These displays typically use AA batteries, which have lifetimes of six months to five years—a performance stat that thin-film printable batteries would not be able to match. However, there is some potential for printable batteries to find a role in this market, especially if power densities can be improved. Many suppliers of these batteries have mentioned electronic paper ESL displays as a potential market for their technology. Given the physical characteristics of thin-film batteries, however, it is possible to imagine a flexible ESL powered by a battery that would look and behave much like today's plastic shelf label. Using specifically printed batteries the entire label including the power source might be printed.

1.1.4 Strategies for the Future

Given the current economic climate and the state of printable battery technology, it seems likely that printable battery firms will focus on: (1) further developing their battery technology to meet specifications of important applications and increase energy density; (2) improving manufacturing processes used to make the batteries—possibly employing printing for all parts of the battery; and (3) establishing relationships with device manufacturers (customers), especially those that are developing devices made via printing and especially those that could lead to early volume production.

1.2 Objective and Scope of this Report

In this report, we analyze and forecast the markets for printable batteries over the next eight years. We review the range of materials used in these devices, including both the electrodes and electrolyte, as well as the processes used to produce these materials. In the context of this report, our focus is on printable batteries, meaning batteries that use printing to manufacture some or all components of the battery. As such, we do not cover thin-film batteries that rely on manufacturing processes other than printing. These will be covered in another report by NanoMarkets.

In terms of applications, we have looked primarily at RFID, smart packaging and labels, smartcards, biometric ID, electronic shelf labels, sensors, medical diagnostic devices, medical implants and drug delivery systems, games and novelties, cosmetic devices, battery-backed up computer memory and embedded chips. In addition to the technologies that clearly belong in the printable categories, we have also discussed some of the other novel technologies that are emerging at this time and which either compete or synergize with printable batteries. Finally, we also provide in-depth review of the major players in the printable battery markets. Our profiles include: Blue Spark Technologies, Enfucell, Power ID, Power Paper, Rocket Electric, and Solicore.

The report is based on a worldwide view of the market, and we have not favored companies from any particular geographic region. We strive to cast as broad a net as possible in our efforts to research the information for this report.

1.3 Methodology of this Report

The information in this report is derived from ongoing interviews with key representatives of the printable battery and related markets. We have also conducted an extensive review of the research literature, as well as publicly available white papers, trade press articles, corporate literature, and government agency reports in order to create as broad and timely a picture of the current market as possible.

The forecasting methodology is discussed more fully in the main body of this report. However, it is based largely on our expectation of penetration of the important application sectors by printed batteries. In making that assessment we have taken into consideration current expectations for both printable battery technology and the applications into which they will fit. This includes the likely impact of the recessionary environment.

1.4 Plan of this Report

Chapter Two of this report delves deeply into the technologies used for printable batteries. It covers the key chemistries used in these batteries, including zinc manganese dioxide and carbon zinc, as well as the potential for a "solid" or "printable" electrolyte material. This chapter also discusses the development and use of different printing technologies.

Chapter Three covers applications and forecasts for printable batteries. It includes consideration of the various applications for these devices, and what impact these technologies may have worldwide.

Chapter Four includes profiles of key manufacturers of printable batteries, as well as of some of the foremost research institutes involved in this space.

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