

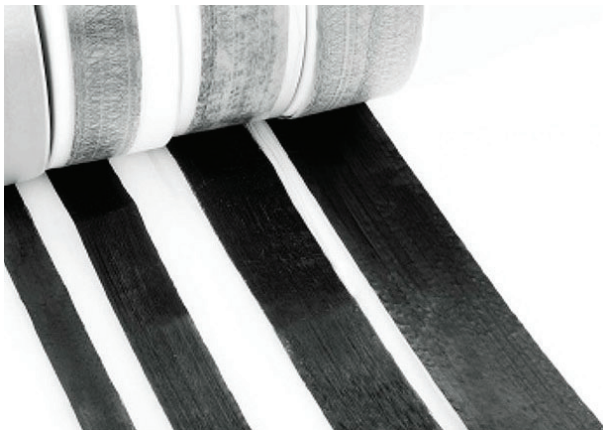
Textiles For The Extreme

By Bowman Heiden and Caroline Pamp

Based on his academic research at Sweden's Chalmers University of Technology, Nandan Khokar developed a new tape weaving technology. This technology and its woven materials became the basis for the foundation of the start-up company Oxeon in 2003. IP protection for the technology helped to attract private investment and funding, and Dr Khokar also benefitted from business support from Chalmers School of Entrepreneurship. This combination of private ownership and public innovation support led to the commercialisation of innovative tape-woven textiles for use in the sports, industrial, and aerospace sectors, and the licensing of the weaving technology for non-competing applications.



TEXTREME Spread Tow Carbon Fabrics.



Textreme Spread Tow Carbon Unidirectional Tapes.

From Conventional to Extreme Textiles

Weaving is one of humanity's oldest techniques and

still applied on a large scale throughout the modern world. However, in many advanced economies the weaving and textile industries have almost vanished as activities are outsourced to emerging nations. Sweden is no exception: its traditional textile industry has been replaced by businesses focusing on design, fashion, and innovation. Emerging from the ashes of the 19th-century Swedish textile capital Borås, Oxeon provides 21st-century textiles—this time woven using carbon fibres.

Nandan Khokar initially came to Sweden from the south of India in the early 1990s. He planned to work on a small project focused on traditional weaving technology at Chalmers University of Technology in Gothenburg. However, a new, related project was starting at the same time. This focused on producing three-dimensional (3D) composite textiles, using new types of fibre, such as ceramics and carbon.¹ He developed fundamentally new 3D fabric-forming techniques, which eventually developed into a full PhD thesis. While working on his thesis, Dr Khokar attended a conference, where a professor confronted him with a technical problem: he was looking for a way to weave tapes of specific fibres and structure into a sheet. In a flash of inspiration, Dr Khokar came up with a solution that evening and created a bare essential prototype the very next day. This provided the basis for several novel ideas, which led to the business development of unique tape weaving technologies and resulting materials. Oxeon, the company Dr Khokar co-founded, was recognised as Sweden's fastest-growing company in 2010.

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1. These 3D materials are made from fibres that are placed in three mutually perpendicular directions.



“Securing patent protection allowed us to have several options when developing our business.”

Nandan Khokar
R&D manager and main inventor

Launching Oxeon to Drive Innovation

The “professor’s privilege”² in Swedish universities awards academics the right to fully own the IP of their research, unless they agree otherwise. With the help of Fredrik Winberg, a serial entrepreneur and private investor, financing was arranged from business angels to patent the tape weaving technologies developed during Dr Khokar’s research. The ownership of these patents was assigned to a company called Biteam and later transferred to a newly created company called Tape Weaving Sweden. Both companies are co-owned by Dr Khokar, Fredrik Winberg, and business angels.

In late 2001, Dr Khokar and Fredrik Winberg presented their tape weaving technology to a group of students at Chalmers School of Entrepreneurship (CSE). At CSE, students support technology ventures together with innovators as part of their university education. As a result, a pre-incubation project was created, enabling four students to work with Dr Khokar and his technologies to further develop a business plan and the go-to-market strategy.

In 2003, Oxeon was created to focus on the use of the tape weaving technology to produce fabric reinforcements for composite materials, in particular using carbon fibres. Oxeon was formed from the combination of the following three key assets (see Figure 1):

- The patented tape weaving technologies made available via the acquisition of Tape Weaving Sweden, which acts as a holding company for the patents, licensing the required IP to Oxeon.
- The management team, comprising Dr Khokar and two of the CSE students, Andreas Martsman (now VP Marketing & Sales) and Henrik Blycker (now CEO).
- Financial capital from private investors, business angels, and AB Chalmersinvest (now Chalmers Ven-



“Developing IP protection early on helped us to attract venture capital.”

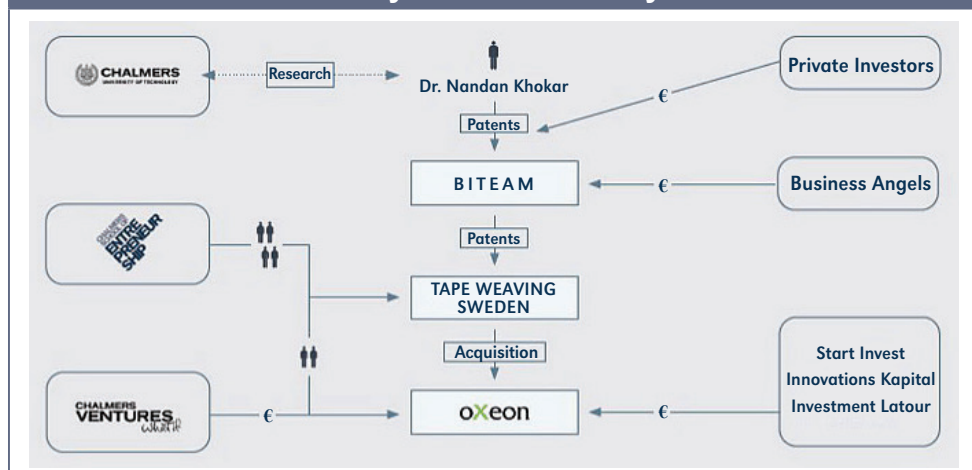
Fredrik Winberg
Board Member and visionary entrepreneur



“We continuously fine-tune our IP strategy to match our business model.”

Henrik Blycker
CEO

Figure 1: The Venture Creation Of Oxeon In The Chalmers University Innovation Ecosystem



2. This is regulated in Swedish law as an exemption to the Right to the Inventions of Employees Act (SFS 1949:345); see Section 1, second paragraph. This ownership model differs from the U.S. Bayh-Dole Act-inspired model used in many countries, where the university becomes the owner of patentable research results created by its employees.

tures), and later from Start Invest (now Almi Invest), Investment AB Latour, and InnovationsKapital.

Benefitting From the Local Innovation Ecosystem

Oxeon's creation wasn't managed by a university technology transfer office (TTO). Instead, it benefitted from other structures within the Chalmers University innovation ecosystem, including CSE for business development support and Chalmersinvest (now Chalmers Ventures) for financial investment. Informal IP assets, such as know-how and trade secrets, were acquired from Dr Khokar, the CSE students, and external consultants. In particular, the pre-incubation project at CSE played a vital role in developing the business and the venture through:

- Provision of significant business development resources to identify market needs.
- Investigation of potential business models and market segments.
- Flexibility for early venture activities outside of the university.
- Availability of working machines provided by earlier development (by Tape Weaving Sweden).

Takeaway: Innovation Ecosystem

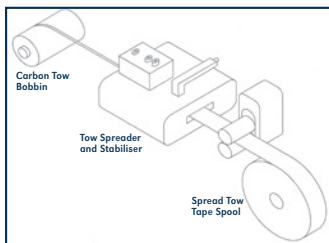
Combining private commercial mechanisms with informal university support can form a valuable public-private partnership for effective and efficient technology transfer.

A Solid Technology Platform

Oxeon doesn't focus on a single technology corresponding to a single product. Instead, it has a platform of technologies that allows for a number of use scenarios in different application fields. Its unique "spread tow" technologies provide better mechanical performance combined with very low areal weight (i.e., weight per unit area) and ease of fabric handling. They are capable of employing different types of fibres and tapes in the production process, which in turn results in a variety of products for different industries.

Oxeon's Family of Technologies:³

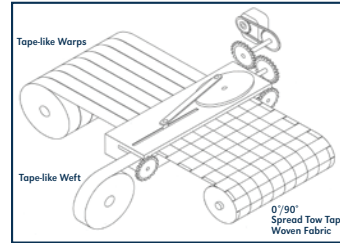
1. Spread Tow Technology



This technology spreads a bundle of continuous fibres ("fibre tow") into a unidirectional tape, known as a spread tow tape. Such tapes are much thinner than conventional carbon-fibre tows or tapes and have more well

distributed fibres packed into the same area, which allows for better mechanical performance.

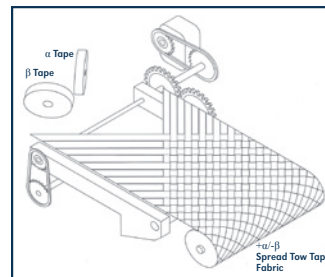
2. Tape Weaving Technology



This production process for weaving with tapes produces spread tow fabrics by interlacing spread tow tapes of the desired fibres. The resulting textile combines the mechanical perfor-

mance of cross-plyed unidirectional materials with the ease of handling of a fabric.

3. Oblique Fabric Technology



This novel production process for weaving with tapes placed at any angle enables continuous-length production of novel fabrics by interlacing two sets of spread tow tapes at different angles, for example +45/-45 (as in

the image), +30/-60 and +50/-25.

The use of tapes instead of yarns allows for a greater concentration of fibre volume. This produces lightweight materials with greater strength and rigidity, improved impact tolerance and surface smoothness.

Creating a Portfolio of Opportunities

Oxeon's novel technologies are applied to a wide range of markets, industries, and business models. A hybrid business model that included both licensing and product sales in different market segments (see Figure 2) drove the evolution of Oxeon's business strategy. This allowed Oxeon to view its patented technologies as a portfolio of commercial opportunities to support business growth through different development phases.

Starting with the tape weaving technologies, the CSE project team evaluated and prioritised the best business options from a long list of possible applications (technology push). This initially included the potential sale of manufacturing machinery. After several dialogues with potential customers, it soon became apparent that there was a bigger need for specific fabrics (market pull). Oxeon's focus quickly shifted to the more promising sales of novel textile materials to other businesses.

Because of the aerospace industry's large market size, Oxeon's long-term plan was to become a supplier to it. However, strict regulatory requirements, long procurement cycles, and risk aversion would have made this a difficult industry to break into, slowing

3. <http://oxeon.se/technologies/>.

Figure 2: Oxeon's Hybrid Business Model And Product Market Segment Development

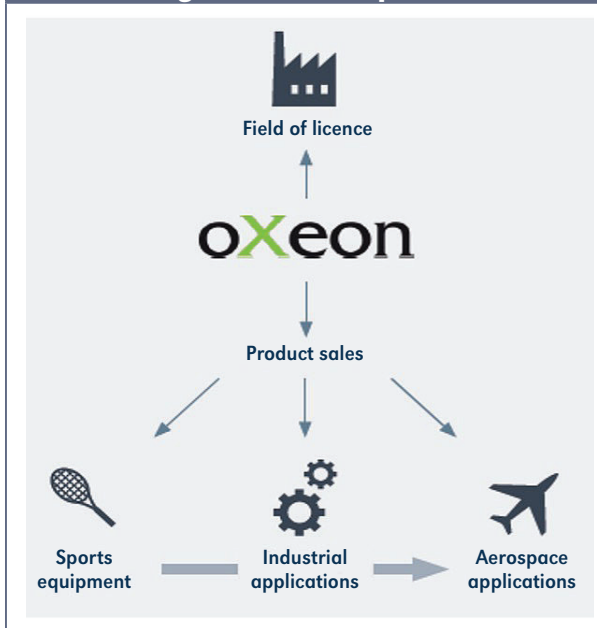
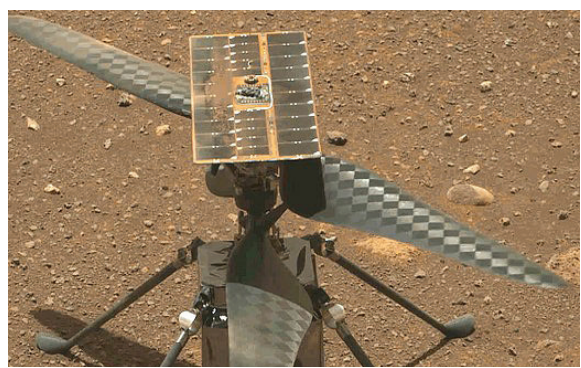


Figure 3a: High-Performance Ski Built With TEXTREME



Figure 3b: Ultra-Lightweight TEXTREME Carbon Fabric Reinforcing The Rotor Blades Of NASA's Mars Helicopter Ingenuity



down the adoption of new technologies. In contrast, sports equipment was seen as a good market segment, open to experimentation with different products and marketing strategies, from hockey sticks and tennis rackets to skis (Figure 3a).⁴ This strategy has paid off in the long run—Oxeon TEXTREME fabric is reinforcing the rotor blades and some other parts on NASA's first Mars helicopter, Ingenuity.

Takeaway: Marketing Strategy

Capturing receptive niche markets to build sales and brand awareness is a useful entry into larger markets with higher entry barriers.

The early evaluation of selling machinery led to the idea of licensing the process technology as a parallel commercial avenue. As a result of early dialogues with interested customers, Oxeon's business model was extended to include licensing. The licensee was a company that wished to use Oxeon's technology to create its own products, but which didn't compete in Oxeon's markets.



"We never excluded the possibility of licensing. We were just waiting for the right opportunity."

Andreas Martsman
VP Marketing and Sales

Technology Proof of Concept Was an Early Necessity

Access to a weaving machine for small-scale production was crucial to Oxeon's business success. Oxeon quickly developed a suitable weaving machine, allowing it to provide samples to potential customers and collaboration partners. This provided proof that the technology was commercially viable and became a convincing argument for the first potential licensee, who was under severe time pressure. "If we hadn't had the machine, I don't think they would have chosen us as a partner," says Mr Martsman.

Therefore, the combination of patent protection and the ability to produce samples created the opportunity to set up a licence agreement. The licensee would probably not have been satisfied by just reading the patent; further steps were needed. Without samples,

4. See, for example, <http://www.textreme.com/the-faction-collective-releases-new-prime-series-ski-collection-reinforced-by-textreme/>.

potential licensees probably would have contacted a machine supplier to find alternative solutions.

Licensing Supported IP Proof of Concept

This early licence agreement became a good source of revenue for Oxeon, co-financing technology and business development in other application areas. It also indicated a strong IP rights basis. Oxeon had to demonstrate that its materials fulfilled the requirements of many applications in different industries. Therefore, the technology proof of concept, which led to the licensing agreement, was a necessary step towards the IP proof of concept. It also created a positive feedback loop towards the extension of the technology into other application areas. As Mr Martsman puts it: “We were able to make licence revenue on our process and use that money to create other business opportunities. That wouldn’t have been possible if we’d only patented the end product.”

The licensing revenues made Oxeon less dependent on venture capital. Nevertheless, Oxeon needed external capital as well. “These investors have had to be patient,” explains Mr Martsman. “We have key investors that understand the long timeline for introducing new material into risk-averse applications with long industry lifecycles.”

Takeaway: IP Licensing

Licensing can complement the implementation of the main business strategy and be a means of co-funding the company at an early stage.

Oxeon doesn’t actively market licensing opportunities. However, it continues to advertise its openness to different licensing possibilities on its website. Oxeon sometimes receives licensing requests that have led to exchanges with potential partners but hasn’t yet found a good match for another licensing deal.

Building a Patent Portfolio

Oxeon has always aimed for broad IP protection, i.e., the combination of processes/methods and fabric materials/structures, and applies for patents as far downstream the value chain as possible. Oxeon also works closely with its customers to identify their needs, and applies for corresponding patents, as appropriate.

Takeaway: Strategic Patent Protection

Consider patenting further along the value chain and protecting applications of a technology close to the consumer market to increase the scope of protection and build a comprehensive control position.

Dr Khokar has been actively involved in Oxeon’s patent strategy and patent portfolio development from day one.⁵ He studies patent databases to review the prior art and checks the competitors’ patenting activity.

Together with his patent attorneys, he co-drafts patent applications (except the claims) and responds to communications from IP authorities, as he knows how to explain the technology. Given his extensive knowledge in the field of weaving technology, Dr Khokar’s active involvement in the patenting process has proven to be invaluable.

Takeaway: IP Management

Involving top managers in the patent portfolio building process is vital to the strategic relevance of patent protection.

Oxeon has several patented inventions, reflecting the continued further development of its technologies. Instead of simply relying on what was achieved with its initial technology, Oxeon has continuously worked at improving and expanding its patent portfolio in the course of new developments.

As there is no real market in Sweden for composites, textiles, or textile machines, Oxeon has always sought to obtain patent protection in other markets. Oxeon holds several patents for its technologies and unique tape-woven materials in a number of countries in Europe, Asia, and the U.S. Patent applications are typically filed first at the EPO with the benefit of a centralised patent granting procedure and the option to choose which countries to validate the European patent in after grant, as well as early certainty about the extent of patentability. In addition, international applications (under the Patent Cooperation Treaty) are used to eventually seek protection in other territories such as the U.S., Canada, Japan, and China.

Oxeon’s patent portfolio protects production methods as well as its unique tape-woven materials (see Table 1). It has been used defensively for the protection of market share in its core business and also to add new markets by allowing access to the technology through licensing.

In one case, Oxeon successfully enforced a patent against an infringer in Germany. Despite the relatively high litigation costs and the drain on internal resources, this helped it secure its leading position. By proving its willingness to sue an infringer, Oxeon reassured its customers and licensee that it was prepared to make meaningful use of its patent rights and defend its market share.

A Holistic Approach to IP

Oxeon follows a strategic approach when it develops its IP portfolio. It always considers the different options, analysing the pros and cons and choosing the

5. Dr Khokar has never completely left academia and has been a professor of textile technology at the University of Borås.

most suitable IP rights. Oxeon decided to sell materials instead of machinery, and therefore its process-related inventions suffer less from the risk of reverse engineering.

Oxeon develops and sells its material under the registered trade mark TEXTREME. This trade mark is registered for different applications in goods, and in several countries and regions, including the EU. The trade mark is more important for sporting goods applications, where TEXTREME is visible on end products, thereby creating an indirect relationship with the end user. It is less relevant for industrial applications where the interaction is business-to-business.

In some cases, Oxeon has chosen not to patent certain inventions and instead keep them as a trade secret. This strategy is typically used for some manufacturing processes that are difficult to reverse-engineer from end products, and for which infringement is difficult to detect and prove. There is then no public disclosure, and no legal time limit to secrecy.

Takeaway: IP Portfolio

A portfolio approach that combines patents, trade marks, and trade secrets provides complementary protection, facilitating both exclusivity and licensing of technologies.

Oxeon's bundle of IP rights, including patents, trade marks, and trade secrets, has proven to be one of the main pillars of the company's commercial success. Oxeon's IP strategy combines the creation of a broad patent portfolio, used for licensing to partners and for blocking competitors, with a trade mark strategy, securing visibility on all products, particularly consumer ones. See Figure 4. ■

Available at Social Science Research Network (SSRN): <https://ssrn.com/abstract=4099723>

Further technology transfer case studies can be found at epo.org/case-studies.

Figure 4: Technology Transfer Timeline

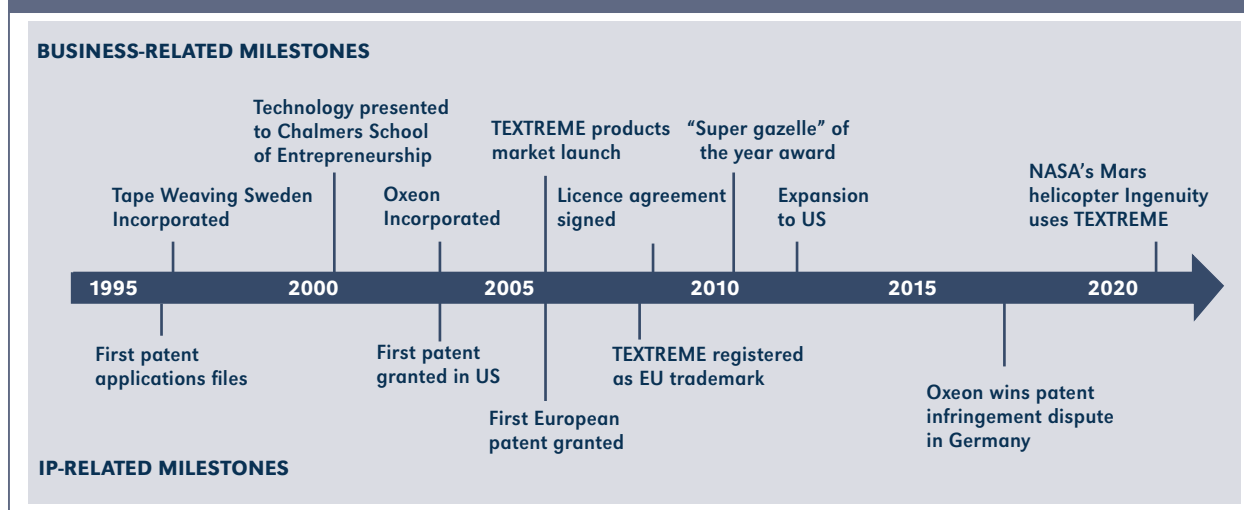


Table 1: Oxeon's Patent Portfolio Applicable To Spread Tow Technologies

Patent Number	Title	Priority Date
EP1354991B1	Woven material comprising tape-like warp and weft and an aid for producing the same	14 April 1997
EP1838909B1	A woven material comprising tape-like warp and weft, and an apparatus and method for weaving thereof	17 January 2005
EP1838911B1	Method and apparatus for weaving tape-like warp and weft and material thereof	17 January 2005
EP2444535B1	Method and means for measured control of tape-like warps for shedding and taking-up	19 October 2010
EP2479324B1	Method and means for producing textile materials, comprising tapes in two oblique orientations	20 January 2011
EP3587477A1	Ultra-thin pre-preg sheets and composite material thereof	21 June 2018

Source of IP

Nandan Khokar

- Researcher and key inventor behind the tape weaving technologies and materials
- Co-founder of the companies Biteam, Tape Weaving Sweden, and Oxeon
- Actively involved in the patent strategy and patent portfolio development

Chalmers University of Technology (chalmers.se)

- One of Sweden's top technical universities; located in Gothenburg, where initial IP was created

Tech Transfer Catalysts

Fredrik Winberg

- Provided entrepreneurial vision and initial business support
- Co-founder of the companies Biteam, Tape Weaving Sweden, and Oxeon
- Member of the board of Oxeon

Chalmers School of Entrepreneurship (Chalmers CSE)

- Pre-incubator, where students create technology ventures as part of their university education

- Facilitated the creation of a viable business model for Oxeon and provided business planning support
- Two students became top managers of Oxeon (CEO Henrik Blycker and VP Marketing and Sales Andreas Martsman)

Business angels and Chalmersinvest (now Chalmers Ventures)

- Provided capital and access to networks

IP Commercialisation

Oxeon (oxeon.se)

- Founded in 2003 and headquartered in Borås, Sweden
- Spin-off from Chalmers University of Technology
- In 2019 it generated a turnover of over EUR 6 million with 34 employees
- “Super gazelle” of the year in 2010
- Provides tape weaving technologies and tape-woven materials to the sports, aerospace, and other sectors
- Materials are sold under the registered trade mark TEXTREME

Editors: Thomas Bereuter, Yann Ménière, Ilja Rudyk
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Photos: Oxeon AB

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