

## *PSCME Manufacturing Entrepreneurship Case Study*

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### **Harmonics, Inc.**

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*Advanced Materials • Ceramic Composites • High Temperature Coatings*

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This case study examines the start-up experience of Harmonics, Inc., a Seattle-based company founded on developing and commercializing innovative ceramic materials. Harmonics' materials were invented by one of the company's founders, and this study focuses on the company's experience with bringing its first product, based on one of these materials, to market. We describe key aspects of the entrepreneurial process, including:

- **The Concept:** Conceiving the product and recognizing a market niche
- **The Business Plan:** Analyzing markets, customer needs, and the potential payoff
- **Starting Up:** Intellectual property, marketing, and building production capacity
- **Operating:** Selling, licensing, shipping, and developing new products

Teaching materials for entrepreneurship are usually organized in a linear and logical way, urging the student to brainstorm for the best product idea, develop a thorough business plan, and exhaustively search for the best funding options before starting their business. This is good advice and should be followed as much as possible. In the real world, however, this orderly approach is often influenced and rearranged by the entrepreneur's constraints and the particular strengths and weakness of any given business opportunity. Unforeseen circumstances – both good and bad – almost always emerge during the early years of new companies, and the real art of entrepreneurship is in responding to these delays, distractions, and opportunities while diligently pursuing and carefully refining the original vision of the venture.

In this case study, we simply try to describe the commercialization pathway of Harmonics' first product. We hope that the narrative here helps those interested in starting a small-scale manufacturing enterprise see the kinds of issues that need to be considered through each phase of the start-up.

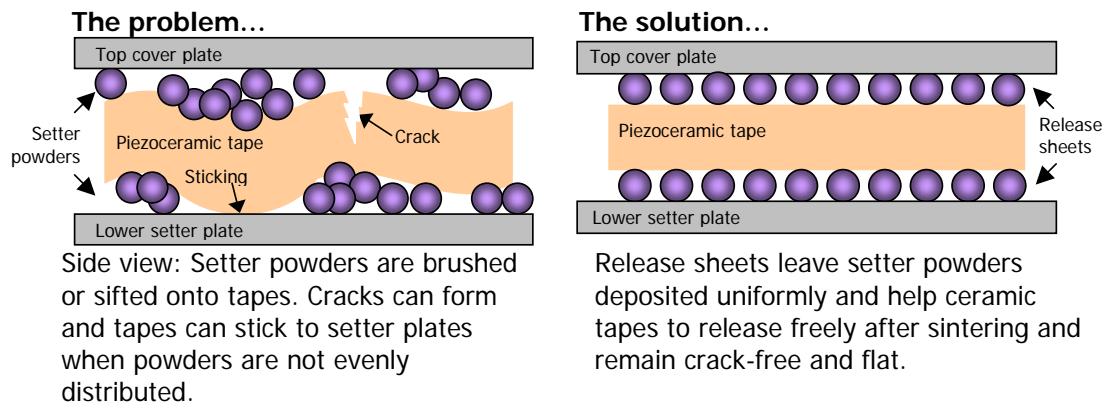
#### **The Concept: Setter Powder Sheets**

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Harmonics' first product was conceived in a University of Washington laboratory out of necessity. Researchers there were trying to produce a thin ceramic material known as

a “piezoceramic,” which is commonly used in buzzers and various kinds of electronic switches and actuators. They were struggling, however, with a recurring problem: when they tried to sinter the piezoceramic material (by heating it up in a furnace, much the same way that clay artwork is “fired” in a kiln), they often found that the material had stuck to the plate on which it rested inside the furnace, called the setter plate. Even worse, the thin piezoceramic tapes often warped or curled up like a potato chip. When the researchers placed another setter plate on top of the thin material to keep it flat, it often stuck to that plate as well during sintering.

The researchers needed a way to deposit very fine sand between the thin piezoceramic tapes and the setter plates to keep them from sticking during the sintering process inside the furnace. What they invented was a special kind of paper to place between the setter plates and the thin piezoceramic material. The paper was made with very fine refractory powder (zirconia). As the furnace heated to high temperatures, the paper burned away, leaving only a thin layer of the zirconia powder, which then acted like tiny ball-bearings and kept the material from sticking to the setter plates. As it turned out, it also provided the added benefit of reducing cracks and warping in the piezoceramic material, as it allowed the material to shrink without any constraints during sintering.



Recognizing the potential value of this special paper to other researchers, and possibly to manufacturers of piezoceramics and other ceramic products, the researchers wrote a **patent** that was eventually granted to the University of Washington (patents that come out of research conducted in university facilities are usually owned by the university).

One of the inventors of the paper was Luke Ferguson, who was near completion of his doctorate. In addition to the release paper that he co-invented at the University of Washington, he also had invented a unique, electrically conductive ceramic material outside of the university. After earning his doctorate, Luke researched the possible applications for the electrically conductive material, and ultimately decided to build a business plan to develop and commercialize that material, which he called “*EC* material” (short for “electroconductive ceramic material”).

Knowing that development of the *EC* material could take months and that it would be at least two years before it generated significant revenues, Luke needed an interim product that could be easily produced in a laboratory setting that could begin generating income immediately. He thought of the “release paper” he had co-invented at the university.

While he had secured funding for developing the *EC* material, he and his business partner knew that the viability of the company depended on generating income from the “release sheets” within the first year. This case study focuses on the commercialization of the initial “release sheet” product.

## **The Business Plan**

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Harmonics was founded with the following business model: the company would develop products based on its several **proprietary** ceramic materials, with the goal of licensing or selling the technology of those products to customers for use in different applications. The “release sheets” were not seen as a central product of the company, but as a way of generating income during the development phase of its other products. In other words, becoming a high volume manufacturer of release sheets was not the objective of the company. If the demand for the release sheets were to grow rapidly, the company would look for a buyer or licensee for the product, so that it could focus on its core competency of developing new ceramic materials technologies and applications.

### ***Researching the market***

Before any of the release paper products could be sold, much work had to be done. The first task was to determine what the market for the material looked like and who the potential customers would be. Market research, unlike what is found in most textbooks, is largely a process of discovery: one finding leads to a series of new ideas and questions. The founders knew that they would have to **license** the technology from the University of Washington, but before they approached the university with interest in licensing, they wanted to have a clear idea of how much of the product they might be able to sell and who the customers would be.

At the outset, they knew little about the market and potential customers, or even if the product would work outside of the laboratory environment. They did know that certain manufacturing industries might have an interest in the product, specifically manufacturers of electronic components that used thin sheets of piezoceramic in their process, such as various kinds of capacitors, actuators and resonators.

They consulted several sources for market information to find out how manufacturers dealt with the problem of sticking, warping, or cracking of their components in the firing process. Some of the best information came out of their discussions with **manufacturer's representatives**. Representatives are often very knowledgeable about the general processes that manufacturers use and how their **supply chains** are organized. They are also a good complement to other sources of market information that can sometimes be biased or ambiguous, such as industry trade journals, manufacturer's websites, or economic data from trade associations or government sources. In fact, a general rule that can be drawn from this experience is that information that comes from interviewing people, based on their direct experience and knowledge, is usually much more valuable than information that comes from paper or electronic sources. The lesson here is that **networking** with other people is not only valuable, but essential for obtaining an accurate picture of market and organization of the target industry. It is also important in the other direction, for marketing your product. Positive news about your product that is passed by word of mouth among industry professionals can be more valuable than conventional advertising methods.

### Sources for market information

Government Sources	Department of Commerce: <ul style="list-style-type: none"> <li>• Bureau of Economic Analysis</li> <li>• US Bureau of the Census               <ul style="list-style-type: none"> <li>• Economic Census (value of shipments by product or industry; growth over past decade)</li> </ul> </li> </ul> Securities and Exchange Commission: <ul style="list-style-type: none"> <li>• EDGAR Database (<a href="http://www.sec.gov/edgar.shtml">www.sec.gov/edgar.shtml</a>)</li> </ul> Individual Government Personnel <ul style="list-style-type: none"> <li>• Determine which federal and state government agencies regulate or are otherwise involved in your target market...then interview them.</li> <li>• Determine whether the government may be a customer for your product (the founders discovered that some of their best early-adopting customers were researchers in national laboratories).</li> </ul>
Manufacturer's Representatives and Trade Associations	<ul style="list-style-type: none"> <li>• Industry trade associations – find on the web and contact for brief interviews</li> <li>• Specialty groups (e.g., the founders gained contacts by attending American Ceramic Society annual meetings which brought together private sector salespeople, engineers, and academic researchers).</li> <li>• Talk with manufacturers' representatives that sell equipment that may be complementary to your product – they will know about the important potential customers and even suggest applications you have not considered. (For example, the founders talked with furnace manufacturers.)</li> </ul>
Online Services	<ul style="list-style-type: none"> <li>• Hoover's (<a href="http://www.hoovers.com">www.hoovers.com</a>)</li> <li>• Harris Infosource (<a href="http://harrisinfo.com">harrisinfo.com</a>)</li> <li>• Use subscriptions available at local university library</li> </ul>
Potential Customers	<ul style="list-style-type: none"> <li>• Call potential customers and explain the new product idea; try to use referrals from manufacturers' reps or other contacts. Don't turn them off by asking for too much information.</li> </ul>
Company Websites	<ul style="list-style-type: none"> <li>• Use internet search engines to find companies, brochures, and articles using a variety of keywords. Many companies often have material that shows up on search engines that they are not even aware of, such as presentations, reports, and other documents.</li> </ul>

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Marketing  
Information  
Companies

- A number of companies sell targeted market information reports for a specific industry or product niche, covering market size, growth, and trends. Many of these charge thousand of dollars for their reports – make sure that they are reputable. (The founders did not use this source – however, these companies often publish tables of contents for their reports, which can be useful for understanding an industry's organization, supply chain structure, and terminology.)
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From their research, Harmonics found that the market for the material was not really very large, probably under \$100 million in the U.S., but that there was certainly room for the introduction of an innovative product. They found that many manufacturers were simply sprinkling the refractory powder (zirconia) over their setter plates and then depositing the piece that they wanted to fire on top of that – a rather laborious process, and, as described earlier, one that performs poorly for thin sheet ceramics.

Marketing research often feeds the development of the product itself. For example, as Harmonics' founders came to understand how manufacturers handled the problem of their parts sticking together or to the setter plates during the sintering process, they began to see that their release paper had a number of potentially attractive features to these manufacturers. First, the paper could potentially be produced in large rolls that manufacturers could easily integrate into their production process, or the paper could be cut into sheets in custom sizes. The sheets could be quickly placed into position prior to setting the parts on the setter plates before firing. Second, the sheets provided a degree of uniformity that could not be attained by simply sprinkling the "setter sand" over the setter plates, which would help manufacturers improve the surface quality of their parts. Third, they realized that manufacturers could often stack their parts, with the release paper placed in between to keep parts from sticking together, resulting in greater efficiency as they could then send more parts through the high temperature furnace at one time.

All of these benefits, which became central aspects of marketing the product, were realized early on by studying the market and the **substitute products** (setter sand) that manufacturers were currently using. They also realized that their product could also be a **complementary product** for some manufacturers that used expensive or exotic setter plates, because the release sheets helped to keep contaminants such as lead from diffusing from the part to the setter plate during firing. A lesson here is that it is important to have an open mind when conducting market research and consider opportunities for your product that perhaps you had not considered. The market research phase, especially initially, is a process of discovery. On the other hand, it is quite easy at this stage to embrace a new opportunity and all but abandon the old one. This is a mistake that the founders made initially, allowing new opportunities to distract them from following through with the initial one.

## *Identifying the Potential Customers*

Perhaps the single most important issue to tackle when developing a business plan is to understand who the customer is. This is often not as straightforward as it may seem, and it was a difficulty for this company's founders.

The customer is not just the "organization" you are trying to sell to. The customer is not necessarily the user of the product. The "customer" is often a series of individuals within the organization whose importance to you will shift over the **selling cycle** of the product. When introducing a new product, the first customer is the engineering director or other technical decision maker who sees the merit in the product. Toward the end of the sell cycle, after the technical people have been won over, the customer becomes the procurement manager and other business decision makers who are focused on the cost and other aspects of getting the best deal possible for their company.

A mistake that the founders of Harmonics made in initial information-gathering calls was to spend a lot of time speaking with someone in the right organization but who, essentially, was not the customer. When contacting a company for the first time (or calling "cold"), you will often be routed to someone in sales. Sometimes, especially if the company is small, the sales person or sales engineer will have excellent information about the company's products, and, if you are tactful, its production processes. The downside in these situations, however, is that these small companies are not likely to be big consumers of your product. In larger companies where greater production volumes make larger orders likely, it is even more difficult to get the attention of a technical decision maker, and the sales people often don't have (or will not offer) much information that is useful in conducting market research. On a number of occasions, we had written off a company based on the conversation with their sales staff, only to find the company placing orders months later when their technical staff heard about the product and wanted to try it.

It is critical to have at least a handful of customers "in progress" before moving forward with the business plan. These are essentially people in other organizations that have said they would buy (or at least try) the product if it were available and offered at a competitive price. Such customers more or less naturally evolved out of calls that the founders made to research the market for the release paper. If you are looking for funding for the venture, having these customers lined up for a sale will help tremendously.

## ***Repackaging the “release sheets” invention as Setter Powder Sheets***

Before calling customers, some thought had to be given toward how to describe and talk about the product. The term “release sheets,” while easy to understand and remember, was a term that had been applied to materials that actually had been tried before in the industry, but with little success (the founders learned this from their discussions with manufacturing representatives and several customers). The founders therefore decided early on to avoid the use of that term, and coined the name “Setter Powder Sheets.”

Feedback from customers and reps also helped to form a clearer picture about the technical requirements for the material, its packaging, and its cost. Some customers needed the paper to be made with refractory powders other than zirconia, such as alumina or magnesia. Some customers even wanted to have sheets customized, using their proprietary mix of powders specifically for their application. These customers usually wanted to enter into a **mutual nondisclosure agreement** with Harmonics, which offers some protection to both companies from either company giving away confidential information.

Some customers wanted the material to be available in large rolls, up to 18 or 24 inches wide, so that they could use it in a **continuous process**. Most customers, however, were satisfied with pre-cut sheets, as they ran a **batch process**, and having the sheets pre-cut to the size they needed would save them time as they loaded their parts to be fired in the furnace.

The range of costs that customers were willing to pay, at least in “ball park” terms, varied widely. The largest customers tended to want a very low cost, as just a few pennies difference in the cost per square inch would translate into a significant share of their product’s total price. The founders quickly determined that these companies would not likely adopt the product at the outset, and that smaller companies or companies with diverse products or **high value-added products** presented the best opportunities. These companies could afford to pay a little higher price and realized a greater value from the benefits provided by the sheets, such as labor savings, improved quality of their thin sheet ceramic parts, and better efficiency from stacking parts during firing. It made the most sense to pursue customers in these **niche markets**, which while not large, provided the greatest opportunity for entry.

The potential use of Setter Powder Sheets by customers that made different products than the founders had originally envisioned also emerged out of the market research. Not only makers of thin sheet ceramics for electronic components were interested, but manufacturers making parts and tools using powdered metallurgy (compressing metal powders at high temperature to form parts), bulk ceramics, and fuel cells showed an interest.

In all, the picture that began to form was that the production of the Setter Powder Sheets needed to be flexible. It should allow for different types of refractory powder (zirconia, alumina, magnesia, or custom powders) to be used and for the paper to be cut to different sizes or put onto rolls. It was clear that some development should be put into the product to develop the capability of using different refractory powders and that the use of the Setter Powder Sheets should be tested.

### ***Analysis of the business opportunity***

After researching the market and identifying the potential customers, the founders looked at the potential opportunity for making a profit from the product. At one level, this was a fairly simple calculation, beginning with estimating how much it would cost to produce and how much it could generate in revenue. In addition to the direct costs of production, such as labor and materials, other charges that come from making and selling the product must be included, such as costs of securing intellectual property, marketing, equipment, and taxes.

Some of these costs had to be paid or committed to before a single piece of material could be sold. Greatest among these were the costs of securing a licensing agreement with the University of Washington, as they held the patent for the product. The founders met with a representative from the University's Office of Intellectual Property who presented them with two options: either an **exclusive** or a **non-exclusive** license. The exclusive license, which was more expensive, would bar other companies from producing and selling the material thereby allowing Harmonics to exercise a monopoly over it. The lesser-expensive non-exclusive license would allow other companies to produce the material as long as they also obtained a license. Although riskier, the founders opted for the non-exclusive license for a couple of reasons. First, they did not think they could afford the exclusive license. Secondly, they felt that even if another company licensed the product from the University, it would be technically very challenging for them to develop the product to the point of commercialization. While the patent contained a formula for the making the Setter Powder Sheets, it was the relatively undeveloped laboratory version, so that any company that tried to use the formula would still have a great amount of work to do before they had a practical (large scale) manufacturing process.

The second largest up front cost would be for the equipment needed to produce the material. The required equipment included two major items, a 25-foot "tapecaster" and a jar mill. The company already had laboratory versions of these items, however they did not have the required capacity. A simple jar mill that had enough capacity to get started was readily available at the local pottery supply store, and would cost about one thousand dollars.

The 25-foot tapecaster, however, would cost upwards of \$200,000 even for the simplest model in used condition. The founders' only option here would be to build a

custom tapecaster based on the design of the 8-foot laboratory-scale tapecaster they already had. They estimated the cost of building the tapecaster in-house at about \$15,000 thousand dollars.



9' Laboratory Tapecaster



Jar Mill

Estimating potential revenues is more difficult than estimating expenditures and costs. There are several ways to approach this. If good statistics on market size are available, one alternative is to estimate a **market share**, and then estimate the dollar value from there. Most often published statistics are not available for a niche product or a new product. In the case of Setter Powder Sheets, the closest product with some published reference data was “refractory ceramic products,” which included both refractory powders and bulk items such as bricks. Some customers gave hints about how much setter sand they used in a year (one said they used more than 100 thousand pounds), but no one had a bird’s eye view of the entire market, including the manufacturers of the setter sand products.

Another method is to study the largest consumers of the product, one by one, and try to estimate how much of the product they would use. To do this research, sometimes it is helpful to look at companies’ Security and Exchange Commission (SEC) filings. If a company is public, it must submit quarterly and annual filings that are publicly available on the SEC’s EDGAR database. Obtaining information about private companies’ sales is more difficult; often manufacturing reps have some idea of their total sales, or if their total employment can be found (for example, by looking at Dun and Bradstreet or Hoovers, both on-line services), a total revenue figure can be roughly estimated by multiplying the number of employees by 100 thousand dollars, if it is a mature company (in business more than, say, five or ten years). This method did not work well for the founders, either, because the use of setter sands was so diverse among the leading companies—how much was used and for which products—that it was very difficult to accept the assumption that adding up these companies’ revenues could be an indicator of the overall market size for Setter Powder Sheets.

Eventually, the founders worked from the opposite direction and considered their potential revenues from the perspective of operating at full capacity with the 25-foot tapecaster, which amounted to about 3 batches of Setter Powder Paper per day. If they could make a profit at this capacity, they reasoned, then starting up the product was worth it. Ultimately, the founders' goal was to license the process to a manufacturer who made similar products and wanted to add Setter Powder Sheets to their product line, or to license the process to individual manufacturers for their in-house use. The immediate goal was simply to get the product up and running, establish a base of customers, and create a robust **value stream** from the product.

### ***Summary of the business plan***

The business plan that evolved out of the market and customer research was somewhat different from what the founders had first envisioned. Doing the essential research *before* investing further time and money into the commercialization of the product is easily justified. They found that the most likely customers were going to be small to medium-sized producers that used batch processing. Thus, it would be wise not to invest in expensive machinery that spun the paper onto rolls – it would be more cost-effective to simply have a cutting device made for cutting the sheets on the tapecaster itself, and then to place the sheets into boxes for shipping.

It was also clear that whatever equipment they used, that it should be scalable, so that they could adjust production easily and provide product customization. The founders also knew that the equipment should integrate well with the production of their other products that they were developing for casting into thin sheets. Based on these requirements, they decided to build the 25-foot production tapecaster in-house, modeled on a scaled-up version of their 9-foot laboratory tapecaster. This solution would provide what they needed to get started introducing the product at minimal cost.

Finally, they learned that they would need to rely heavily on contacts generated through networking to get their initial customers. These would include manufacturers' reps, trade association contacts, and referrals from customer calls. As they were nearing completion of the business plan, the founders attended an American Ceramic Society meeting in St. Louis, where they met the vice president and lead sales engineer from Zircar, a leading supplier of refractory products. Zircar was highly interested in acting as a distributor for the product, which was an attractive idea because their customer base lined up nearly exactly with the customers that Harmonics was targeting, while also helping the founders consider new industry segments where the product could be applied, such as fuel cells, batteries, and metallurgy.

## Starting Up

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The founders had obtained funding for the company on the basis of developing its *EC* material from a **venture capital** firm. After conducting some market and customer research, they proposed the business plan for the Setter Powder Sheets to the investors, who then provided low interest loans to fund that project. The major additional start-up cost of the project was the non-exclusive license from the University of Washington to produce and sell the product. This license specified that the company would pay a licensing fee (which was roughly equal to the legal costs that the UW incurred in obtaining the patent) and royalties. To ease the burden of having to pay the full amount of the licensing fee up front, the payment was spread out over two years in quarterly payments. Beyond the primary **fixed costs** of the licensing fee and constructing the tapecaster (which would actually be used for other products that the company made), most of the other types of costs associated with the project were **variable costs**, being incurred at the time of production.

Fixed Costs: Licensing Fee Construction of the tapecaster (shared with other uses)
Variable Costs: Materials (per batch) Labor (hours per batch) Packaging (average cost per batch) Manufacturing taxes (quarterly, based on value of production)
Overhead Costs: Marketing Administrative costs Shipping (charged to customer)

After the business plan was presented to the company's **board of directors**, the founders began construction of the 25-foot production tapecaster. The new tapecaster followed the general design of the smaller laboratory-scale version. The tapecaster was built at Harmonics using aluminum and glass supplied locally.



25-foot Tapecaster built at Harmonics

### ***Marketing and Selling***

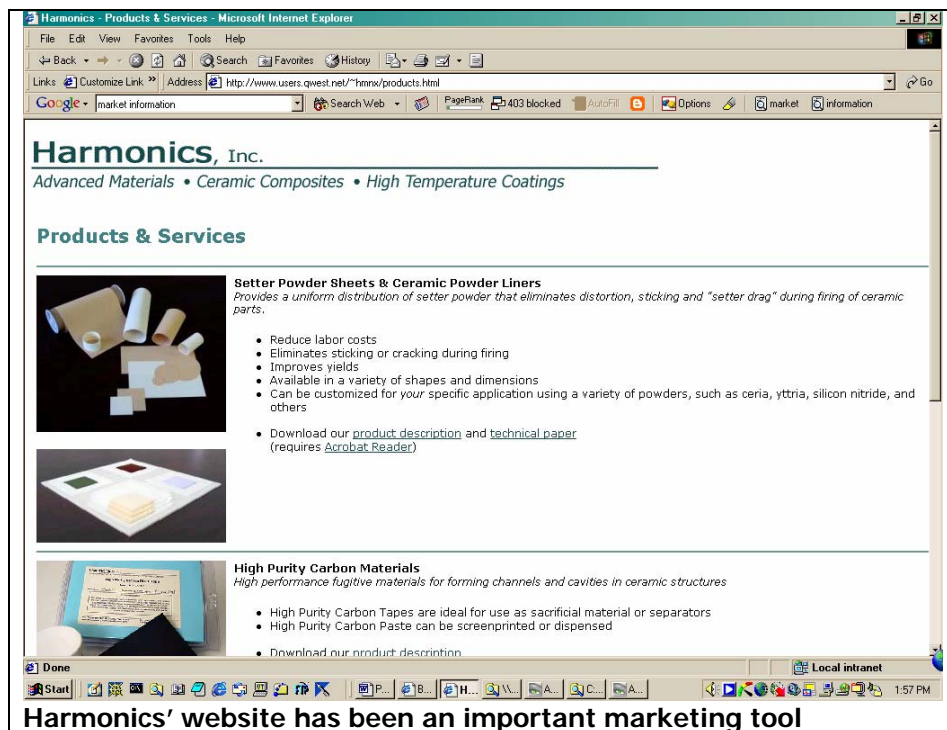
At the same time, the company's materials engineer was further developing the Setter Powder Sheets and the process for producing them. Several new types were developed based on suggestions from discussions with potential customers.

Eventually, several types were developed enough to begin shipping as samples. Before samples could be provided, however, technical data sheets and other marketing materials needed to be developed, and a packaging process needed to be designed. It was not until this point that the significance of the marketing materials and packaging was fully understood by the founders. A good first impression is essential for the success of any new product, while an unprofessional appearance will reduce customers' valuation of the product, even at an unconscious level. (This is why many companies invest heavily in marketing new products).

For packaging, the founders eventually decided on using pre-formed 5" by 7" plastic "clamshell" packages for samples, and cardboard boxes for shipping larger orders. The plastic clamshells were purchased on a carton-by-carton basis from a local supplier after obtaining quotes from several suppliers nationwide (found on the internet). The clamshells also worked well for storing in-house samples that had been tested for later reference and for packaging some of the company's other products. Because many customers needed odd sizes for their testing of the product, the cardboard boxes were initially hand-made to order – the minimum order from a local supplier was for 500 boxes, and the founders did not want to be stuck with a box size that they may not be able to use later.



Samples sent to customers also needed to include product descriptions. This was required not only to give the sample a professional look, but also to help insure that the customer fully understood what to expect from the product and how to use it in their evaluation. These product descriptions and other marketing materials were also added to the company's website. The company's website was designed (in-house) to be simple to understand and to load quickly, as the customers most likely to use it were engineers and technicians looking for specific information on a product.



These marketing aspects were not implemented right away, but evolved as the process of sending samples unfolded. The first several samples that were sent to potential customers were quite different from what eventually became the standard sample package, which did not really emerge until after several months. While it is important to be flexible, especially at the outset (for example, don't order thousands of labels or boxes until you have "pilot tested" them), it would have been better to plan the new product introduction more carefully, perhaps even hiring a consultant to help. One opportunity that was missed was to advertise the product in trade journals, which usually have a section featuring new products – the founders decided not spend money on this, but in retrospect, this could have been quite effective in generating more interest.

Instead of advertising, the founders relied on following up with previously contacted customers, "cold calling" new ones, and enlisting several sales reps to find customers on a commission basis. To keep track of sales calls and the information obtained from specific customers, they developed a customer database (using Microsoft Access) that tracked the customer's information (name, address, location, industry, contact person, sales, employees, etc.) and distribution information about any sample that was sent to them (quantity, lot number, sales details, date, etc). The sample's lot number was matched to the production details about that lot (date, composition, production anomalies, etc.). This way, if a customer called with questions about their sample, the founders or the production engineer could quickly pinpoint exactly which material was sent, and when and how it was made. This database was very useful as time went by, because many customers took months to try the Setter Powder Sheets, and then called back wanting to order more of exactly what they had sampled. As the standard composition changed for the Setter Powder Sheets and improved over time, it was important to be able to identify the earlier composition that worked well for a particular customer. As in most companies, the customer database itself became an important asset.

Initially, the founders made the mistake of distributing samples free of charge to customers who requested them. In retrospect, this was a mistake for several reasons. First, it used scarce cash. Second, and probably more importantly, it implicitly devalued the product. The founders eventually learned that customers that were serious about using the product would gladly pay the nominal price for a sample package. While this was not a large expenditure, it did signal that the product – even in sample quantities – had value. Third, because the samples were initially supplied free of charge, many customers that may have had only a mild interest requested samples and then never actually tried it. It would have been more efficient for everyone involved if these customers were required to pay for the sample: they would have been more likely to try the sample, or else not order it, and time spent following up with customers who did purchase samples would have been more effective.

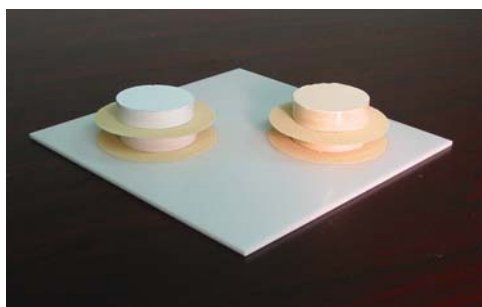
The founders also learned that the **selling cycle** of the Setter Powder Sheets was much longer than they anticipated. Many manufacturers are reluctant to change a production process, and trying to sell them on a new product that would require them to do so, even when there are measurable advantages, can be challenging. In nearly every case, engineers that tried the material were impressed with the results but were reluctant to risk using the material in a production run. In these cases the sale had to wait until the customer had an opportunity to try the product in a production batch.

Despite the underpowered marketing of the product in its introductory months and its relatively long selling cycle, customers began requesting **quotations**. Quotations were developed on a customer-by-customer basis. Developing quotations requires a careful balancing of the estimated costs of production, plus an acceptable profit margin, and the customers' ability and willingness to pay. On large orders, great care must be taken not underestimate costs or undersell below an acceptable margin, because once a deal is made based on the quotation, it is difficult (and not good business) to backtrack and adjust the selling price.

The founders soon realized that many of the quotations they gave to customers were higher than they were willing to pay right away, however, several smaller companies with high-value added niche products did order the product. Within 8 months of introducing the product, one customer placed a large order for a trial production run after having tested the product on a smaller scale.

### ***Product Development***

As the founders learned more about the market, they realized that many customers needed a type of release sheet that was suitable for larger, heavier parts. The Setter Powder Sheets, made with fine refractory powders, were very thin and did not provide a thick enough layer of setter powder for larger parts during firing. They experimented with using larger powders, and eventually invented a thicker type of release sheet that was made with much coarser (larger grain) refractory powders. To distinguish this new product from the original Setter Powder Sheets, they called the product "Ceramic Powder Liners" (or CPL).



**CPL is well-suited for larger parts**

One aspect of the CPL was that its formulation fell outside of the scope and definition of the product that was covered under the University of Washington's patent. Before they could sell the product, the founders had to make a choice about how they were going to safeguard this new **intellectual property (IP)** – the formula and process for making CPL. There are two primary ways that companies can safeguard their

ownership of intellectual property. One way is to apply for a patent, the other is to guard it as a trade secret. Both have their advantages and disadvantages:

Patent	Trade Secret
<p><i>Advantages:</i></p> <ul style="list-style-type: none"> <li>• Legally-backed protection</li> <li>• More attractive to potential investors</li> </ul> <p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> <li>• Invention is publicly disclosed – violators have access to the IP</li> <li>• Patent is for limited duration (17 years)</li> <li>• Higher cost</li> </ul>	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> <li>• IP is not publicly disclosed</li> <li>• Lower cost</li> </ul> <p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> <li>• If IP is disclosed, little can be done to prevent others from using it</li> </ul>
<p>More information about the protection of IP can be found at the US Patent and Trademark Office's website: <a href="http://www.uspto.gov">www.uspto.gov</a></p>	

In the United States, a company has one year to file a patent after first offering the product for sale, so the founders had some time to make a decision. Eventually they chose the lower cost option of protecting the IP as a trade secret.

## Operating

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Very soon after the founders began sending samples of CPL to customers, one company placed a large **blanket order** for the product, meaning that it was to be shipped as monthly releases over the course of a year. This was the first major order for the product, and it marked the transition from its introductory phase to its production phase (or, at least the beginning of that transition). This success was a great boost for everyone at the company.

Right away, the most important task was to be sure that this initial customer was always satisfied with the product, which meant putting effective quality control measures into place. The founders hired a part-time technician who would be dedicated to producing and packaging the monthly shipments and any other orders for SPS or CPL. To ensure quality, one of the founders did the final packaging, giving him a chance to visually inspect every box of Ceramic Powder Liners that was shipped. Every box was marked with the lot number of the product, which was recorded in a database along with lot characteristics such as the formulation used, the date, and any anomalies that may have occurred in the production process. Once every few batches, some sheets were randomly selected, examined for their physical characteristics (thickness, uniformity, weight, etc.), and tested in a furnace. Because the CPL was also used in-house in the process of R&D, it was also "tested" on a daily basis.

An important part of any quality control program is to carefully inspect and test the ingredient materials that come from suppliers. This task was done by the company's

materials engineer, and results were recorded in a log in case the need arose for future reference.

Because the company was now using larger quantities of inputs, for example, more refractory powder, it was able to realize savings by negotiating a lower price from suppliers. In the case of the supplier for the refractory powder, the founders were able to negotiate a quarterly shipment schedule as well, spreading out their costs over a year. This is an example how companies can realize benefits from **economies of scale**. With the new blanket order in hand, the company was now able to further save money by ordering the small boxes for packaging that until then were cut out and put together by hand. The **minimum order** for these boxes from a local supplier was 500 units, and the company had been unwilling to commit to a purchase of these because of the changing dimensions of CPL sheets ordered by different customers. The new blanket order helped the founders to decide on a “standard” dimension, and then add on a small surcharge to customers wanting other dimensions, which helped to cover the costs of customized packing boxes that had to be made by hand. Often times this is the way **product standardization** evolves in small manufacturing start-ups, that is, driven by the needs of initial customers, rather than being determined prior to the initial growth in sales. The lesson here is to think about the “standard” characteristics of the product (for example, size, quantity per package, labeling, and so on), but to avoid committing to standardization early in its introduction, leaving room to find standard characteristics that are both cost-efficient and acceptable to customers.

### ***Product Licensing***

Several companies requested quotations for very large quantities of SPS or CPL from Harmonics. In the majority of cases, these were very large components manufacturers who liked the material, but who could not afford the material for the price that Harmonics would have to charge in order to supply it. As the goal of the founders was not to grow a large manufacturing company, but rather to license their technology to other companies, they proposed the possibility of licensing the technology and producing the SPS or CPL to these larger customers for their own use in-house.

One large electronic components company was open to this idea, and after five months of negotiation, an agreement was signed. Harmonics supplied the customer with a formula for CPL that was tailored to their application, several days of training at Harmonics’ facilities, and design plans for the company’s custom tapecasting equipment. In return, the customer agreed to pay an initial licensing fee and smaller renewal fees in subsequent years in exchange for the right to produce unlimited quantities of CPL in their facility for use in the manufacture of their components. The agreement prevented them from disseminating the formula or process to other companies in any way.

This was not only a significant sale for the company, but it verified that the founders' model of developing new technologies and then licensing them was working. The customer's modifications to the production equipment and development of the process for their own use also was an important source of new ideas and experience for Harmonics, demonstrating how sales and interactions with customers can often have intangible but important benefits.

### ***Operational Difficulties***

With the large blanket order in hand and the recent licensing agreement, the founders were becoming much more optimistic about the prospects for CPL and began to consider the possibility of expanding the operation. They approached a second venture capital firm to join the original investors in co-financing the expansion. This firm was quite interested in participating, but during their process of **due diligence** in evaluating Harmonics and the potential of the SPS/CPL opportunity, the customer who had placed the large blanket order ran into a technical difficulty causing them to stop production, and therefore had to suspend shipments of the CPL. Ultimately, this dissuaded the venture firm from following through with the investment – they preferred to see stronger sales before participating.

This is the type of difficulty that often faces start-up companies. Before investors will participate, they want to see a solid **value stream** or see evidence of highly committed customers (who, for example, have provided **purchase orders**). However, financing is usually required to develop such a value stream or secure such purchase orders. Sometimes, an entrepreneur can get an advance from a particular company to begin production of a niche product that the customer needs – often, the founder of such a company is an ex-employee from the customer company.

After several months, the customer reinstated their order and eventually placed another blanket order for a year of monthly shipments. The founders by this time had reconsidered their ambition of expanding the product. They reasoned that the expansion of the product would probably not occur quickly enough to be worth the diversion of energy and resources away from their core business of developing materials for specific applications, and so they adopted the approach of slowly building the SPS/CPL business alongside of their other activities.

### **Concluding Remarks**

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Thus far, Harmonics' introduction of Setter Powder Sheets and Ceramic Powder Liners is probably best described as moderately successful. The company continues to sell the product and the sales are an important supplement to the company's revenues from R&D contracts and sales of other products.

In retrospect, the introduction of the product would most certainly have been more effective if more resources could have been put into marketing the product, for example, in advertising and possibly employing a sales engineer to seek out and respond to customers and develop sales. The case shows that a weakness in marketing, especially initially, can profoundly affect the odds of success. In this case, the effects of underpowered marketing of the product were further compounded by the long selling cycle of the product that stemmed from customers' unwillingness or inability to alter their production processes, even when they would have realized cost savings by using the product. It is precisely in such a selling environment that one-on-one attention to customers is needed to demonstrate the product's features, as may have been accomplished by a sales engineer.

At the same time, the founders made a number of sound decisions that prevented the product-launch from failing. They conducted enough market research to know which customers to target and how to present the product to potential customers. They were conservative in their equipment investment and designed the process to be scaleable and flexible. They continuously developed the product based on feedback from customers, leading to the innovation of the more popular CPL product. Finally, they were careful to assure product quality and to deliver the product on time. This last point is especially important in niche markets comprising few customers, as favorable reports by word of mouth about a company's product and business practices (or **referencing**) can be a valuable marketing tool.