Memorandum

To: Department of Commerce, National Institute of Standards and Technology (Diane Henderson)

Subject: Response to Request for Information, "Manufacturing Technology Acceleration Centers"

Re: Federal Register Announcement, June 23, 2013

Date: August 5, 2013

Introduction

On June 23, 2013, A Request for Information (RFI) was published in The Federal Register[1], to solicit ideas relative to the formation of the proposed new program, named the Manufacturing Technology Acceleration Center. Our group, based in Rochester, NY, and guided by our local MEP representatives, has met frequently and considered actions necessary to establish a center for Accelerating Manufacturing Technology. We have adopted an identification as a group, focused on **Flexible Film and Coating Technology**. Our first action is to submit our comments on the aforementioned RFI. This document contains our group answers to the questions posed in the RFI, in addition to a suggestion that NIST MEP considers adaptation of Flexible Film and Coating Technology as a candidate for an Institute. We attach a "White Paper" on Flexible, Thin Films, and draw attention to the many industries that this robust technology serves.

Disclaimer

This is strictly to be regarded as response to the RFI. It is NOT a proposal to become a Center. We understand that NIST MEP will issue a request for proposal for the technologies they adopt, and will respond at that time if a technology is requested that is within our expertise.

NIST Questions:

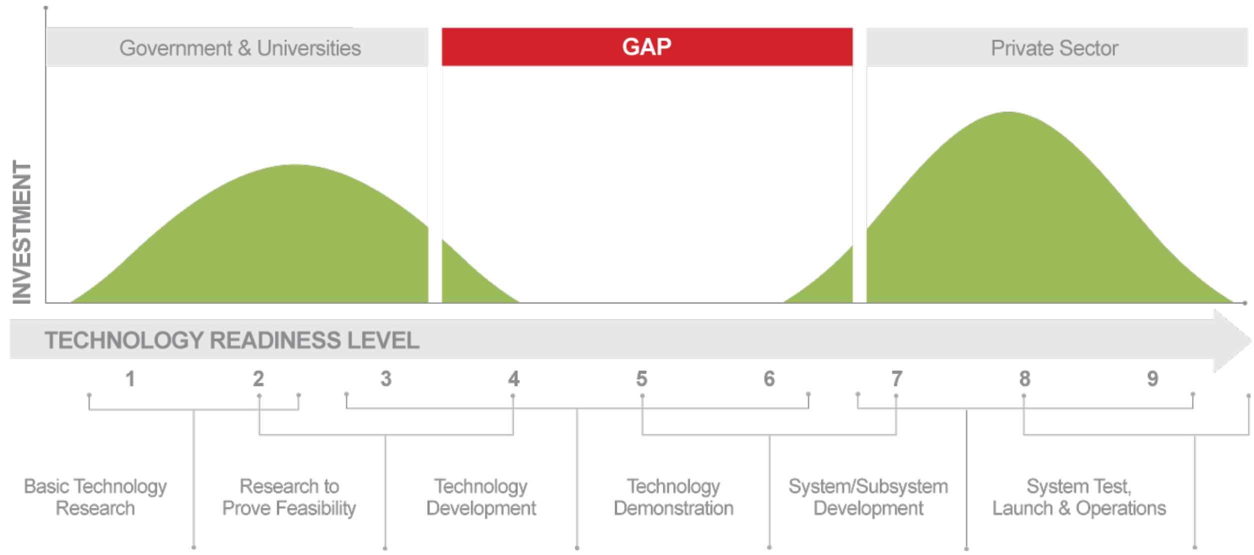
1. **What are the specific types of technology transition and commercialization tools and services that should be provided by M-TACs? Emphasis is on the alignment of these tools and services with the most pressing needs of small and mid-sized U.S. manufacturers.**

   M-TACs should focus on making America's unique research, innovation, and skilled workforce capabilities more broadly available and to create an environment for manufacturing innovation that will ensure the next generation of processes and products invented in the U.S. will be scaled up and manufactured in the U.S. as well. In order to compete globally, the U.S. *must* nourish its intellectual property beyond the lab through prototyping and proof of concept ; with robust pilot and scale-up, to ultimately achieve commercialization. The philosophy of products that are invented and built in America is critical to the United States' economic future and is especially important to a majority of new economy opportunities, (e.g. energy, clean-tech, consumer electronics & computing, functional printing and bio-tech and optics, photonics and imaging) in which the U.S. potentially has the first mover advantage. In order for our country to have a strong manufacturing sector, we need to understand that scale-up is NOT a university led function, but rather is associated with manufacturing. It is important that we innovate these scale-up tools and processes at the same pace that we create inventions, otherwise we cannot be efficient, low cost producers. To achieve this, we suggest these key focal points:

   - Development tools and business processes to bridge proof of concept to commercialization.
   - Technology clusters applicable to large international markets, which include a full suite of state-of-the-art development tools. These can be made readily available via underutilized assets and talents now "open to the public" at heritage manufacturing sites across the country such as Eastman Business Park. (View at this link: Eastman Business Park)
   - A rich, integrated network of small and mid-sized manufacturers that have access to these tools.
   - World class research institutions and community colleges.
   - Share-able experience with Technical Readiness Nomenclature.
   - Practical Experience with usage in a manufacturing environment.
   - Technology roadmap – help SME's map their course through TRL.

a. **How would M-TAC services complement the services currently offered by MEP Centers?**

   The commercialization process for any manufacture-able good is a compendium, from basic technology research all the way to system testing and full launch/operations. We think M-TACs have the opportunity to focus on the 'missing middle' or the current gap that exists between innovation/invention in the lab and full scale product commercialization. How? By leveraging existing workforce/intellectual capital; and partnering with companies who have development assets thereby preserving capital, reducing risk and improving predictability. By doing those things, a successful MTAC model can help our nation's best and brightest tech start-ups more quickly become profitable, self-sustaining, job-creating enterprises.



Specific to this region, we have some extraordinary physical tools for the development and manufacture of flexible, including functional films – within its numerous application areas in today's economy. We also have exceptional business processes originating with area manufacturers such as Kodak – processes focused on taking inventions from the Research Labs and commercializing them. Kodak's product portfolio has been enabled for more than a century by manufacturing innovation, which is why Eastman Business Park still has state-of-the-art tools at its disposal today like the Digital Pilot Coater, which has the capacity to take materials from the lab bench to early commercial production   using this roll-to-roll industrial coating facility at whatever scale needed to create products and evaluate how they will perform in field:

- **Extrusion coating** - create thermoplastic resins with various properties and cast as sheets or extrusion coat as layers onto paper or plastic webs
- **Aqueous coating** - put material into aqueous solutions and coat as thin films onto paper or plastic webs using roll to roll process
- **Solvent coating** - put materials into solvent solutions and coat as thin films onto paper or plastic webs
- **Gravure printing & coating** - roll to roll manufacturing process for printing vast numbers of solvent systems onto variety of substrates with the ability to print up to 8 distinct functional layers in a single pass

Formal business process such as the Manufacturing Assurance Process, the Kodak Material Commercialization Process, and the Kodak Equipment Commercialization Process will also be key elements to advancing companies coming through the M-TAC. These processes include documented steps, along with well-defined phases and gates, to ensure all aspects of technology readiness, development, pilot and scale-up have been addressed and answered. They also link very well to TRL levels 4-7, where there appears to be an opportunity from a federal standpoint.   Following this rigorous process will reduce time, and improve success of the commercialization phase.

These services augment the MEP services available not only in Rochester (at High Tech Rochester), but all over NYS with the 10 Regional Technology Development Centers(RTDC's), as well as MEP centers in every state. Arguably, these M-TAC specific services tend to address TRL levels 4-7 as expressed above. MEP offerings include:

- Innovation Engineering, pervasive at all readiness levels,
- Tech Scouting and Technology driven market intelligence (TDMI) aimed at pulling from 1,2 through 4-7
- NYS (tCAR) projects in active tech matching through solutions fairs, as pulling from 1,2
- Lean Product Development, aimed at 4-7 levels
- Virtual design and Prototype, another tCAR project, supporting commercialization through prototype and pilot.
- Lean, Supplier Scouting, Exportech, all aimed at 7 and higher levels of readiness.

2. What role should future M-TACs play with respect to supply chain needs? How should OEMs participate? How can industry associations, professional societies, and other appropriate national organizations participate?

There are approximately 1,300 small and medium sized manufacturers (SME) employers in the Finger Lakes' nine-county region (with 5-500 employees). Over the past century many of these SME's served as the supply chain for Kodak, Xerox, Bausch and Lomb, and General Motors manufacturing operations. A number of these companies were either suppliers to these large manufacturing companies or spin-offs from them, and still form a critical part of the region's manufacturing economy. These SMEs have generally maintained or grown their workforce, and they also form the critical backbone of the region's manufacturing ecosystem, which will enable further growth of the manufacturing sector in the Region. This speaks of our regional experience. An M-TAC would work with its partner organizations to develop targeted lists of manufacturing companies who in turn supply to the targeted technology, and maintain it as a database to support M-TAC benefactors with supply chain elements. This is yet another area of collaboration between M-TAC and MEP. MEP Supplier Scouting Service, for example would be augmented by the M-TAC for the targeted technology's supplier needs.

3. Is there a particular long-term scalable and financially sustainable business model that should be implemented by future M-TACs that will enable small and mid-sized U.S. manufacturers to effectively access and benefit from the technology transition and commercialization assistance and other resources they need?

The country's economic future must be centered on efforts to directly leverage research and product development to create manufacturing jobs. Innovation, which was once the focal point of America's booming manufacturing economy, can be again. However, manufacturing, R&D, and innovation must go hand-in-hand. No country, including the United States, can outsource manufacturing while keeping the higher-value-added service activities domestically. And while the very nature of technology development requires co-location of all these activities – oftentimes start-up technology companies cannot afford to progress from prototype to the next step on the path to market due to high capital costs.

As such, by focusing a future M-TAC at a place like Eastman Business Park (EBP) – Eastman Kodak Company's primary film manufacturing hub for over a century – the M-TAC program has the opportunity to provide a robust infrastructure to support the next generation of innovators, entrepreneurs and employers. This type of model can help accelerate these middle-stage technology companies, and allow them to develop their businesses from the lab-scale prototype stages of innovation to the later stages of production and commercialization.

EBP has developed into what is today one of the largest, most diverse industrial and technology parks in the United States. And, it is the only US industrial park of its size that was built in a vertically integrated fashion to support the R&D and commercialization components of a single industry sector, with the products manufactured on-site driving a broad range of technological advancements over the last 100 years, spanning: photography; motion picture; health care; printing; national defense and document imaging. These assets are now available to drive many 'new economy' opportunities needing materials science, chemistry, pilot testing, and infrastructure support:

- Energy
- Clean tech
- Consumer electronics/computing
- Functional printing
- Bio tech

Of course, having these assets alone is not enough to achieve the desire result of growing our manufacturing. The other element is to ensure that there is an adequate supply of technical resources to support an emerging manufacturing eco-system. This combination of tools and capability will drive an "industrial commons" that will again rival those that existed in this country many decades ago.

We believe that an appropriate set of development tools, along with proper technical and operational staff, can be a profitable, standalone , self sustaining business. With support by member companies, along with modest state and/or federal funding to maintain state-of-the-art capability, these businesses should be able to thrive.

The business model that could be employed to complement the business park model could consist of the formation of a Not-For-Profit corporation, which would undertake the leadership of the M-TAC. Fees for services rendered, such as training, pilot development, process development, and supply chain development, could offer the sustainability desired. Alternatively, a MEP center could undertake the leadership of the business park model, relative to the M-TAC, charging the same fees, and continuing to operate under the MEP model. This sustainable model could be the ideal arrangement, to accomplish the desired interaction between MEP and M-TAC.

One needs to be mindful of IP issues, and IP expertise will become critical to the success of the M-TAC. Distinction between pre-competitive IP and commercialization will be a key to success here. Promoting the proper IP chain, giving rights to the inventor as due, but securing rights for commercialization in a cooperative manner would be paramount. This service could represent yet another sustainable fee-producing feature of the M-TAC.

a. **Because of the programmatic connection to the NIST MEP Program, M-TACs may require cost share. Are there cost share models for future M-TACs that promote scale up to reach**

nationally dispersed clusters of small and mid-sized manufacturers? If so, what are those models, and why might they be successful?

Utilizing a model that focuses on repurposing America's heritage infrastructure, also allows for turn-key cost share in the form of donated assets and facilities, such as existing buildings, office/lab space, systems and machines, etc. Additionally, M-TACs will receive a substantial share of their operating cost share from small, but numerous fee-based service charges for accessing the tools. These charges will be modest for the small and mid-sized manufactures, but a fraction of the cost of building out this equipment and developing their own tool set.

b. The generation of intellectual property is possible, and even likely as a result of M-TAC operations. What types of intellectual property arrangements and management constructs would promote active engagement of industry in these pilots, especially among small and mid-sized U.S. manufacturers that would be supportive of the business model? As appropriate, please include a set of potential options, and please explain your responses.

Intellectual property is somewhat likely to be generated, although with a focus on manufacturing, IP issues are less likely to occur than with work done within universities to create proof-of-concept units. However, the creation of custom development tools may have proprietary components, as such, that IP should only be available to those willing to enter into an IP agreement. We propose to use our standard IP rights documents for licensing and royalty payments, as the standard mechanism for IP arrangements.

It is anticipated that our M-TAC will be generally IP friendly, as the goal is to help companies successfully navigate the commercial valley of death, and not to extract licensing or royalty fees. We expect to offer technical support as part of our fee based charge, which will cover general know-how on the tools which is being used. If a technical problem is encountered during one of the experiments, and a solution is available that requires protected IP, then a discussion about licensing would be conducted at that point in time.

For M-TACs to be successful, they must have be an IP friendly facility, which is necessary to attract customers and generate revenue to cover operating expenses

4. **How should an M-TAC's performance and impact be evaluated? What are appropriate measures of success for future M-TACs? Please explain your response including the value of the performance measure to business growth.**

- Established bridge between applied research and production scale development, redeploying the Region's underutilized infrastructure that was developed over decades of high volume manufacturing activity and remains largely intact today
- Technology and execution risk dramatically reduced for SBIR companies coming through pipeline. Measure: percent of SBIR companies making it to revenue bearing, i.e., successful commercial scale
- Collaborative model, connecting area's rich network of institutions of higher education, supply chain manufacturers, and human capital that remain in the Finger Lakes Region
- Tactical, implementation-ready elements to grow the Region's employment in the short term and sustain that growth over the long haul. Measure: jobs created in the technical cluster areas.

- Support for important key clusters such as functional films, and implementation of advanced manufacturing technologies at local manufacturers
- Strong capacity for innovation and entrepreneurship in the Region's primary industry segments, providing broad-based support for all manufacturing companies
- Support and assistance for existing companies in their expansion, encouraging the founding of new companies, thus supporting new job creation within key clusters across the region
- "Community" Support – building and promoting collaboration among technical, educational, finance, and infrastructure resources within a region.

5. Are there any other critical issues that NIST MEP should consider in its strategic planning for future M-TAC investments that are not covered by the first four questions? If so, please address those issues here and explain your response.

One of the key issues is who will run these and how will they be staffed, and where will they be located.

Attachment:

FLEXIBLE FILMS WHITE PAPER

INTRODUCTION

Despite a diversity of opinion, there is little debate over the commonly acknowledged roots of the present-day economic malaise in the U.S., which if not addressed, may lead to substantially greater economic trouble in the future.

Of this issue, these three points persist:

America needs to:

- Reduce its dependence upon foreign oil and non-renewable energy sources;
- Find a consistent, sustainable source of jobs for an expanding workforce;
- Leverage its technical superiority and strengths in Advanced Manufacturing.

Fortunately, all three needs can be addressed and definitively resolved. This white paper will focus on the development of solutions to chart the course toward a brighter future – all made possible by the further development and re-utilization of readily-available capabilities and expertise in chemistry, flexible films, and coating/deposition technologies.

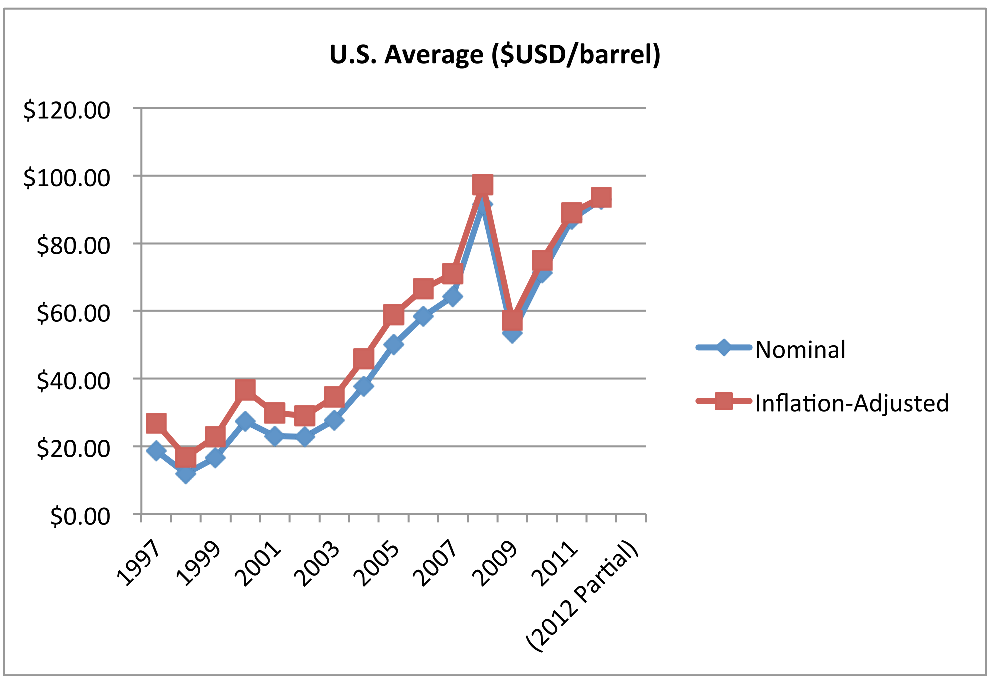
UNDERSTANDING THE FACTS

Understanding the problem America faces is central to this discussion: dependence upon foreign oil and other non-renewable energy sources; the loss of American jobs resulting from outsourcing of manufacturing and technology-based jobs to lower cost sources of supply; and America's inability to leverage its non-duplicative strengths in advanced manufacturing.

Reducing dependence upon foreign oil and non-renewable energy sources

Problem 1: Rising cost of oil and limited availability of domestically-generated energy sources

A stop at the gas pump or a passing glance at our utility bill are all it takes to realize where we are headed in terms of the cost of fueling our vehicles and warming (or cooling) our homes. Oil prices have increased **400%** over the past **15** years, and are predicted to continue to rise. To stay ahead of the inflating bubble, whether by buying a hybrid vehicle or installing solar panels for their house, people have found a benefit to doing so – not only in energy savings, but with government tax breaks for adopting energy efficient technologies.



In his 2013 State of the Union Address, entitled 'An America Built to Last,' President Barrack Obama identified several key initiatives for supporting job growth by investing in manufacturing and infrastructure, particularly in the next generation clean technology and alternative energy sectors.

The President specifically called on Congress to build upon our success as a world-leading manufacturer of high-tech batteries. He reiterated his call for action on clean energy tax credits. And he called upon a national shift toward clean sources of electricity by setting a standard for utility companies – with expectations that by 2035, 80% of the nation's electricity will come from clean sources – wind, solar, biomass, hydropower, nuclear power, efficient natural gas and clean coal.

According to US Energy Secretary Steven Chu, "When it comes to clean energy, our motto should be: 'Invented in America, made in America, sold around the world.'"

Recognizing it is not possible to perpetually fulfill the U.S. demand on oil products entirely with its own supply, America must augment its oil reserves with alternate sources of energy – putting itself in a position whereby oil serves as a secondary or tertiary, rather than the primary source. There are numerous alternative sources of energy under development; but each has a relatively long path to commercialization. However, many alternatives can be leveraged today, or are quickly approaching market availability.

- **Large trade deficit – largest contributor is foreign oil**

Problem 2: Consumption of oil and non-renewable sources adversely impacting environment, leading to the need to increase utilization of alternate, clean energy sources.

The environment impact of oil consumption and other non-renewable energy sources is an international concern. For example, the amount of energy consumed by electric vehicles (EVs) is far less than conventional gasoline vehicles, converting about 59-62% of electrical energy from the grid to power. Conversely, conventional gasoline vehicles convert 17-21% of the energy stored in gasoline to power. And, as electricity as a power source generates no tailpipe pollutants, it is natural to conclude that the development of alternate energy sources is critical to America's future. Battery-powered vehicles are just one example of an industry that can take full advantage of thin film technologies – including the benefits of longer battery life, lighter-weight materials, and more efficient use of energy stores.

With advantages to industry, commercial business and consumers alike – the effective integration of clean, renewable and efficient energy sources into day-to-day practices and operations should result in a positive impact on the environment, as well as balance sheets and wallets alike.

American job creation

Problem 1: Rising unemployment in the manufacturing sector due to outsourcing

According to a study supporting the case for the development of a National Manufacturing Strategy, conducted by the Information Technology and Innovation Foundation (ITIF), creating these higher-skilled, advanced manufacturing jobs is critical to the U.S. economy for five key reasons:

1. It will be extremely difficult for the United States to balance its trade account without a healthy manufacturing sector.

2. Manufacturing is a key driver of overall job growth and an important source of middle-class jobs for individuals at many skill levels.

3. Manufacturing is vital to U.S. national security.

4. Manufacturing is the principal source of R&D and innovation activity.

5. The manufacturing and services sectors are inseparable and complementary.

Manufacturing, R&D, and innovation go hand-in-hand. No country, including the United States, can outsource manufacturing while keeping the higher-value-added service activities domestically. The very nature of technology development requires co-location of these activities.

Greg Tassey, a Senior Economist at the National Institute of Standards and Technology (NIST), has written: *"When technological advances take place in the foreign industry, manufacturing is frequently located in that country to be near the source of the R&D. The issue of co-location of R&D and manufacturing is especially important because it means the value-added from both R&D and manufacturing will accrue to the innovating economy, at least when the technology is in its formative stages. Thus, an economy that initially controls both R&D and manufacturing can lose the value-added first from manufacturing and then R&D in the current technology life cycle—and then first R&D followed by manufacturing in the subsequent technology life cycle. This is the economics of decline."*

But the honeymoon may be over. The once attractive lure of significantly lower costs for manufactured products produced half a world away has begun to wane. Off-shore manufacturing companies and the workers that flowed freely between them in pursuit of rapidly escalating wages, are becoming as non-competitive as the U.S. companies that helped facilitate the influx of foreign manufacturing jobs.

However, reversing years of outsourcing and the resultant job losses to Asia and other low-cost labor markets may prove to be a challenge for the U.S. manufacturing sector, as American companies were quick to take advantage of the movement of work by capitalizing on the sale of manufacturing assets that would otherwise have been crucial in enabling the eventual return of such production opportunities back to the U.S.

That's certainly not to say that all overseas outsourcing efforts are 'bad' or that such efforts aren't beneficial to the companies selecting this approach as a part of their forward-going strategy. In fact, many companies have relocated their advanced manufacturing and development work to alternate locations to maintain proximity to their customer base.

However, as a recent article posted on GlobalPost.com states, *"For America, this could be the start of something good, according to the Boston Consulting Group. In 2011, BCG reported that, due to a number of changing economic realities — including rising salaries and economic expectations among Chinese workers, new labor, environmental and safety regulations abroad, the higher cost of energy required to ship products halfway around the world, and the US market and the uncertainties of political risk in these places — the cost benefits of producing in Asia no longer automatically outweigh the risks."*

Indeed, the BCG report predicts a "renaissance for US manufacturing" citing the fact that labor costs in the United States and Asia are expected to converge around 2015.

"Executives who are planning a new factory (abroad) to make exports for sale in the U.S. should take a hard look at the total costs," says BCG's Harold L. Sirkin, an author of the report. "They're increasingly likely to get a good wage deal and substantial incentives in the U.S., so the cost advantage might not be large enough to bother and that's before taking into account the added expense, time, and complexity of logistics."

Some examples of companies bringing work back to the U.S.:

- Caterpillar is building a $120 million plant to make giant earthmovers in Victoria, Texas, including some models that were previously built in Japan and shipped back to North American customers. The plant in Japan is now free to devote more capacity to the booming Asian market.
- General Electric reversed a decision to build a new "green" refrigerator plant in Asia and decided instead to invest $93 million in refurbishing a plant in Bloomington, Indiana, saving 700 jobs. The company followed up in 2010 by investing $80 million in a water heater plant in Louisville, Kentucky, saving another 400 jobs.
- Dow Chemical, the cash register company NCR, Sauder Woodworking and the machine tool firm GF AgieCharmilles have all brought overseas production back to the U.S. market in the past three years

Problem 2: Developing technologies in Asia equates to loss of intellectual capital

Along with transferring manufacturing ***jobs*** to low cost labor territories, American companies have also transitioned the know-how critical to the development of manufacturing ***technologies*** to these same off-shore sites. It can be argued that, where manufacturing goes, innovation follows.

In addition to its low-cost labor advantage, Asian-based companies have worked fervently to reduce the manufactured cost of their own products and have been all too willing to learn how to implement and master technological advancements developed in the U.S. to drive efficiencies within their own factories. American companies have openly offered U.S.-developed know-how, seeking very little in intellectual protection, and asking for even less in return beyond a less expensive manufactured product, effectively risking the chance of ever regaining a future competitive edge.

In fact, 90 percent of all electronics R&D now takes place in Asia, in part because firms need volume production to be able to afford general R&D. This, combined with lack of legal oversight in guarding intellectual property, increased lead times, imposition of additional duties and taxes, as well as proximity challenges to the end markets served, American companies are now awakening to the true cost of what it has given up.

As cited in the Information Technology and Innovation Foundation's (ITIF) study arguing the case for a National Manufacturing Strategy, the process of innovation and industrial loss becomes additive.

"Once one technological life cycle is lost to foreign competitors, subsequent technology life cycles are likely to be lost as well."

Examples abound of the United States losing technology leadership in one product life cycle with the result that it falls behind in subsequent technology life cycles.

For example, the United States lost leadership in rechargeable battery manufacturing technology years ago, largely because increasing demands in consumer electronics for more battery power in smaller packages largely drove innovation.

When U.S. companies abandoned the "mature" consumer electronics business, the focus of R&D manufacturing—not just for laptops and cell phones but also for advanced batteries—shifted to Asia. And, as global attention has turned toward developing energy-efficient vehicles using advanced electric batteries, Japan's and Korea's strong battery (and auto) industries have assured them of an early advantage over U.S. companies in developing electric and hybrid vehicles. Hence, GM has had to source the advanced battery for its Chevy Volt from a Korean supplier.

Likewise, the migration of semiconductor foundries to Asia has caused a sharp decline in silicon-processing and flexible-film-deposition capabilities in the U.S. Flexible-film-deposition is now a critical process in manufacturing photovoltaic solar cells, printed electronics, and battery and energy storage devices, so the U.S. increasingly risks in the development and manufacture of these next generation products. The net effect is the deepening erosion of the U.S. industrial base, the hollowing out of advanced production supply chains, and the loss, for many U.S. industries, of their "industrial commons" – the R&D know-how, advanced process development, engineering skills, and manufacturing competencies related to a specific technology. As Harvard's Willy Shih and Gary Pisano conclude,

"Decades of outsourcing manufacturing have left U.S. industry without the means to invent the next generation of high-tech products that are crucial to rebuilding its economy.

Leveraging Advanced Manufacturing and Manufacturing Development Capabilities

The U.S. is the birthplace of advanced manufacturing, in terms of technological capabilities and intellectual capital. However, we have not leveraged our technical superiority and strengths in this space. To be successful, Manufacturing Development requires skillful application of Advanced Manufacturing Technologies. And while America has surrendered well-paying manufacturing jobs to Asia, we cannot necessarily expect, nor do we want, all of those jobs back. True, meaningful job creation means bringing to life those jobs that require skilled, advanced technology positions – they develop higher capabilities and demand higher pay.

READILY AVAILABLE SOLUTIONS

Some of the solutions to these issues are readily available as a result of budding developments in the Flexible Film & Coating Technologies industry.

America's manufacturing industry footprint needs to be re-tooled to take advantage of current day applications of renewable energy sources to bolster its competitive edge against non-U.S. manufacturing hubs that are currently winning through the use of low cost labor. The horizon over which the cost of labor will inflate in these territories as a result of demand for increasingly skilled workers is quickly approaching a point where the economic advantage of placing work in countries outside of the U.S. will wane. Therefore, the development of more efficient manufacturing processes, including the increased efficient utilization of energy supporting those processes, is critical to future manufacturing success and survival in the global marketplace.

The use of flexible films offers numerous advantages in reducing the cost of energy options, and in acting as an enabler for the development of future energy alternatives. Equally important is the commercialization know-how and development center focused on bringing such technologies from proof-of-concept to commercialization.

As such, this paper will describe the Functional Film Commercialization Center located at Eastman Business Park in Rochester, NY - an existing, turn-key asset specifically designed to bring functional films solutions to life. As a nucleus of technological innovation, and rooted in a dynamic and robust history, the Functional Film Commercialization Center, as well as Eastman Business Park both house state-of-the-art infrastructure that differentiate them from other industrial facilities nationwide. Furthermore, both actively leverage their access to a richly talented labor pool in the Greater Rochester region, which has had direct experience in the efficient manufacture of thin film technologies and materials for a variety of end-use applications.

The facility is operated and being maintained and updated as a sustainable business park which will, long-term have synergistic potential between park tenants and with integrated energy and material systems that further bolster the sense of place this facility brings to the reinvention of the modern American manufacturing sector.

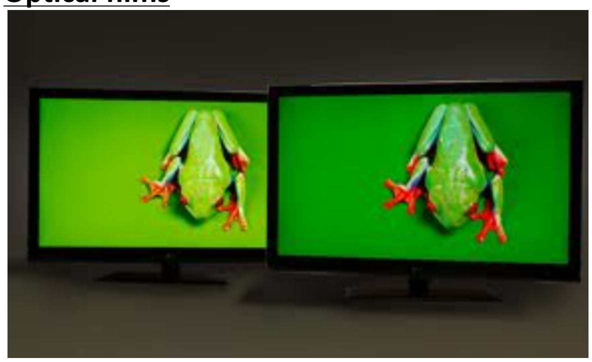
What comprises **Flexible Films & Coating Technologies**?

Flexible Films and Coating Technologies cover a very broad set of market applications – both as an end-use, product, as well as an enabling and value-adding, integrated component. It's important to note that, while this paper focuses on Flexible Films and Coating Technologies as an enabler to the development of alternative and clean energy solutions, Flexible Films has the potential to create many jobs in a variety of market segments, including: automotive, consumer electronics, medical and pharmaceutical, display technologies, window films, etc. Specifically, roll-to-roll produced flexible film products have the potential to provide breakthrough technology in a number of market segments beyond clean technology. Multiple functionality combined in a single, low cost film creates a competitive advantage that can be leveraged into a number of devices. In the past several years there has been significant activity in the development of flexible films in the following technology areas:

Electronic Films

- Transparent conductors
- Patterned conductive layers
- EMI shielding

Optical films



- Display films (polarizers, retarders, brightness enhancers)
- Lighting film (filters, diffusers)
- Window films (passive solar, filters, tinting)
- Holographic display films
- Electrochromographic films (changes color when a current is applied)

Medical and diagnostic films

- Detection films (presence of certain biological agents)
- Monitoring films (e.g. glucose level)

Security films

- Anti-counterfeiting
- Identify verification/protection

Packaging films

- Functionalized substrates (moisture and oxygen barriers, UV protection, smart functions, etc)
- Functional materials added to commodity substrates
    - Contamination indicators
    - Embedded electronics (RFID, LED)

Environmental films

- Anti-pollution filter media
- environmental detection films

Flexible Films and Coating Technologies in Renewable Energy Applications

The development of flexible films and coated materials to facilitate the manufacture of highly-efficient products for enabling integrated sources of alternative energy is on the rise. *"Alternative Energy Applications integrating thin film technology has grown by X % and represents Y$ globally. The U.S. stands to benefit from having national resources dedicated to the R&D, manufacture, and distribution of thin films from a global competitiveness, economic, and energy security point of view.*

Flexible films have enabled significant advancements in the development of the following technologies, each of which will be described in this paper:

- Ultracapacitors for energy storage
- Lithium ion batteries
- Photovoltaic cells
    - Flexible
    - Organic
    - Inorganic
- Silicon anti-reflective coatings
- Fuel cell membranes and electrodes

For each of the technologies described, we will investigate the market advantages of utilizing flexible films in the manufacturing of these applications and inherent production challenges, as well as next steps toward enabling commercial application of these market-leading advances.

Flexible Films and Ultracapacitor Development

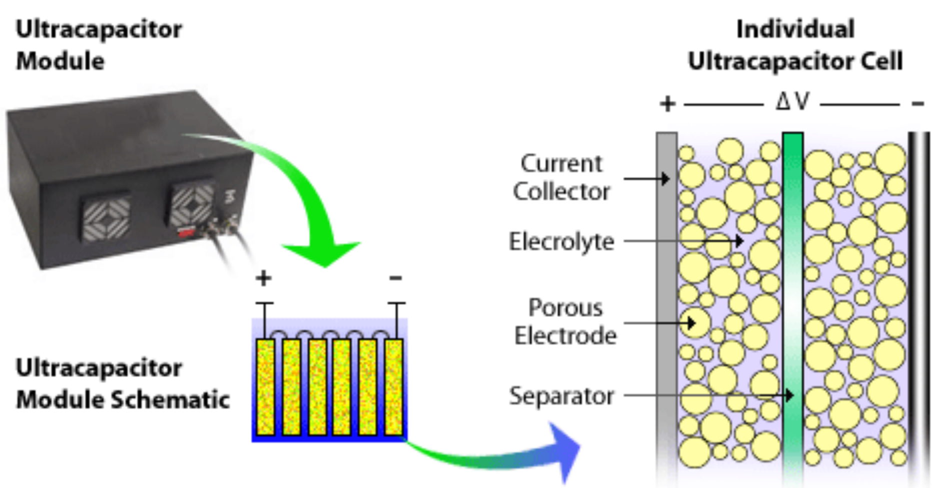
Ultra Capacitors are part of a foursome of energy storage and generating technologies that also include Batteries, Fuel Cells, and Electrolysers. Each of these technologies has, at their core, flexible film coatings of various materials. The key to these technologies becoming widespread and commercially viable at high volume will be the reduction of costs through both material improvements and manufacturing yields.

Many applications can benefit from ultracapacitors, whether they require short power pulses or low-power support of critical memory systems. Ultracapacitors can be primary energy devices for power assist during acceleration and hill climbing, as well as for recovery of braking energy in transportation applications. An ultracapacitor used in conjunction with a storage battery combines the power and performance of the former with the greater energy storage capability of the latter. It can extend the life of a battery, save on replacement and maintenance costs, and enable a battery to be downsized. At the same time, it can increase available energy by providing high peak power whenever necessary.

Technology Description

The ultracapacitor, also known as a double-layer capacitor, polarizes an electrolytic solution to store energy electrostatically. Though it is an electrochemical device, no chemical reactions are involved in its energy storage mechanism. This mechanism is highly reversible, and allows the ultracapacitor to be charged and discharged hundreds of thousands of times.

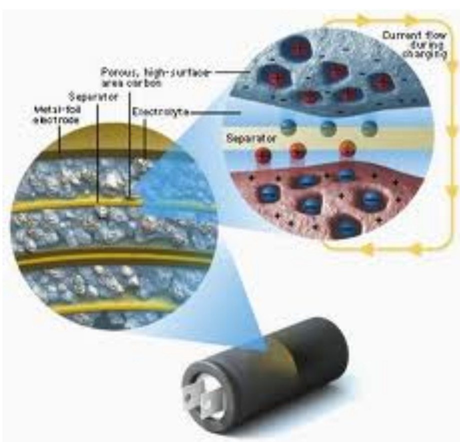
Like an ordinary capacitor, an ultracapacitor has two plates that are separated. The plates are made from metal coated with a porous substance such as powdery, activated charcoal, which effectively gives them a bigger area for storing much more charge. In an ordinary capacitor, the plates are separated by a relatively thick dielectric made from someflexibleg like mica (a ceramic), a flexible plastic film, or even simply air. When the capacitor is charged, positive charges form on one plate and negative charges on the other, creating an electric field between them. The field polarizes the dielectric, so its molecules line up in the opposite direction to the field and reduce its strength. That means the plates can store more charge at a given voltage. That's illustrated in the diagram you see here.

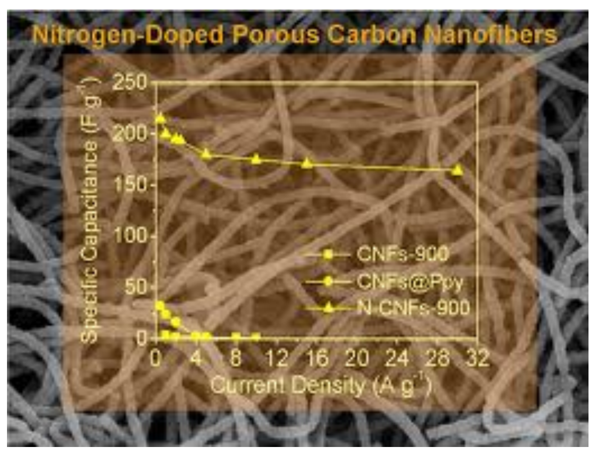


In an ultracapacitor there is no dielectric as such. Instead, both plates are soaked in an electrolyte and separated by a very flexible insulator (which might be made of carbon, paper, or plastic). When the plates are charged up, an opposite charge forms on either side of the separator, creating what's called an electric double-layer, maybe just one molecule thick (compared to a dielectric that might range in thickness from a few microns to a millimeter or more in a conventional capacitor). This is why ultracapacitors are often referred to as double-layer capacitors, also called electric double-layer capacitors or EDLCs).

Once the ultracapacitor is charged and energy stored, a load can use this energy. The amount of energy stored is very large compared to a standard capacitor because of the enormous surface area created by the porous carbon electrodes and the small charge separation (10 angstroms) created by the dielectric separator. However, it stores a much smaller amount of energy than does a battery. Since the rates of charge and discharge are determined solely by its physical properties, the ultracapacitor can release energy much faster (with more power) than a battery that relies on slow chemical reactions.

The first ultracapacitors were made in the late 1950s using activated charcoal as the plates. Since then, advances in material science have led to the development of much more effective plates made from such flexiblegs as carbon nanotubes (tiny carbon rods built using nanotechnology), graphene, aerogel, and barium titanate as seen below.





Manufacturing Requirements

The requirements for making Ultracapacitors, Batteries, Fuel Cells, and electrolysers all are focused on flexible coatings of specialty materials. The precision and placement of these materials is paramount to the performance and life of these devices as well as being a substantial element of the product cost. As new materials are developed the manufacturing processes for continued precision and quality will need to be developed. Additional performance will be able to occur as increased density of the basic materials can be increased.

Flexible Films and Battery Development

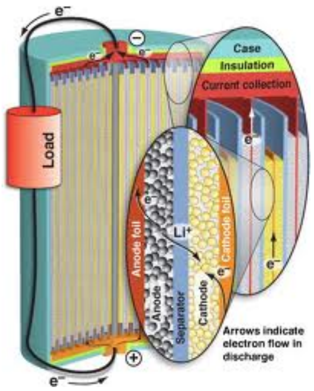
The battery industry is expanding rapidly in both the grid and transportation sectors. The drive for increased energy efficiency on the road and the ability to store off peak electricity makes batteries one of several key technologies that are being exploited in many industries. The current technology leaders are applications using Li-Ion technology. There are many new chemistries being developed around Li and all of them require flexible coatings applied to both sides of various separator materials. To realize cost potential very high volume roll to roll processing capability will be required. The inherent capabilities of the Rochester Flexible Film Manufacturing Technology Center have just such expertise. Additionally, the ability to both analyze the new materials as well as develop them will be a critical parameter for the commercialization of the complete evolution of Li Chemistry battery technologies and beyond.

The processes used for manufacturing Lithium batteries are very similar to those used in the current production of Nickel Cadmium cells and Nickel Metal Hydride cells with some key differences associated with the higher reactivity of the chemicals used in the Li cells -
http://www.mpoweruk.com/battery_manufacturing.htm

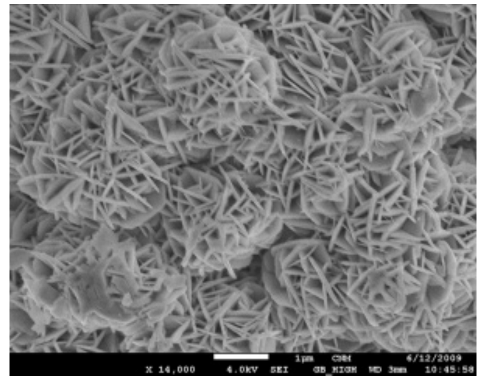
Technology Description

Li-Ion Batteries are generally much lighter than other types of rechargeable batteries of the same size. The electrodes of a lithium-ion battery are made of lightweight **lithium** and **carbon**. Lithium is also a highly reactive element, meaning that a lot of energy can be stored in its atomic bonds. This translates into a very high **energy density** for lithium-ion batteries. Here is a way to get a perspective on the energy density. A typical lithium-ion battery can store 150 watt-hours of electricity in 1 kilogram of battery. A **NiMH (nickel-metal hydride) battery** pack can store perhaps 100 watt-hours per kilogram, although 60 to 70 watt-hours might be more typical. A **lead-acid battery** (like the cranking battery in your car) can store only 25 watt-hours per kilogram. Using lead-acid technology, it takes 6 kilograms to store the same amount of energy that a 1 kilogram lithium-ion battery can handle. That's a huge difference.

The anodes and cathodes in Lithium cells are of similar form and are made by similar processes on similar or identical equipment. The active electrode materials are coated on both sides of metallic foils which act as the current collectors conducting the current in and out of the cell. The anode material is a form of Carbon and the cathode is a Lithium metal oxide. Both of these materials are delivered to the factory in the form of black powder and to the untrained eye they are almost indistinguishable from each other. Since contamination between the anode and cathode materials will ruin the battery, great care must be taken to prevent these materials from coming into contact with each other. For this reason the anodes and cathodes are usually processed in different rooms.



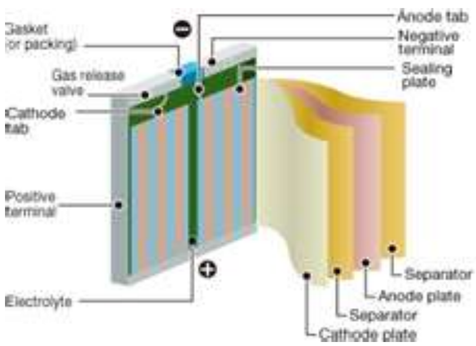
Li-Ion Battery Architecture



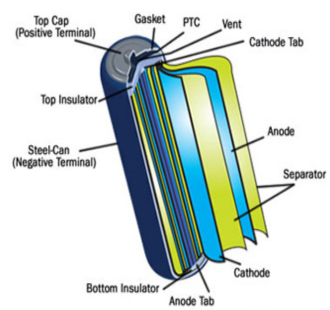
Li-Ion Anode structure

Particle size must be kept to a minimum in order to achieve the maximum effective surface area of the electrodes needed for high current cells. Particle shape is also important. Smooth spherical shapes with rounded edges are desirable since sharp edges or flaky surfaces are susceptible to higher electrical stress and decomposition of the anode passivating SEI layer, which can lead to very large heat generation and possible thermal runaway when the cells are in use.

The metal electrode foils are delivered on large reels, typically about 500 mm wide, with copper for the anode and aluminum for the cathode, and these reels are mounted directly on the coating machines where the foil is unreeled as it is fed into the machine through precision rollers. Batteries can be configured in either cylindrical or prismatic cells.



Prismatic type cell



Cylindrical Cell

Cell Assembly

In the best factories cell assembly is usually carried out on highly automated equipment; however there are still many smaller manufacturers who use manual assembly methods.

The first stage in the assembly process is to build the electrode sub-assembly in which the separator is sandwiched between the anode and the cathode. Two basic electrode structures are used depending on the type of cell casing to be used, a stacked structure for use in prismatic cells and a spiral wound structure for use in cylindrical cells.

Formation

Once the cell assembly is complete the cell must be put through at least one precisely controlled charge / discharge cycle to activate the working materials, transforming them into their useable form. Instead of the normal constant current - constant voltage charging curve, the charging process begins with a low voltage which builds up gradually. This is called the Formation Process. For most Lithium chemistries this involves creating the SEI (solid electrolyte interface) on the anode. This is a passivating layer which is essential for moderating the charging process under normal use.

During formation, data on the cell performance such as capacity and impedance, are gathered and recorded for quality analysis and traceability. The spread of the performance measurements also gives an indication of whether the process is under control. (Beware of manufacturers who use this process for sorting their cells into different performance groups for sale with alternative specifications).

Although not the prime purpose of formation, the process allows a significant percentage of early life cell failures due to manufacturing defects, the so called "infant mortalities", to occur in the manufacturer's plant rather than at the customers' premises.

Manufacturing Requirements

Tight tolerances and strict process controls are essential throughout the manufacturing process which involves high speed roll to roll coatings and assembly. Contamination, physical damage and burrs on the electrodes are particularly dangerous since they can cause penetration of the separator giving rise to internal short circuits in the cell and there are no protection methods which can prevent or control this. Manufacturing expertise in flexible films will help drive down costs and minimize material usage as well as insure repeatability from part to part at high volume.

Flexible Films and Solar Technology Development

Among Renewable sources of energy to satisfy the demands of our society, the abundance of sunlight offers enormous potential both as a source of thermal and a source of electrical power. Photovoltaic (PV) cells afford the direct conversion of incident sunlight into electricity via the photoelectric process. Largely a semiconductor process, the absorption of a photon by a semiconductor material creates a charge carrier, which becomes mobile, moving from atom to atom, past a semiconductor junction, where it exits as an electron, capable of providing electric current, due to a potential formed across the semiconductor junction. See Figure 1.

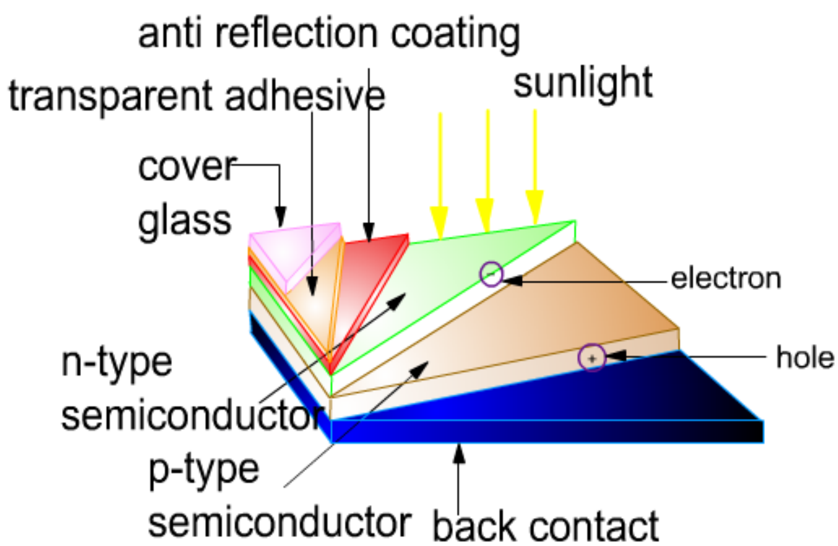


Figure 1 (Source: http://library.flexiblekquest.org/03oct/02144/glossary/solar_cells.html)

Early efforts to harness the Sun's power for electricity included silicon PV cells, consisting of crystalline silicon, formed into semiconductors. Even early devices exhibited relatively high efficiency, in the area of 20% of the incident light converted into useful power. Different silicon materials (mono- and poly-crystalline) and different junction arrangements yielded higher efficiencies (approaching 50%), but at the sacrifice of higher cost. As experiments progressed the manufacturing technology grew with progress, enabling relatively large "rods" of silicone, typically monocrystalline, to be produced, sawn into wafers, and sandwiched between two pieces of glass to form a solar cell. External electronics afforded control and direction of current, as well as electromechanical positioning of the PV cell, in order to efficiently capture maximum sunlight as time passed. The cell and its current carrying and positioning components comprised as solar cell system. While approaching reasonable efficiency, the cost of production has remained high, with systems affording the lowest cost at around $10/watt. In 2012, China has undertaken questionable economic policies (dumping) to bring crystalline silicon panels down to $1/watt, $2 to the customer, that have resulted in driving installed costs down, albeit artificially[1].

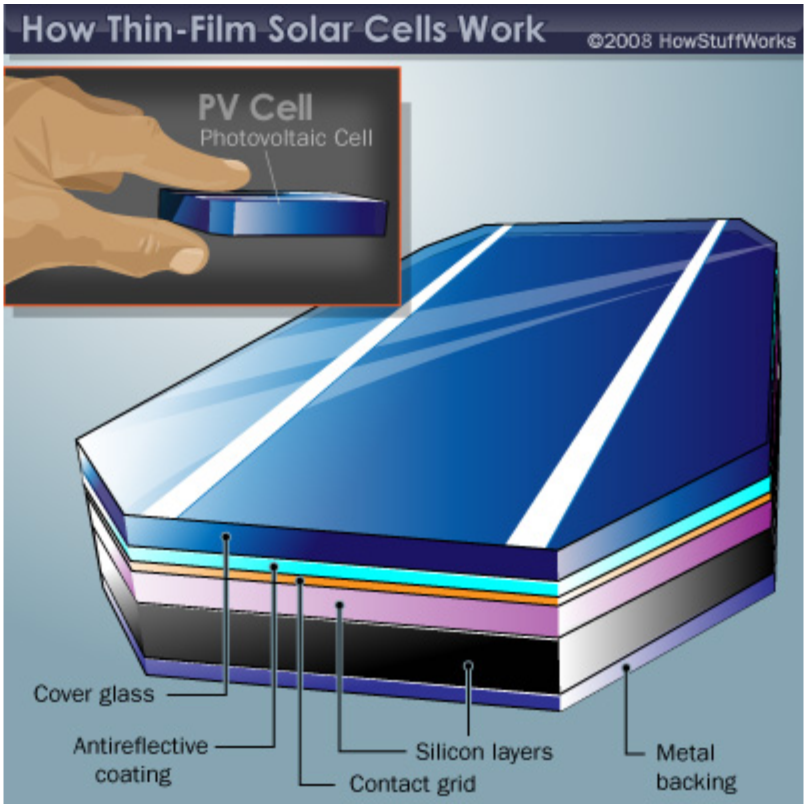


Figure 2 Flexible Film Solar Cell(http://science.howstuffworks.com/environmental/green-science/flexible-film-solar-cell.htm)

A majority of the World has adopted and is developing solar energy systems using the silicon technology. In the US, attention has turned to Flexible Film photovoltaics, where the semiconductor consists of newly discovered materials such as Cadmium Telluride (CdTe) and Cadmium Indium Gallium Diselenide (CIGS), and the the semiconductor junction is formed in layers, as shown if Figure 2..
One of the bright promises of flexible film solar cells includes cost. By 2008, solar cells made of CdTe had dropped costs to $1.14/ watt, and by 2011, CIGS cells were manufactured in California at a cost of $0.99, resulting in systems installations in Germany at $3/watt. Most recently**,** the high-tech engineering firm Manz (Reutlingen, Germany) has achieved a technological breakthrough: its integrated production line for CIGS flexible-film solar panels, the Manz CIGSfab, can be used to manufacture solar panels that in the future will supply power costing between four euro cents (Spain) and eight euro cents (Germany) per kilowatt hour (Levelized Cost of Energy, LCOE), depending on the location, the company reports[2].
The greatest promise of the future is the cost of organic materials, such as Fullerene-Polymer-Polyethylene terephthalate(PET) are dissolved in solution, such as chlorobenzene (CB) and sprayed onto a film substrate, to form a flexible, low cost, flexible solar cell, as depicted in Figure 3.

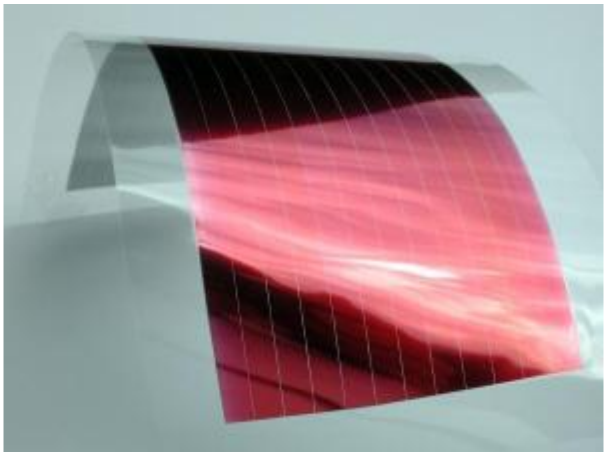


Figure 3 – Flexible film solar cell (Source: ScienceDaily 2/10/08)

The operation of the organic photocell is diagramed in Figure 4, below.

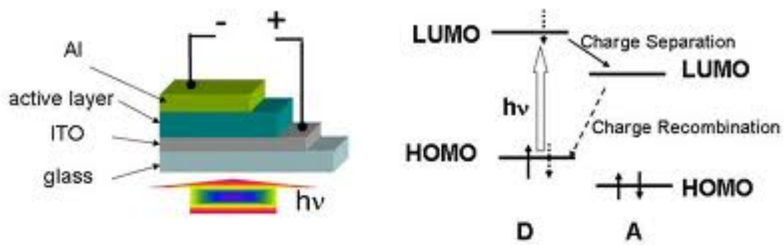


Figure 4. Organic photocell operation (.http://staff.science.nus.edu.sg/~chmxqh/research.html)

The drawback has been low efficiency. By mid-2010, organic PV cell efficiencies remained in the 5% area, as evidenced by Figure 5, which shows relative efficiencies of all of the configurations of cells to mid 2011. ON September 10, 2012, a German company reported a new world record for organic photocell efficiency of 10.7% , indicating 15% was reachable wiflexible 5 years.

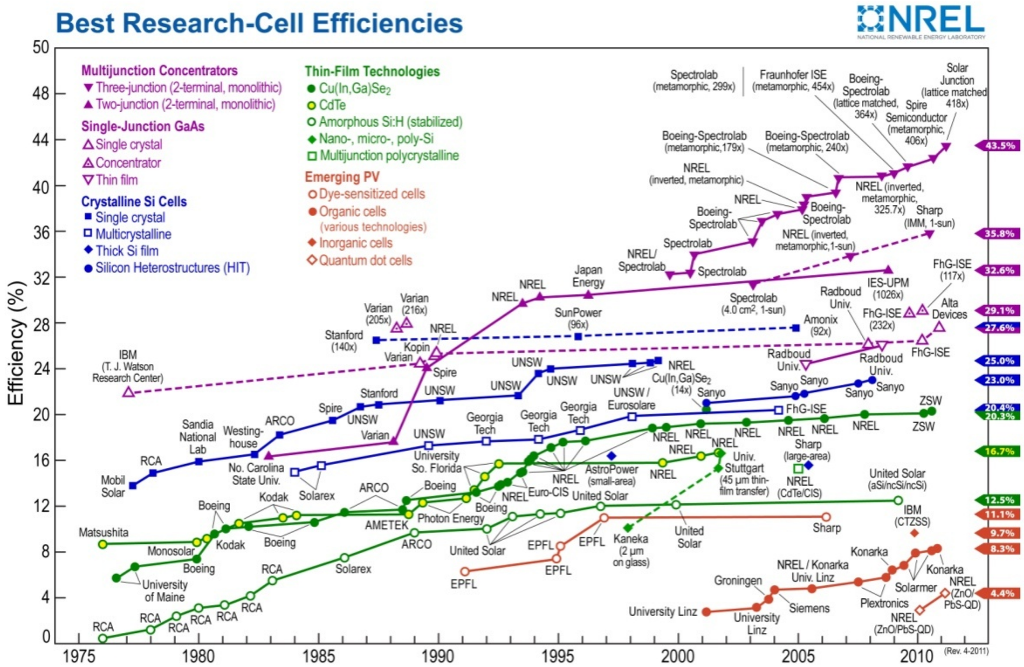


Figure 5. Various Photovoltaic Cell efficiencies.(Source Wikipedia, reprint from NREL)

Flexible films will play a major role in the further development of solar cells, particularly in the organic arena, where the semiconductor material is sprayed onto a film substrate. A polycarbonate film may be employed as the entry layer, instead of more costly glass. Beside cell material construction, Films may be deployable as a means to concentrate sunlight onto arrays of photocells, optically. Film- based Fresnel lenses are easily and inexpensively formed, and are capable of increasing efficiencies greatly, In a configuration as shown in Figure 6, below.

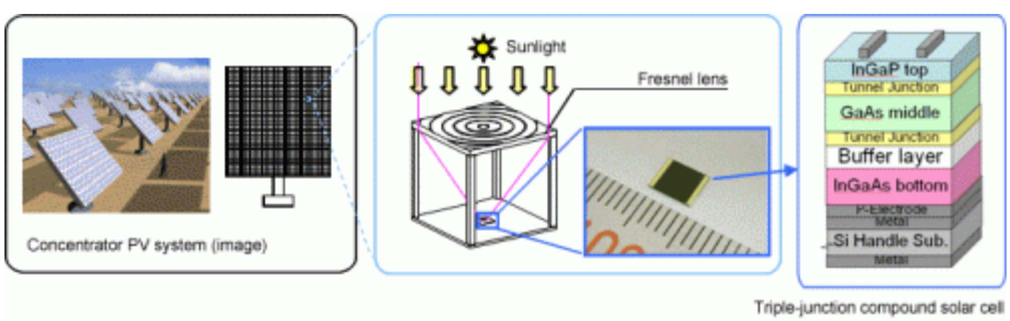
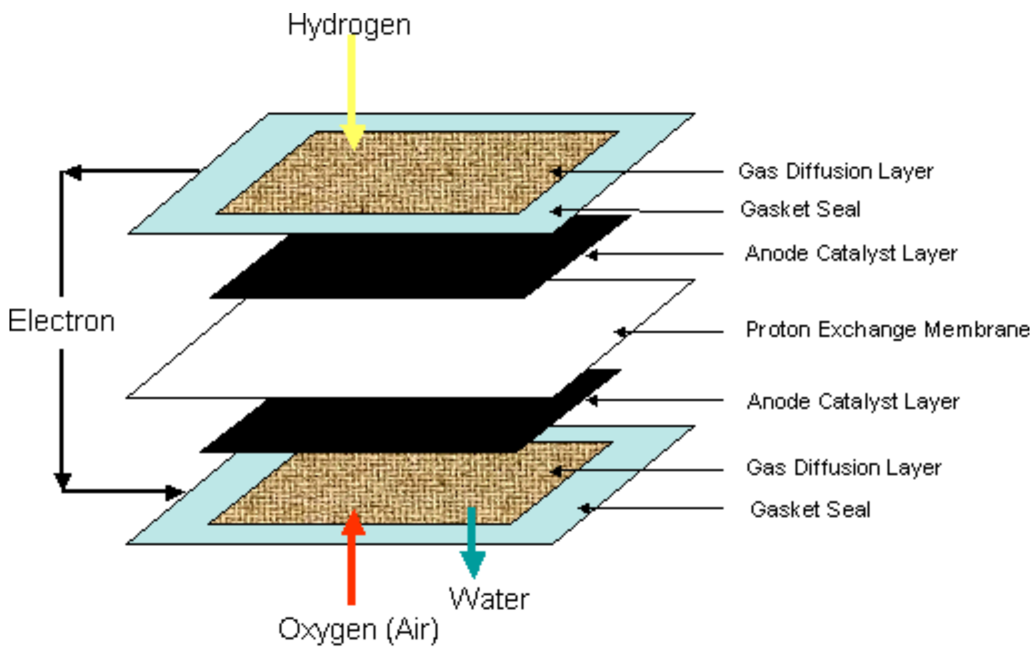


Figure 6 Concentrator Solar Cell arrangement. (http://sharp-world.com/corporate/news/120531.html)

In May of 2012, a multi-junction solar cell with a Fresnel lens set a record-breaking efficiency of 43.5%. Lastly, research may provide the keys to unlocking more potential of solar cells. Advances in functional printing, printed circuitry (already used to fabricate organic PV's) and low-temperature sintering techniques may facilitate a return to complex, silicon, high-efficiency photovoltaic cells. Flexible Film Commercialization Center may play a key role in the research and fabrication of next-generation PV materials and cell production methods, achieving efficiencies greater than 50 % In a low-cost, flexible, solar cell.

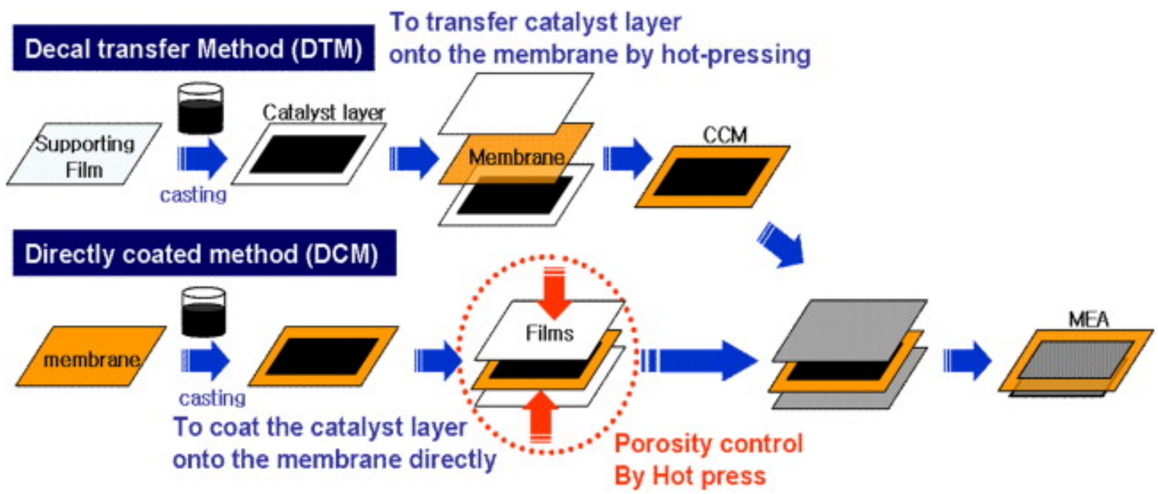
Flexible Films and Fuel Cell Development

The most important part of the PEM fuel cell is the membrane electrode assembly (MEA). Due to this and to the catalyst costs, many researchers have been studying the membrane and electrode assembly manufacturing processes that can reduce the content of Pt in the electrocatalyst layer while maintaining the performance. The MEA is the heart of the PEMFC and catalyst plays an important role into the fuel cell operation. The MEA consists of a proton exchange membrane, catalyst layers and gas diffusion layers (GDL).



■ Construction of MEA (Membrane Electrode Assembly)

There are different methods to make a MEA. The most employed methods are thin-film methods. In this method it is necessary to prepare an ink with the catalyst. This ink can be directly coated to the membrane. When the coat is made, it is necessary to dry the membrane under vacuum at temperature. Alternatively, the catalyst layer can be applied using a transfer printing method in which the catalyst material is coated to a PTFE blank. A subsequent catalyst layer is then decaled on to the membrane. Another method is to spread a thin film of catalyst slurry either onto the gas diffusion layer or the membrane. The assembly between gas diffusion layer and membrane is made by hot pressing or rolled.



The Flexible Films Commercialization Center at Eastman Business Park

As important as the advancement of Flexible Film applications is, little of the technological advantages can be realized in the absence of the capability to bridge the gap from proof-of-concept through to global-scale manufacturing. That is why it is important to harness the major breakthroughs and game-changing innovations taking place at the intersections of materials science, chemistry, and engineering, in concert with advanced manufacturing methods.

Many of the 21st Century business opportunities related to energy, clean tech, and functional printing require the same strong technology foundation and manufacturing capabilities of companies with well-established material manufacturing/integration capability, and manufacturing infrastructure and capacity. Today, these capabilities can be applied in the development of: optical and specialty films; batteries; fuel cells; ultra capacitors; solar; flexible electronics; highly conductive films; and light filtering films (e.g. window applications).

The **Flexible Films Commercialization Center at Eastman Business Park** leverages these key capabilities, enabling future jobs growth and utilizing existing capacity.

Located at Eastman Business Park in Rochester, NY, this manufacturing technology innovation hub would possess world-class expertise at one, centralized site, and offer: pilot/testing; deposition expertise and assets in printing and coating; roll-to-roll manufacturing capabilities; materials, formulation and scale.

Providing access to state-of-the-art manufacturing/manufacturing capability (people and equipment), the Center is placed where advanced materials can be moved into well-understood manufacturing processes. As such, it helps fill a vital role in the commercialization continuum, translating technology investment into manufacturing and jobs growth by connecting organizations that have innovative concepts or prototypes with the Center's technical know-how, scale-up and assets.

The primary advantages of utilizing the Center's capabilities:

1. Manufacturing efficiency – enabling the production of high speed, low waste, multi-layer structures
2. Technical superiority – advanced practical application of deposition and curing technology
3. Commercialization Expertise - bridging the gap from innovation to market reality
4. Strategic Alliances and Partnerships – providing support now and well into the future

Manufacturing Efficiency

High speed deposition

The emphasis should be on high-speed deposition techniques that can be run using a continuous-feed, roll-to-roll process. CVD (chemical vapor deposition) and vacuum coating methods are slow and generally run in a batch mode one roll at a time. Replacing films made by vacuum or chemical vapor methods with films made using higher speed deposition techniques could significantly disrupt existing markets and pull manufacturing volume back into the US.

Low waste

Use of high-tech analytical and process measurements can enable precision control of key material and manufacturing variables. This will result in low waste and high yields.

Multi-layer structures

Films with multiple layer structures can be made at low cost by coating them in a single pass through multi-station coating machines. Using this type of manufacturing process would enable device manufacturers to streamline their assembly process and reduce their product cost by replacing multiple films with a single film with multiple functionalities.

Technical superiority

Novel deposition technology

Development of the equipment and materials required to enable coating materials, structures, or patterns that are not possible with "generic" methods widely used in the coating industry around the world.

Novel curing technology

Development of the equipment and materials required to enable rapid, in-line curing of coated materials to enable the desired performance features. This is especially important in the development of high speed deposition of metals on flexible substrates.

Commercialization Expertise

The expanded pool of resources available at **The Flexible Films Commercialization Center at Eastman Business Park** (assets, technical expertise, funding, research guidance, government interactions, etc.) is well-positioned to help innovators to move projects through development and to successful commercialization, stimulating the creation of high-tech jobs for prototyping and commercial scale manufacturing of these technologies. The Center's unique vertically integrated structure successfully facilitates control over each step of the commercialization process, from material synthesis through pilot coating and printing to commercial scale manufacturing. Customers can be assured they will receive consistent, superior, high-quality products that can be sold as an initial offering into their target markets. This vertical integration enables new flexible film products to get to market and begin earning revenue with a minimal amount of capitalization. If market acceptance is demonstrated and product volumes grows, then companies can expand using their own funds to capitalize this growth.

<u>Strategic Alliances and Partnerships</u>

At **The Flexible Films Commercialization Center at Eastman Business Park**, partners have access to years of experience in driving innovation from proof-of-concept through to high-scale manufacturing. This includes sound knowledge on the challenges of manufacturing flexible films.

We have interacted with over 100 companies looking for help in bringing a flexible-film, roll-to-roll manufactured product to the marketplace. In general, these companies have a defined (usually patented) material technology with demonstrated performance feature that has a defined market need. What they lack (almost all of them) is an understanding as to what is needed to bring these product concepts into full-scale commercial manufacturing. Typically, they demonstrate their product concept using a lab generated device that was made with a process that would not be economically viable in the marketplace.

In order to commercialize their product concept, technologies typically need additional development work in the following areas:

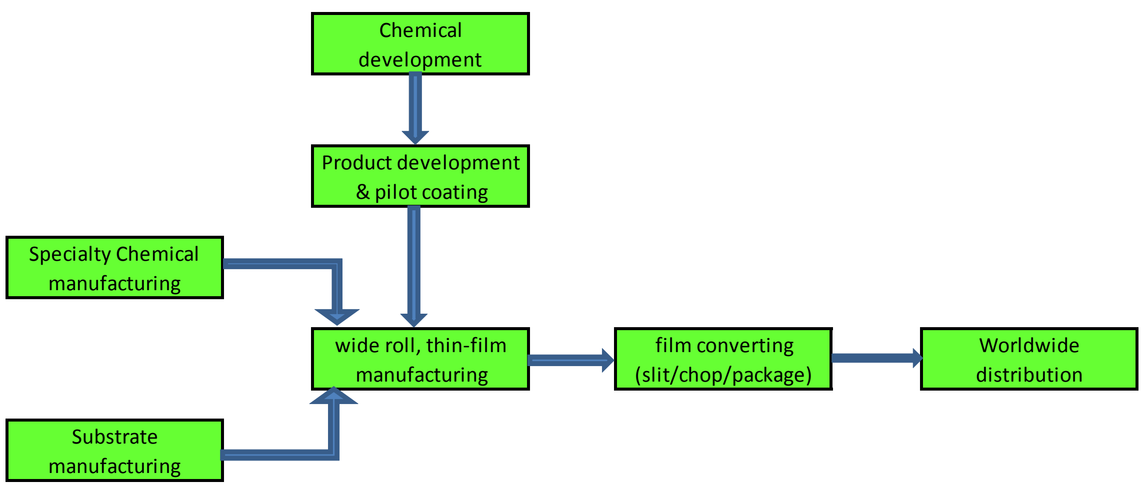
1. Material/formulation optimization to enable the materials to perform properly when exposed to the shear rates that are typical of a R2R manufacturing process.
2. Manufacturability assessment of the expected reliability, manufacturing speed, and yields in order to determine the economic viability of the product concept
3. Manufacturability development to maximize the manufacturing efficiency and develop a manufacturing manual and quality control process
4. Evaluation of customer-usage-based performance of the product, specifically the impact of environmental conditions and aging.

Most emerging companies lack the proper understanding of the scope of the work required to successfully navigate through the above issues.

More significantly, these companies lack the assets required to complete this work. Some have tried to build their own assets, but this strategy drains cash and consumes valuable time. Once the assets are on-line, the companies typically lack the expertise and experience required to use the equipment in the most efficient manner. The cash and energy of an emerging technology is better spent refining their materials and developing a viable go-to-market strategy (preferably in partnership with an end user of the envisioned product).

EBP is well positioned to provide the capability required to create a flexible-film based innovation accelerator to aggressively push the commercialization of flexible-film, roll-to-roll manufactured products. Existing assets and expertise are available to provide this function right now. Additionally, Kodak can provide assets and expertise to do initial manufacturing of a number of products and technologies at a cost effectiveness that will allow the product manufacturing to remain in the US. The facilities at EBP offer all that is required to get a flexible-film product to market and generating revenue. This would enable emerging companies to establish a positive balance sheet and focus on growing their market share. Once the product volumes grow large enough, they will have both the cash and the knowledge to create their own manufacturing process to meet their expanding needs.

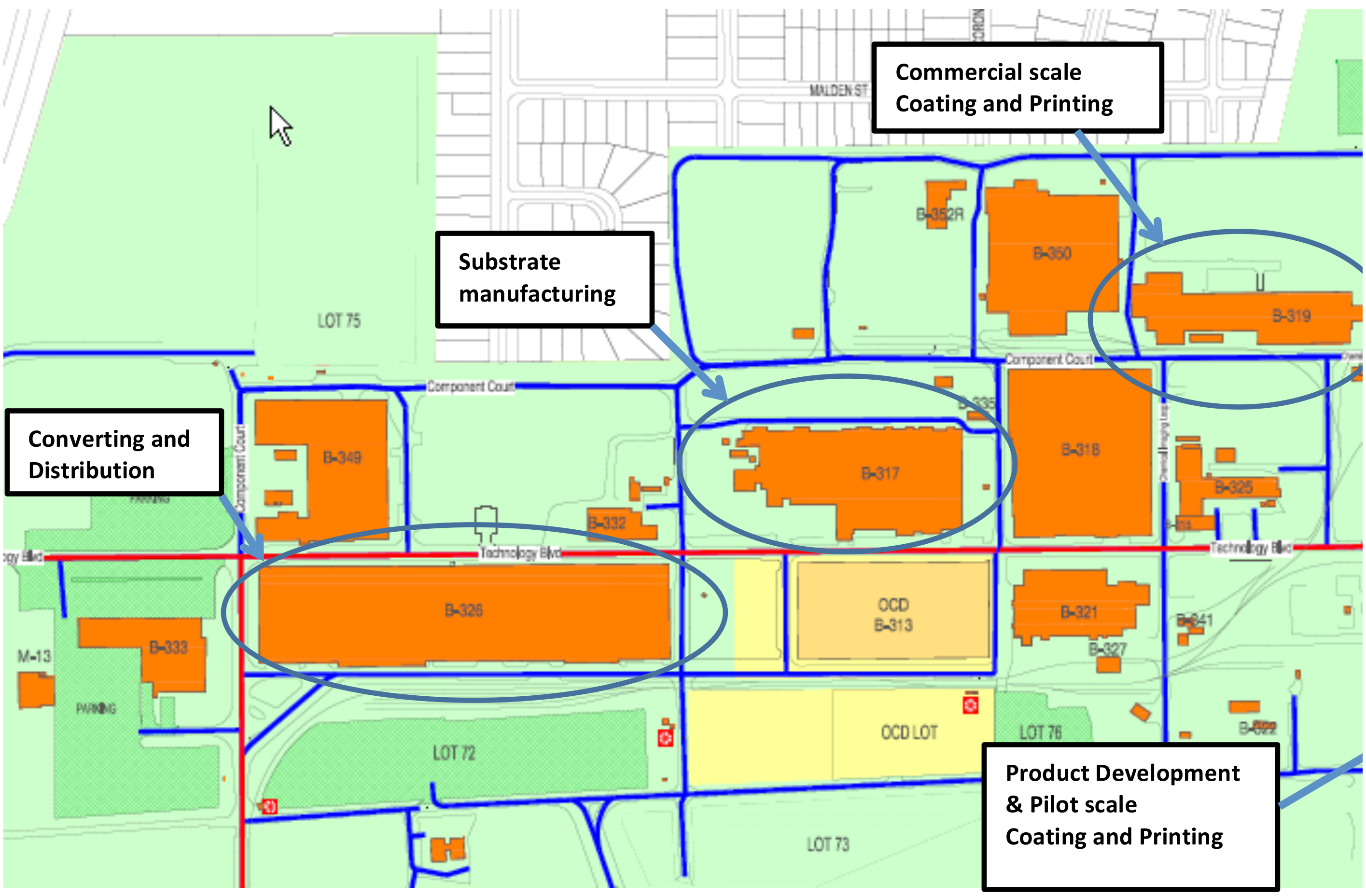
The capabilities that exist at EBP are highlighted in the diagram below.



Companies would have the option of using these capabilities in any combination that made the most economical sense to their product commercialization needs. For example, substrates and chemicals can be sourced externally and still coated in the wide roll manufacturing plant. Similarly, converting operations could be done externally to Kodak, with Kodak providing wide rolls of product to an identified vendor for subsequent product converting and assembly.

A unique feature of the EBP capabilities is the fact that all of these functions are housed in a contiguous set of building on the Eastman Business Park site (see site map below). This co-location greatly simplifies the logistics of manufacturing and distributing a product, and thus reduces the final manufacturing cost.

<u>**Eastman Business Park**</u>



At the heart of this capability is the pilot and manufacturing coating facilities. These facilities can produce films from a wide range of materials over a wide range of configurations (thicknesses, patterns, # layers, etc) using a wide variety of deposition techniques.

The pilot facility is designed to develop the product from benchtop product concepts to fully commercialized products ready for sale. The specific capabilities available are:

For thermoplastic materials:

Compounding - Blending of materials to make customized thermoplastic resins

Extrusion Casting - Creation of films from 10 to 1000 microns from thermoplastic resins. Composite films with up to 3 distinctive layers are possible.

Extrusion Coating - Addition of up to 3 layers of a thermoplastic material onto a variety of paper and plastic substrates.

Bi-axial stretching - Apply stretch ratios up to 4:1 in both the x an y axis over a wide range of temperatures.

For aqueous and solvent based solutions (pumpable liquids):
Solution preparation/mixing - Blend and disperse a variety of materials and particle sizes into a wide range of organic solvents.

Gravure coating - Direct, reverse, offset gravure using pan, weir, or pressure applicators
Gravure printing - Custom patterning using direct gravure
Flexographic printing - Custom patterning using Kodak's state-of- the -art Flexcel NX system
Slot die coating - Precision deposition of continuous or striped patterns over wide range of thicknesses
Slide/cascade coating - Simultaneous, multi-layer deposition of materials
Curtain coating - High speed deposition of multi-layer coatings
Rod/Blade coating - High speed deposition of viscous materials
Dip coating - Multi-tank dip processor for ion exchange and plating type applications

All of these capabilities are available in both small and intermediate scales. These two scales are ideal for commercializing a new material from the bench top to first-run manufacturing.

Small-scale for material development
This equipment can create samples with solution volumes as low as 500 ml. The equipment is designed to efficiently screen many materials variations using a representative shear rate.

Intermediate-scale for process development/manufacturability
This equipment can create samples at line speeds that equal or exceed what is possible in commercial-scale processes. The equipment is designed to develop manufacturing process specifications and accurately determine the most economical manufacturing configuration. If final product format has a dimension of 16" or less, this equipment can also be used for commercial manufacturing of the product.

The manufacturing facility is designed for high volume, commercial manufacturing of most flexible-film products. This facility can produce flexible-film products at widths up to 60” and speeds up to 1000 fpm. Eight in-line coating stations enable the manufacture of a multi-layer product design in a single pass through the machine. These features (width, speed, multiple stations) enable the low cost manufacture of complex product designs.

All together, these facilities located on the EBP site offer a great opportunity to develop new flexible-film-based product concepts and create companies who generate a positive cash flow with a minimal amount of initial capitalization. Once successful, these companies can capitalize their business with their own funds, thus limiting the dependence upon government and venture funding sources.

What they're already saying about The Flexible Films Commercialization Center:
The flexible film capabilities at EBP have been leveraged by a variety of companies over the past 3 years. These companies range from start-ups to Fortune 100 companies who are looking to expand their product lines, but are unable to invest the required time or money to create the capital assets required to enable that growth.

Feedback from companies that have used the EBP capability over the past 5 years have discovered its differentiated value, as compared to other alternatives that offer similar services. Here are a few examples of where Eastman Business Park demonstrates a clear advantage.

1. ***Connected services – one-stop-shop***
   All required services are located within the EBP campus. This significantly reduces development time and the costs and inefficiencies associated with travel and shipping.

2. ***Full range of process scales – bench to commercial manufacturing***
   You do not need to change service providers as you move from material development to manufacturability assessment to commercial manufacturing. You can stay with the same people on the same site through the entire commercialization process.

3. ***Wide range of process options***
   Developing the optimum process for an emerging product concept is a critical part of the commercialization process. Typically, several process options are trialed prior to selecting the most robust and economical methods. EBP assets offer a wide range of methods and equipment across all phases of the manufacturing process, thereby enabling a rapid screening and selection process.

4. ***Technical experience and know-how***
   The critical factor in developing a manufacturable product is the understanding of the interaction between the materials and process equipment being used to convert that material into a flexible film product. Resources at EBP understand both the equipment and the materials, and offer valuable insight into how to optimize both to most effectively commercialize the product.

The Flexible Films Commercialization Center at Eastman Business Park enables fulfillment of the objectives of the Alliance for American Manufacturing, which has identified key steps toward for reversing the current trends in manufacturing and R&D job loss, including,

- Establish a manufacturing investment facility to leverage private capital for domestic manufacturing
- Expand and make permanent clean energy manufacturing tax credits and industrial energy efficiency grants to allow America to lead on green job creation
- Make permanent the research and development tax credit and enhance it to incentivize commercialization and production in America
- Focus federal investments in new technology and workforce training on promoting regional clusters of innovation, learning and production

This long-term public-private partnership between industry and universities enabled by Government provides shared facilities open to industry, forming an innovation ecosystem, stimulating cooperative ventures and providing technology entrepreneurs with straighter, faster, more efficient and economical pathways to develop their businesses.

By speeding their progress to the marketplace, **The Flexible Films Commercialization Center at Eastman Business Park** is actively transforming some of the world's largest and most essential industries, providing environmental benefits, reducing energy costs, enhancing job creation efforts, and acting as powerful economic drivers.

Moving Forward…

The development and production of flexible, functional films is a large and growing opportunity in a wide variety of market and technology segments, especially those in the emerging clean technology sector. While there are a growing number of materials innovations in these technology/market areas, there have not been many breakthroughs in terms of U.S.-based revenue-generating products with a measurable impact on job creation or our dependence on non-renewable energy sources.

A major reason for the difficulty in getting these material technologies into profit-generating flexible film products is the lack of assets and expertise in the area of flexible film development and manufacturing. Millions of dollars of private and government funding have been spent in this area, but these facilities are too specific in their design and often lack the proper technical expertise to make the most effective use of the tools. Additionally, many of these facilities are not available to the community of users who need them to commercialize their film products.

> Fortunately, the problems we've been facing are already solved. A full range of flexible film development and manufacturing assets is available now at the EBP. These assets are operated by personnel with decades of experience at using the equipment and capabilities to convert materials into flexible films. Emerging companies and products can get to market with breakthrough products made at disruptively low costs and with little capitalization. Once established, these companies can "graduate" from the flexible film commercialization center and leverage the revenue they are generating to grow and capitalize their business on their own. Meanwhile, the flexible film commercialization center would be moving on to support the development and initialization of the next generation of flexible film products and businesses.