From Idea to Product to Market

Gernot H. Gessinger

Abstract

Developing innovative products from new materials or processes can take up to 20 years and requires a consistency of focus and the capability to change direction many times. Speed and intuition based on knowledge and experience are more important than following rigidly a business plan or relying on the use of tools and outside pressures. From a list of 13 case studies 5 have been selected to focus on the different learning experiences. In-house R&D, outsourcing of R&D, licensing technology and teaming up with government and university labs can be equally successful, provided the right competencies and the right leadership are combined.

Introduction

Materials are parts of systems. Through their properties they provide functions, which can be utilized in products. Practically all products contain materials. New products can be developed on the basis of new materials, or existing products can be improved by new materials. To be successful in developing products, many more skills are required which have to be identified and brought into a network – materials processing, manufacturing technologies, design engineering, economic considerations etc. There are also tools which are becoming increasingly available, but innovation will always remain the challenge to discover the unexplored with continuously changing approaches.

To learn more about the various approaches and skill levels needed, 13 case studies (either examples of own research or new business development examples) were conducted. The objective of this presentation is to highlight some of the major learnings from five case studies.

Learnings from Five Case Studies

Table 1 shows a list of the case studies – materials used, functionalities thought after, penetration of the market, managerial observations.

List of Case Studies				
	Source of Innovation	Position in Product/ Growth Matrix	Existing/ New Company	Key Learning
Isothermal Forging	new knowlege	product development	existing	unexpected design and merket change
LNT HIP Pressing	process needs and high-speed computing	diversification	start-up from state R&D lab	focus on technology
NDC Nitinol Devices	new knowledge	diversification	start-up from existing comp.	keep focus, prepared to say ‚no'
La2O3 Mo- Cathodes	new knowledge	product development	existing	incomplete specification
ZnO-Varistors	new knowledge	product development	existing	importance of speed
LCD at BBC	new knowledge	diversification	existing	low-cost competition
CERCON®	process needs	product development	from university lab to licensing	skill covergence
Metoxit	biomedical market	diversification	start-up from existing comp.	keep focus, use intuition
HTSC	new knowledge	prod.dev.vs. diversification	existing vs. start-up	willingness to take risks
Day4Energy	new knowledge	diversification	start-up	build production and market know-how
IHPOS Fuel Cells	new knowledge	diversification	existing from state R&D lab	high speed/low cost by partnering
NanoSphere®	new knowledge	product development	existing from university R&D	efficiency of out-sourcing R&D
Amroy	new knowledge	diversification	start-up from state R&D lab	speed

Table 1 List of case studies

The following case studies will be described in more detail

- NDC (shape memory alloy stents)
- CERCON (machining ceramic dental implants)
- Metoxit (high-precision, high strength bioceramic materials)
- ZnO –surge arresters
- Amroy – CNT-strengthened epoxy

NDC- Nitinol Devices – Remaining on Focus

Research on shape memory alloys at the BBC Research Center started in 1976. The main objective was to replace thermal bimetals by SMA. A new high temperature material, CuAlNi, was developed, but the effort was abandoned. Three researchers from both BBC and Rau GmbH in Germany left to work for Raychem, the only company at the time in the business of SMA shrink fits. The business was loosing money, and Tom Duerig became executive manager of the division, but was told one day after to sell the business. He then decided to form his own company, taking a license from his venture capital partners for producing eyeglass-frames from superelastic SMA. The effort, though successful technically and cost-wise, failed, because a Japanese company had the exclusive license. After finding new investors they decided to move into the direction of stents, and within a few years became profitable (Figure 1).

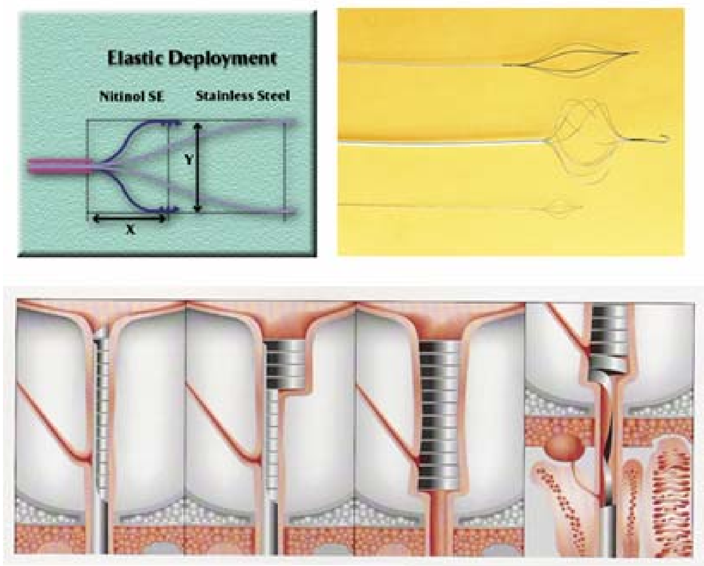


Fig.1 Superelastic shape memory alloy stents and their deployment in a cannula

The reason for the rapid success was an existing network with specialists in Germany, who helped to speed up the manufacturing process, and with Julio Palmaz, the inventor of many designs of stents. Johnson &Johnson, who already had bought licenses from Palmaz, became interested in the stents business, and bought NDC. In May 2008, Tom Duerig bought the company back together with new investors. In parallel Tom had been managing annual meetings of research progress in the field of SMA.

Learning points

Keep your focus and accept set-backs, which were

- Raychem loosing interest
- VC directing business in wrong direction (they claim that the eyeglass business would have been the cash cow for the development of the medical applications)
- Using the advice of lawyers, who are not part of the business

- Don’t be afraid to say no and offering your resignation.

<u>CERCON® – Convergence of Different Skill Sets</u>

Materials scientists were continuing to look for new and better ceramic materials with higher fracture toughness. One of the leaders was Prof. Gauckler. Dental specialists were looking for practical solutions for making high precision, good-looking ceramic dental implants. One of them was Prof. Schärer at Univ.Zurich. Both got together and agreed to develop a product. Then a mechanical engineer to work on his Ph.D. in materials science, Filser, came and brought and developed a series of skill-sets which were necessary to develop a product rapidly

- Materials engineering
- Mechanical engineering design
- IT
- Marketing
- Business development

With all the skills combined within just a few individuals the product development went very fast to a successful conclusion – a machine, which accepted as input the contours of the tooth, and then was used to machine a presintered perform. After sintering to full density the component was ready to be inserted (Figure 2).

Fig.2 From powder to dental implant with various processing steps in CERCON®

The product CERCON® was quickly licensed to Degudent and was immediately successful on the market.

Learning Points

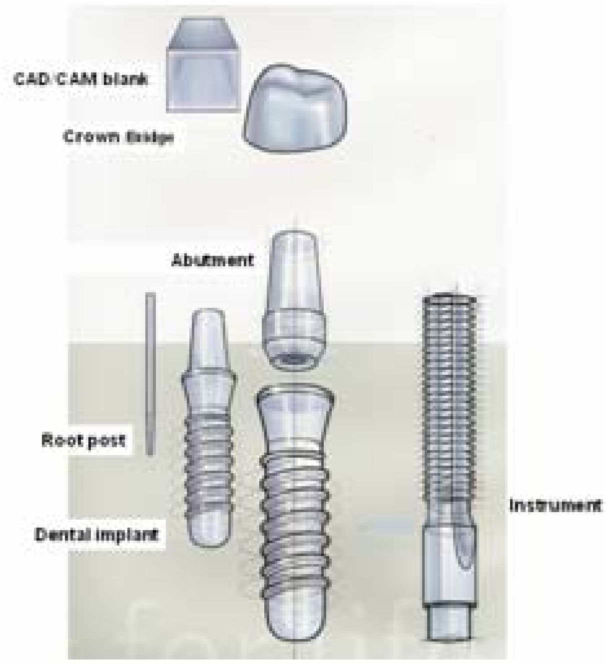
Keep the initiative and be aware of the tasks to be accomplished – start with a mind-setting tool to cover the whole range of influencing parameters.
Talk to suppliers and potential partners in an open way, but be ready to jump in and do some of their work yourself, e.g.

- Design the machine

- Do comparative cost analysis
- Do your own marketing research
- Assure to have all the minimum patent rights

<u>Metoxit – the Importance of Using Intuition and Common Sense</u>

Alusuisse, a former Swiss aluminium company, created a research center and hired many gifted scientists to develop new product ideas. Some tools were supplied in form of management training courses, but basically there was a large degree of freedom to conduct research. The idea came up to diversify into the area of alumina ceramic products. H. Rieger was one of the drivers for coming up with ever tougher ceramic materials. Eventually the idea arose to use them for biomedical applications (hip-implants, dental implants) (Figure 3).



Implant posts and ceramic crown

Fig.3 Hip-implants, showing the processing steps, and ceramic dental implants

To gain more technical competence, a 50/50 JV with an old-fashioned ceramic company was initiated. Alusuisse lost interest, and the JV was bought by another company – Metoxit now was a stand-alone start-up. After some initial set-backs, all necessary approvals were obtained by US and European medical associations and the business started to flourish. An important corner stone was the acquisition of SWIFT, a high precision grinding company, who could shape and grind the surface with an extremely high precision.

Learning points

- Don't loose track of your vision, but be ready to readjust your course frequently
- Use intuition and common sense to make the right decisions fast.
- Be cautious towards the benefits and help you expect to get from consultants, government funding, bankers, and people with only an MBA degree but no practical experience – the bottom-up approach is usually better than a top-down one.

ZnO Surge Arresters – In-House Research or Licensing the Technology

ZnO varistors were developed in Japan by Matsushita. Soon GE took a license and came unto the market with a portfolio of new products. BBC, as soon as they learned about it, started its own R&D program to develop this class of materials. With a bit of delay, Asea, after also learning about the material, decided to take a license and came quickly onto the market. The transfer phase from BBC Corporate Research into the business unit had been very slow and a pilot line was only established as a defensive reaction. Things changed immediately, when BBC learned about Asea's new products on the market, and within a few years they had caught up with Asea. After the merger of the two companies into ABB the joint business started to grow fast (Figure 4). Although a NPV calculation shows that both approaches were almost equally good investments, the importance of speed by licensing and the role of the then different organizational cultures were demonstrated.

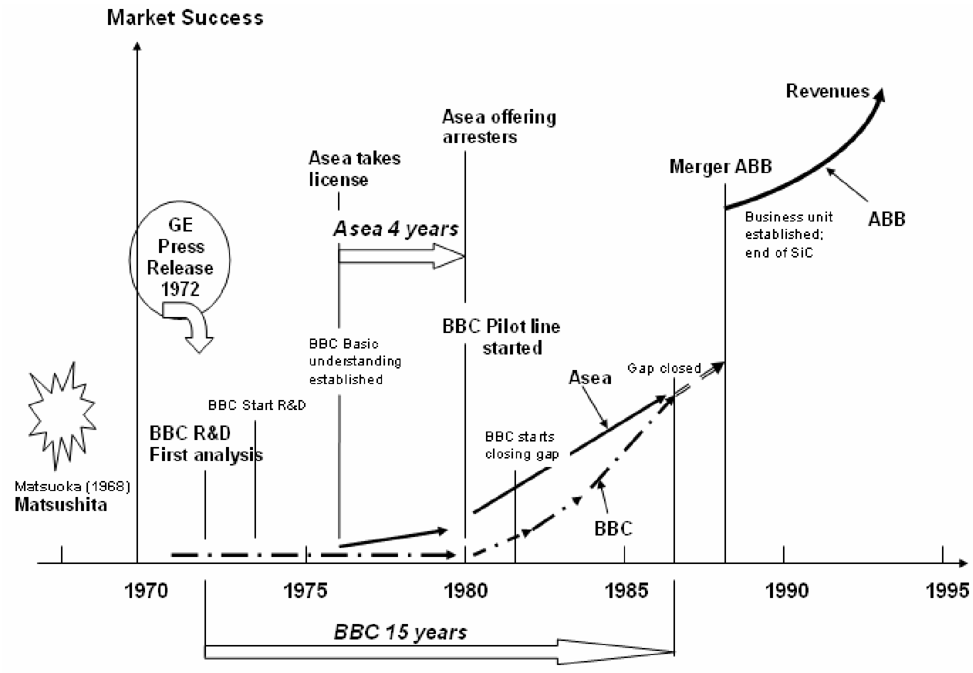


Fig.4 Historical comparison of varistor business development at BBC and Asea

Learning Points

- Conducting focused in-house R&D is a good long-term investment, because a knowledge base is created.
- Independent of the approach, speed is of the highest importance
- Get all functions of the organization involved as early as possible.

Amroy- From Search to Right Idea to Right Products

. The giant CNT- molecules are amongst the most important materials innovations due to their exceptional high mechanical strength and electrical/thermal conductivity. There is a continuous need for stronger and lighter materials.

Although it seemed to be an obvious next step, CNTs and other nano-sized additives have not been used successfully as strengthening components in a plastic matrix due to the poor bonding. For the best results nano-sized additives must be chemically compatible with the surrounding matrix.

Three researchers at Nanolab Systems Oy, a holding company to encourage new product development and spin-offs at the NanoScience Center in Jyväskyla in Finland – Pasi Keinänen, Jorma Virtanen and Mikko Tilli – were trying to develop sensors for detection of explosives, and tried to find a way to disperse CNTs. By sheer accident they discovered a new technology how to create radicals at the end of CNT molecules by ultrasonic vibration (Figure 5). Other methods like mechanical or optical cutting of the CNTs can be used as well to brake up the CNTs, creating highly reactive radicals. This made it possible for epoxide and other functional groups to chemically bond to the modified CNTs.

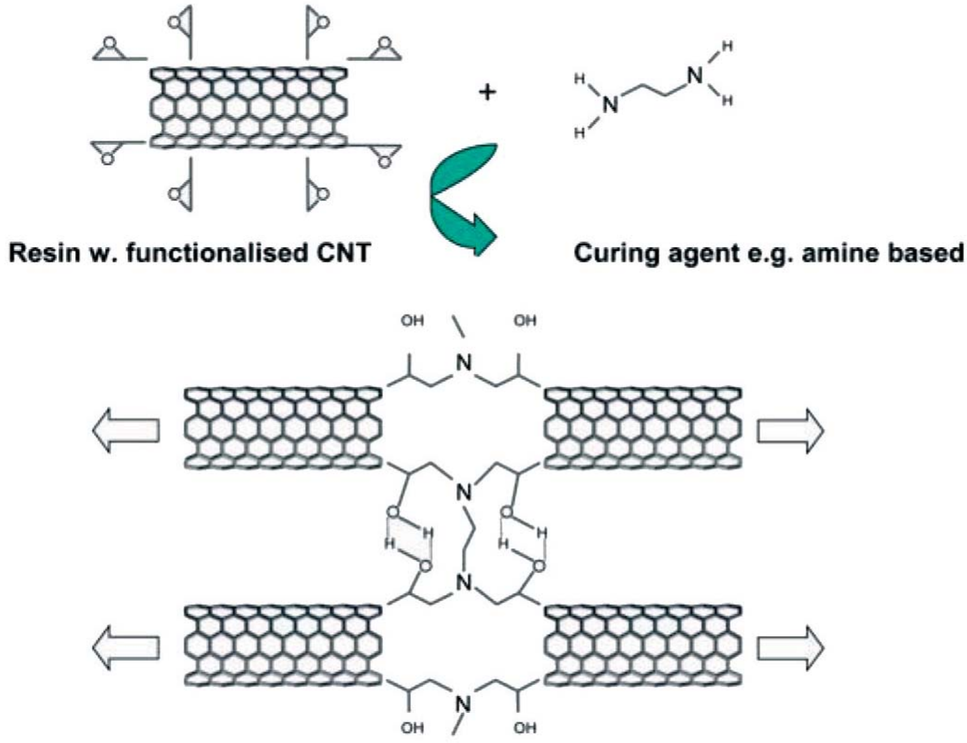


Fig.5 Creation of CNT-reinforced epoxy by simultaneous application of ultrasound and a curing agent.

This fusion structure is now known as Hybtonite® epoxy. This novel hybrid material can outperform other additive based carbon nanotube resins by pure chemical power and the nature of covalent bonding. The Hybtonite® epoxy resin is suitable for high performance coatings and for all composite processes from injection to prepregs due to the controlled viscosity and performance out of the covalent bonds.

Since the team had no epoxy production facilities they found an established partner in the field, SBT (Specialty Binder Timber) Oy. SBT Oy already had an established customer base of 200. Amroy Oy was founded, and the first products were hockey sticks, developed in 2005 for Montreal Sports, who were owned by a NHL player, who had his own production line. Lab tests at the University of Tampere showed a 70% better energy absorption compared with the established product. Very early other sports equipment such as cross-country skis, light-weight boots for ski-jumping etc. was tested and brought successfully to the market. The range of other applications is huge, covering all fields in the automotive, aerospace and construction industry, where high strength and light weight materials are needed. One of the potentially largest applications is for wind turbine blades. The blade would be 61.5m long and weigh 18 tons with 10 tons of resin There the motivation to switch to epoxy resin from polystirol is the emission of styrene, which is carcogenic. At present the material is in the test phase for this application.

Bayer, the main supplier of CNT succeeded to drop the price per kg from 1MEuro in 2002 to 150 Euros in 2007, and the present production capacity there is at 60tons/year.

Although Amroy is still very small, production grew very rapidly, because of partnering with SBT Oy, from 5 tons in 2005 to 350 tons in 2007.

The company had annual sales of 2MEuro, 7 employees and a 4000ton production capacity. The average annual growth rate has been at 100%, keeping the net profit zero.

<u>Growth Strategy and Main Risks</u>

All companies, weak and strong, at this embryonic stage of development, emphasize the development of a distinctive competency and an associated business model. During this stage, investment needs are great. Companies require large amounts of capital to build up new competencies such as production, sales and marketing, and services. A company’s success depends on its ability to demonstrate a distinct competency to attract outside investors. Entering a growth phase, the task facing a company is to consolidate its relative competitive position in a rapidly expanding market. Since other companies may enter the market and catch up with the first movers, they often require successive waves of capital infusion to maintain the momentum generated by their success in the embryonic stage. Partnering with other companies such as SBT Oy is one way to surpass the need to invest in building up all competencies oneself.

Learning Points

- Amroy evolved in the right environment. Finland is a leader in Europe in terms of innovation. Although the government is funding projects it delegates lots of decision power to companies, helping them to find quickly their own path.
- The team of the founders of Amroy brought a large combination of skill levels – many years of research in nanotechnology, some early experience in creating new companies.
- Recognizing that growth is important, but that it also requires lots of capital, the team made early on an important decision to partner with an

existing company which had both the skills in epoxy manufacturing and came with an established customer base.

- Securing a good patent base is mandatory.
- Finding the right growth strategy remains a huge challenge.

Use-Inspired Basic Research

Over the last 40 years the philosophy of R&D in an enterprise, but also at academic institutions has changed significantly. The old linear and top-down approach has been replaced by a two-dimensional and organic approach, involving teams of people from all over the organization. Stokes has created a very good matrix model to describe the situation, called Pasteur's quadrant (Figure 6).

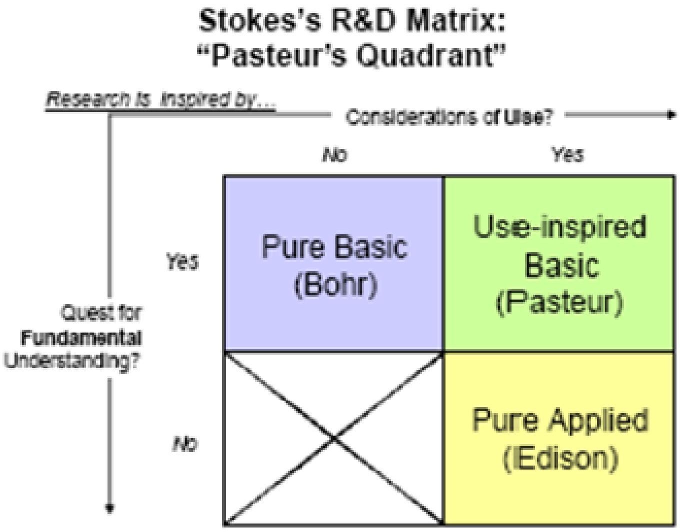


Fig. 6 Stokes' R&D matrix and Pasteur's quadrant

Between the two extremes – pure basic research and pure applied research - there is a third one, which he calls use-inspired basic research. Here a vision of an application inspires the researcher to think of basic research issues to be solved. Professor Gauckler's group is an excellent example of how to conduct this type of research. But what is also important is a strong sense of optimism. Here is an example: A former CTO at ABB, who had stopped his earlier research project on fuel cells at GE Corporate Research because of the high cost of Pt used as catalyst, called them 'fool cells'. When telling Gauckler about this view, which I partially shared at the time, his comment was:

Just believe in the technology, because one day an application will come that brings it to a working application.

Conclusions

There are two ways how to approach case studies. One is, to come up with a hypothesis about how things work in innovation, and conduct a large number of interviews to see if there is a positive statistical correlation. Then you have discovered a new ‘theory’ of management.
Two, you conduct each case study with a totally open mind, trying to understand which were the major learning points. The result is not a tool-kit which you can now employ to make the next project a winner, but a much more open mind-set, which you need to become successful quickly.

Here are some of the major learning points

- Come up as soon as possible with one or several ideas of potential applications and let your research be driven by it
- Establish, together with people of different experiences, a list of the skills required to make your product development project come to a success
- Working in a business-minded environment (science parks plus university) helps
- Realize that it is quite normal to revise your strategy and move into directions never contemplated before
- Stay connected to your focus
- Use common sense and intuition based on experience to make quick decisions
- Large organizations are focused more on coming up with new technologies for their existing markets. Although a lot of money may be involved, small and medium-sized enterprises are often more likely to introduce a radical innovation.