Industry Case Study Series on IP-Management

HERAEUS
From amorphous metals to digital business models

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Since 2015 he is Executive member of the managing Board of Materials Valley e.V. – a network of universities, institutes and industry in the Rhine-Main area to foster collaboration between the partners.

From 2015 until May 2019 Dr. Wachter was Board member and since 2016 treasurer of the European Institute for Innovation & Technology of Raw Material (EIT RM) with headquarter in Berlin.

PART I

About Heraeus

Heraeus is a German technology group combining unique material expertise with technology leadership, especially in the fields of precious and special metals. The father of today's global company was Wilhelm Carl Heraeus, a pharmacist and chemist who took over his father's pharmacy in Hanau, Germany, in 1851. At the time, platinum was in high demand for jewelry making, but posed a major challenge for goldsmiths: it had to be forged in a white-hot state, because it is extremely hard and has a melting point of 1769 degrees Celsius.

Wilhelm Carl Heraeus, who worked with local goldsmiths, was familiar with the problem – and he found a solution. After extensive attempts, he succeeded in melting two kilograms of platinum in an oxyhydrogen gas flame. The "first German platinum melting house" was born, and success was not far off. The young entrepreneur's customers soon included goldsmith shops and jewelry factories around the world, as well as dental factories, chemical laboratories, and companies in numerous other industrial sectors. Wilhelm Carl Heraeus continued to experiment with platinum and found one new application after another for the precious metal.

By the end of the 19th century, his sons Wilhelm and Heinrich had inherited their father's business, and W. C. Heraeus relocated to new facilities just outside the city gates of Hanau together with 40 employees. At that time, around 1 metric ton of platinum was melted and processed each year. Another success factor developed at the beginning of the 20th century, namely the company's systematic collaboration with the scientific community and its commitment to basic research. As a result, Heraeus discovered a method for manufacturing quartz glass in 1899. Rock crystal was melted in an oxyhydrogen blowpipe, permitting the production of almost bubble-free quartz glass of highest purity for industrial and medical purposes.

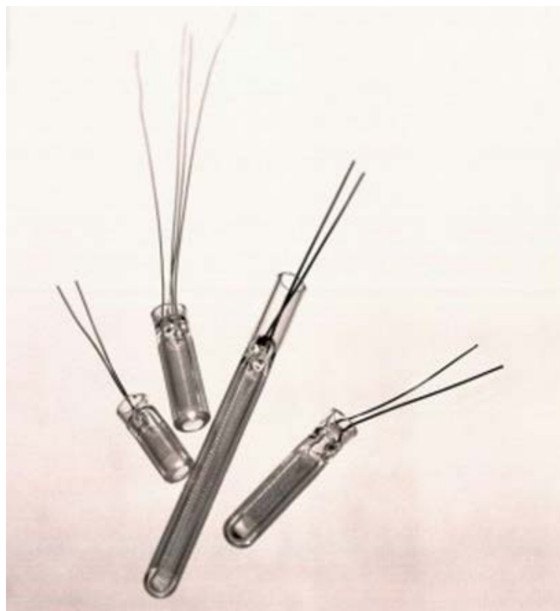


Figure 1: The patenting of the "electrical resistance thermometer made of platinum wire" by W. C. Heraeus in 1906 marks the beginning of modern temperature measuring technology. The novel design (platinum wire wound up on a piece of quartz glass and protected by a quartz glass tube) permitted the safe, accurate and fast measuring of high temperatures.

Other milestones included the melting of metallic materials inside a vacuum. Between 1923 and 1933 alone, the then independent Heraeus vacuum melting facility was granted 84 German patents. Despite the collapse of the markets in the wake of World War I, the company's growth continued. In 1939, 1,000 people worked for the company; its annual revenues had reached 20 million German marks. With Dr. Reinhard Heraeus at the helm, the family-owned company for three generations had finally developed into a multi-product enterprise.

Figure 2: Wilhelm Rohn introduced vacuum metallurgy at Heraeus in 1912. In specially developed electric resistance furnaces, refractory base metals were melted under vacuum to produce entirely new alloys such as chromium-nickel alloys as an alternative to platinum wires in thermocouples, or nickel-iron alloys for components in transmitter and receiver systems in communications engineering. From the 1920s onwards, Heraeus used induction furnaces to produce base metal alloys by the barrel.

Production in the post-war period was focused on high vacuum technology and contact technology. The company benefitted from the economic boom after the Second World War and became an international company. The first foreign sales offices were established in France and Italy in 1958. Foreign subsidiaries and affiliated companies in the USA, England, and Japan would follow, along with production facilities in Korea and the Philippines. In 1979, foreign revenues surpassed domestic sales for the first time.

In 1983, Dr. Jürgen Heraeus, the fourth generation of the Heraeus family to lead the company, took over. Under his management, the enterprise became a full-fledged global organization. After founding Heraeus Holding GmbH in 1985, he reorganized the Group from the ground up. He assigned its core activities to five decentralized, independently operating managing companies: W. C. Heraeus (precious metals), Heraeus Electro-Nite (sensors), Heraeus Kulzer (dental and medical products), Heraeus Quarzglas (quartz glass), and Heraeus Noblelight (specialty light sources). These new management structures would set the tone for the company's globalization.

In 2001, the Heraeus Group celebrated its 150-year anniversary. The small Unicorn Pharmacy, where Wilhelm Carl Heraeus began his work, had developed into a Group with more than 13,000 employees in facilities all over the world.

Today, Heraeus is a diversified technology group consisting of six business units. The largest division with over 3,000 employees manufactures sensors and measuring systems for molten metals. Other large business units include: Precious Metals (2,748 employees), as well as the materials and technologies business (2,900 employees). In total, the Heraeus Group currently employs some 12,500 members of staff.

Change has been a constant companion throughout the company's 160-year history. New products were invented (Heraeus currently holds over 5,300 patents) and the company set new priorities. Other fields of business were abandoned. In 2013, Heraeus sold the long-established dental products business. But platinum continues to be an important material until today: It is used for coating catalysts but also for developing active ingredients for cancer treatment.

Heraeus Medical was awarded the title of "Top Innovator" in 2018 and voted one of the 100 most successful think tanks in Germany by innovation researcher Prof. Dr. Franke from the Institute for Entrepreneurship and Innovation of the University of Vienna. An award-winning idea: new bone cements, for example, which are used to fix prosthetic joints in the bone tissue, can be mixed with utmost precision during surgery, making them not just innovative, but also user-friendly.

By its very nature, Heraeus creates high-quality solutions for its customers and sustainably strengthens its competitiveness by combining materials expertise with technological know-how. The company's ideas revolve around subjects such as the environment, energy, health, mobility, and industrial applications. The portfolio ranges from components to coordinated materials systems for use in a variety of industries, including steel, electronics, chemicals, automotive, and telecommunications. In FY 2017, Heraeus generated EUR 21.8 billion in sales with over 13,000 employees, and held more than 5,700 patents and pending patents. Excluding trading activities with precious metals, Heraeus generated a turnover of 2.185 billion. Nearly EUR 150 million were invested in research and development in 2017. Some 700 developers around the world develop new products, materials, and system solutions in 28 locations around the globe.

Innovative materials: amorphous metals or metallic glasses

The importance of metals for our technology culture cannot be overstated. Metals such as copper, bronze, or iron changed the world so profoundly that entire periods were named after them. This is also referred to as 'metal culture'. In the so-called Neolithic revolution, man developed his skills to extract ore, turn it into metal, and use it for agriculture, art, and war. This required ever larger social groups to act in a planned, forward-looking, and collaborative manner, making man "the architect of his own fortune". Copper was the first metal humans took possession of. About 10,000 years ago, our Stone Age ancestors in the Middle East began to process the strange green stone. They discovered that the lumps were much easier to mold when thrown into the fire and heated, and soon began to harvest this natural resource using their tools made of stone. The result: decorations for death masks giving the new material a mystical meaning on the one hand, and new weapons on the other. Later on, tin bronze was used, which is harder and melts at lower temperatures. Even in Greek mythology, blacksmiths were celebrated as highly skilled gods, and with them began the age of human mechanization. Hephaestus, who was called Vulcanus by the Ancient Romans, was the Greek god of fire and smithery.

Metals are those chemical elements which are located on the left of the periodic table and below the separation line from boron to astatine, and include 80 percent of all chemical elements. Metals have the following four characteristic properties:

- High electrical conductivity which decreases with increasing temperature
- High thermal conductivity
- Deformability (ductility)
- Metallic shine

These properties are based on the atomic lattice structure of the metallic bond, whose most important feature is the freely moving electrons within the lattice structure. In other words, individual atoms of these elements have no metallic properties and are therefore not considered metals. Only when atoms are joined together in a metallic lattice bond, groups (clusters) of atoms display metallic properties. These regular bonds of atoms are also called crystal structures, describing a regular repetition of symmetric patterns known as a crystal lattice. If the atoms cannot form a crystal lattice structure in an extremely fast cool-down process – at one million degrees per second, for example – and if they form an amorphous structure, we speak of metallic glasses or amorphous metals.

Glass does therefore not refer to the common drinking glass, but is a much more generic term in materials science. In scientific jargon, a material is called vitreous when the atoms within the material are arranged in entirely irregular rather than regular patterns. Exactly this state of 'disorder' can be found in metallic glasses, and this has far-reaching consequences for their properties.

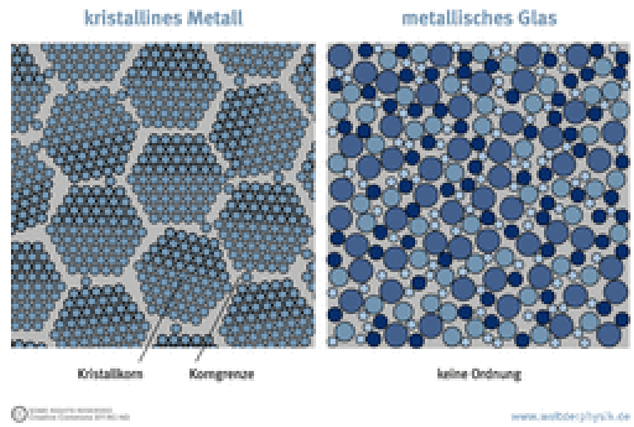


Figure 3: Atomic (dis)order determines the material properties.

The strength of metallic glasses far outshines that of steel. And yet, they can be molded into shape at less than 300 degrees Celsius in much the same ways as plastic. This unique malleability of metallic glasses permits much greater precision in the production of components than with conventional metals. Minutiose details of just one millionth of a meter – that's sixty times thinner than a hair – can be cast with utmost precision. Some shapes have even just been made possible by metallic glasses. Foam materials which consist of 99% air but are 100 times harder than Styrofoam almost sound like pure fantasy. And yet, metallic glass has already made such materials become reality. The reason for their astonishing properties is the arrangement of the atoms in metallic glass materials. Their amorphous structure results in some interesting properties and great practical/technical benefits: in particular, they are characterized by high electrical resistance and a magnetically soft behavior, meaning that they follow changes in the direction of a magnetic field even at low field strengths.

But the absence of crystalline particles also brings with it the archenemy of metallic glasses: brittleness. Although metallic glasses are extremely tough and elastic (yield strength 10 x higher as for crystalline materials) they tend to collapse completely if they do collapse. While their crystalline counterparts initially withstand plastic deformation by becoming more rigid, defects in metallic glasses spread like avalanches. Once a crack forms the crack progresses and a crack can easily progress through the entire material. Since sudden component failure would have catastrophic consequences in critical applications, the use of metallic glasses is limited. But intensive research on how to overcome this hurdle is underway, and a possible solution to the problem may already have been found. The growth of cracks can be limited by adding individual crystal particles to a metallic glass.

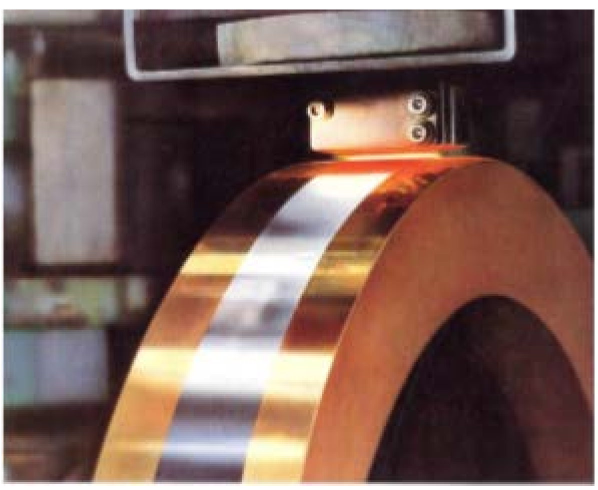


Figure 4: Melt spinning process

Amorphous metals are no novelty, researchers from the California Institute of Technology were the first to succeed in producing a metallic glass from a gold-silicon mixture in 1960. However, they have not found any widespread use in the art for it yet. One reason for this are the difficult manufacturing conditions, which have so far only permitted the manufacture of thin strips and films. Industrial research groups have developed the so-called melt spinning process for the production of metallic glasses to maturity: the molten alloy is poured onto a rapidly rotating, water-cooled metal wheel through a ceramic spinneret. The close contact between the emerging molten metal and the wheel, as well as the high thermal conductivity of the wheel, cause the material to cool down extremely fast. Before one revolution is completed, the metal film is lifted off and gradually forms a thin strip. In order to achieve cooling speeds of one million degrees per second, however, the material must be significantly less than 0.1 millimeters thick. This is primarily controlled by the cylinder speed: thickness values of 0.02 to 0.04 millimeters can be achieved at speeds of 20 to 50 meters per second. The dimensions of the spinneret and the cooling wheel determine the width of the film.

Only recently have there been promising developments in the manufacture of so-called bulk metallic glasses (BMG), which will lead to new technological applications in a few years' time. Purposeful changes in the chemical composition, however, have led to significant improvements in the ability to form glasses. The required cooling rates for alloys with four or five different metal components, for example, are now only a few K/s, meaning that component dimensions of several centimetres thickness can be achieved. What continues to be a problem, however, is the fact that a high degree of purity of the initial melt is required for production, because even minor impurities caused by high melting composites, by example metal oxides, can lead to undesirable crystallization.

Significant progress was also made with the development of metallic solid glass, which has a very low glass temperature. This describes the transition from the elastic, low-viscosity state of the melt to the solid, brittle state of the glass, and is already well below 1000°C in most of the compounds. As a result, such metallic glasses can be thermoplastically molded at a low cost in similar ways to plastics. In contrast to the latter, however, they possess the typical properties of a metallic alloy at room temperature, such as great hardness and good electrical conductivity. Solid metal glasses molded in this way are already in use as housing materials for high-quality mobile phones. Due to the enhanced hardness of metallic glasses, the wall thickness of the housings can be reduced further, enabling weight savings and greater degrees of miniaturization.

The absence of crystallization prevents the shrinkage of the molded part during cooling, thus permitting the highly precise molding of the material. This makes metallic glasses suitable as materials for nano- or microelectromechanical components (NEMS/MEMS). On the one hand, they can be used as molding and embossing tools; on the other hand, they can also be molded or embossed into nano- and microstructures themselves.

Another large field of application is the medical industry. Solid metallic glasses are already being used as materials for scalpels in this field as they can be sharpened with particular precision and their hardness and corrosion resistance makes them very durable. But these glasses could also be used as bone implants in the future. Because of their chemical composition, alloys based on Ca, Li, and Mg, for example, are inexpensive to produce and have a low density. At the same time, they possess a high degree of rigidity and elasticity which is comparable to that of human bones. A similar application for Mg-Zn-Ca-containing alloys are biodegradable screws for use as fixation screws in bone surgery. The relatively rapid and complete decomposition of the screws inside the body during the healing process would eliminate the need for a second procedure in order to remove the screws.

Solid metallic glasses could also increasingly be used in the field of energy supply in the future, e.g. for minimizing energy loss in large-scale transformers. Furthermore, metallic glasses based on Ca, Li, and Mg can be used as hydrogen storage devices, e.g. for fuel cells, as these elements bind hydrogen well and form hybrid compounds such as MgH_2.

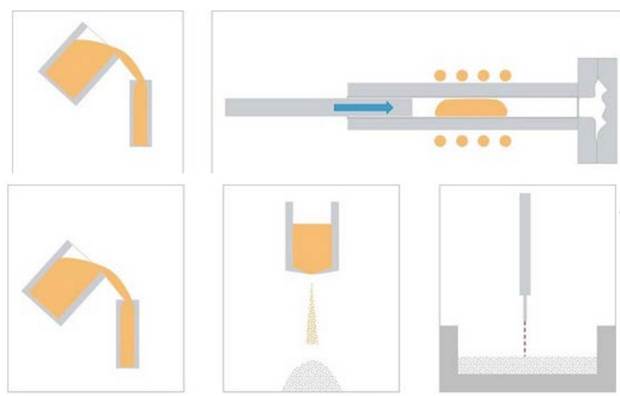
Due to the aforementioned hurdles and limitations of this innovative class of materials, research efforts have so far been focusing primarily on the development of alloys as such, and less on their processing and possible applications. But it is precisely the skillful combination of alloys, their processing, and their constructive physical/technical application that holds the greatest economic potential for metallic solid glasses.

Heraeus Amloy / Amorphous Metals

In addition to the so-called Global Business Units (GBUs) under the umbrella of Heraeus Holding, which are positioned in a market-oriented and functional manner, the company also runs “Heraeus Start-ups”. These start-ups deal with new markets and business models. In order to benefit from more agile and networked thinking, as well as interdisciplinary research and development, Heraeus promotes these business ideas outside of a GBU structure. Heraeus Amloy (AMLOY: Amorphous Alloy Technologies) is such a start-up structure. Heraeus Amloy seeks to develop real-life technological applications for a unique combination of material properties (high strength, outstanding elasticity, corrosion resistance, biocompatibility, and isotropy). Current market trends for high-tech applications play an important role in this endeavor. Another buzzword in many fields is miniaturization, which is to be achieved by means of easily machinable materials of good flexural strength – a contradiction in itself for traditional materials. Isotropic behavior, i.e. the same mechanical properties along all dimensions, enables simplified specifications and product designs. In contrast to amorphous metals, which combine all of the characteristics mentioned above, most crystalline high-strength materials available today are not easy to process or require a complex process chain.

Metallic glasses develop their full potential when they can be processed on an industrial scale. Heraeus has developed a wide range of different manufacturing technologies which can be used individually or in combination. This allows the company to offer its customers the best industrial equipment for their respective applications. The product portfolio and the available process solutions are continuously developed further in collaboration with the customers, as well as internal and external partners. Depending on the requirements for each application, Heraeus can select the best production method for amorphous metals: injection molding, additive manufacturing, or casting and rolling.

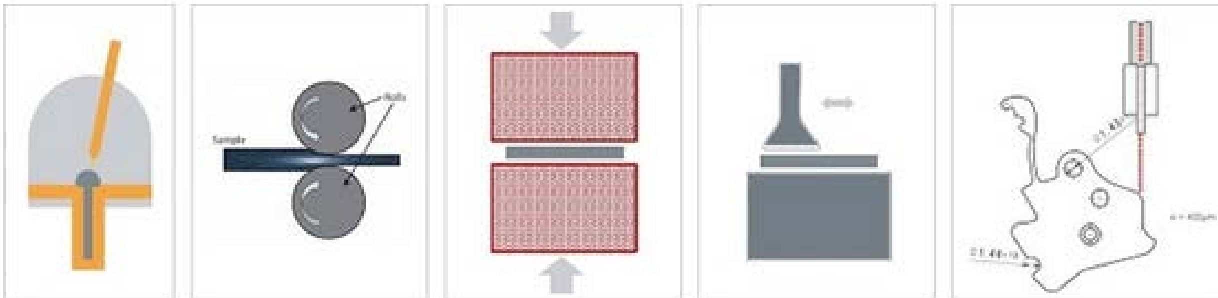
Melting Injection molding



Injection molding has the advantage of enabling 24/7 high-volume production in an automated process. It can be used as an alternative to mechanical machining or metal injection molding.

Melting Atomization Printing

Additive manufacturing permits large dimensions and complex geometries of adequate strength and flexibility. It enables the production of extra strong final-shape



Melting | Rolling | Heat Treatment | Polishing | Laser Cutting

components and sophisticated designs. However, economic viability considerations permit the production of small to medium quantities only.

Casting and rolling is suitable for small components with excellent mechanical properties.

This method provides for a very high reproducibility of the material properties. Narrow tolerances such as those typical in the watchmaking industry can be adhered to in this way. In addition, this method permits high-quality polished surfaces.

3D printing is an additive manufacturing method. “Additive” refers to manufacturing processes for the layer-by-layer production of components made of metals, polymers, or special materials. Computer-controlled 3D printers are able to construct customized three-dimensional workpieces from liquid or solid materials. Laser or electron beam melting plants are used for refractory metal powders. The laser method consists in heating metal powders beyond their melting point. The fine particles become liquid and solidify into a dense layer that forms a firm bond with the layer underneath. The computer-controlled scanner head steers the laser beam across the powder layer and produces complex components layer by layer.

The special competence of Heraeus is particularly evident in 3D printing. Special alloys need to be optimized for processing and their subsequent application. The challenges start with powder production. Homogeneity, purity, viscosity, and bulk density determine the quality of the components melted by laser or electron beam. Only powders with a precisely defined particle size distribution, which are also absolutely round, enable the additive production of complex components without any unwanted porosity or other construction defects.

Part II

The challenge: Material 4.0 – the digitization of materials science

Digitization has already created groundbreaking impetus in all fields of application within the engineering sciences. This applies in particular to the major growth markets of mobility, communication, safety, health, and energy – and not least to the broad field of materials science and materials technology, which plays a central role in all these areas. Especially where materials have to be light and function reliably even under extreme stress, i.e. where precise knowledge of the local properties of materials and components is fundamental, digitization is proving its worth as an optimization path. Studies have shown that almost three quarters of all new products are based on new materials. At the same time, material costs in the processing industry account for up to 55 percent of total costs.

Digitization poses a particular challenge for materials science and materials engineering. This is due to the large number of overlapping disciplines, resulting in different standards, analysis methods, and models in this field. Especially physics, mathematics, metallurgy, chemistry, various engineering sciences, and crystallography play a prominent role in this respect. Since the beginning of the 21st century, these views have been complemented by strong influences from the corresponding computer-aided disciplines such as computational physics/chemistry, computational mechanics, or computational materials science, as well as numerical mathematics and computer science. In addition to ever more realistic simulations, this also enables modern approaches to data analysis from which experimental simulations can benefit, for example.

Research and applications range from adaptive materials equipped with sensors to self-learning production systems or additive production as described above. 3D microstructural analysis using machine learning also offers great potential. The digitization process spans the entire value chain, from the atomic to the macroscopic level, including conceptual design, testing of previously unknown material combinations or alloys, manufacturing using database-supported characterization methods, quality assurance, analysis of product and material life cycles, proficiency testing, and extended relationship management (XRM) during and after delivery. Industry 4.0 and "digital twins" (virtual images of materials, components, or products on which certain design ideas, or the effects of the properties of different materials can be verified and modified in each processing step on the computer before real production takes place), as well as "big data" are key technologies in the digitization of materials technology.

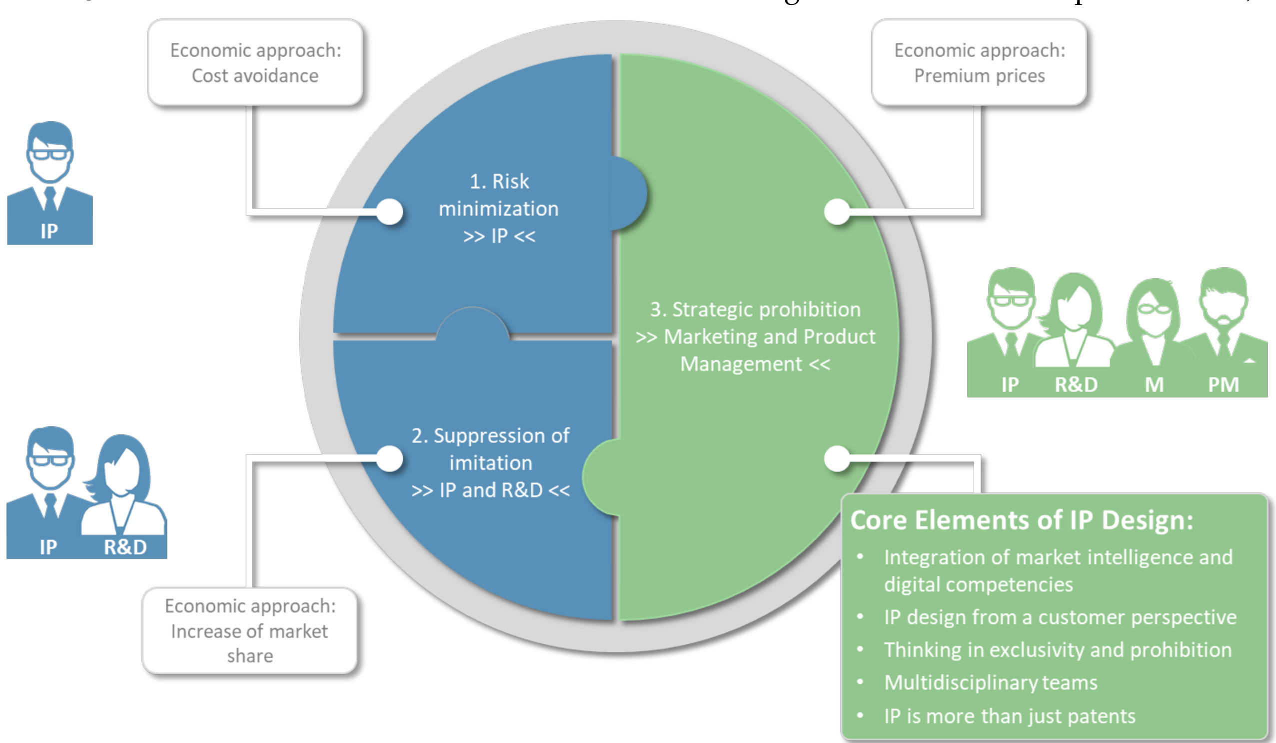
Databases storing material properties and characteristics can save time and energy during development, taking into account various factors such as temperature, ageing, or stress. Systems simulations or digital tools can also be used to reduce production costs and save resources. Digitization therefore increasingly facilitates individual and integrative customization of materials and processes.

IP design for developing and protecting digital business models at Heraeus Amloy

The digital transformation is an enormous challenge for structurally complex established companies. It requires a transformation of leadership thinking. Digitization is more than the use of digital technologies; it entails fundamental changes in the way companies work and deliver results. This is why the start-up structure of Heraeus Amloy is ideal for implementing the digitization of business models for innovative materials along the entire materials chain.

Digitization paves the way for new business models beyond product transactions, and companies require the right mindset to use these possibilities. Digitization brings about a fundamental change in customer relationships that requires an understanding of customer decisions along the customer journey. It also requires the ability to eliminate silos. Work is increasingly organized in task-based teams rather than in departments. Solutions require multidisciplinary. Speed is a key success factor in a digital competitive environment.

IP design enables us to protect digital business models today that will only be implemented in the future. Digitization scenarios are patented in order to create digital options for the inventing company's own further development. IP design enables thinking in terms of business models, i.e. Thinking from the customer's point of view,



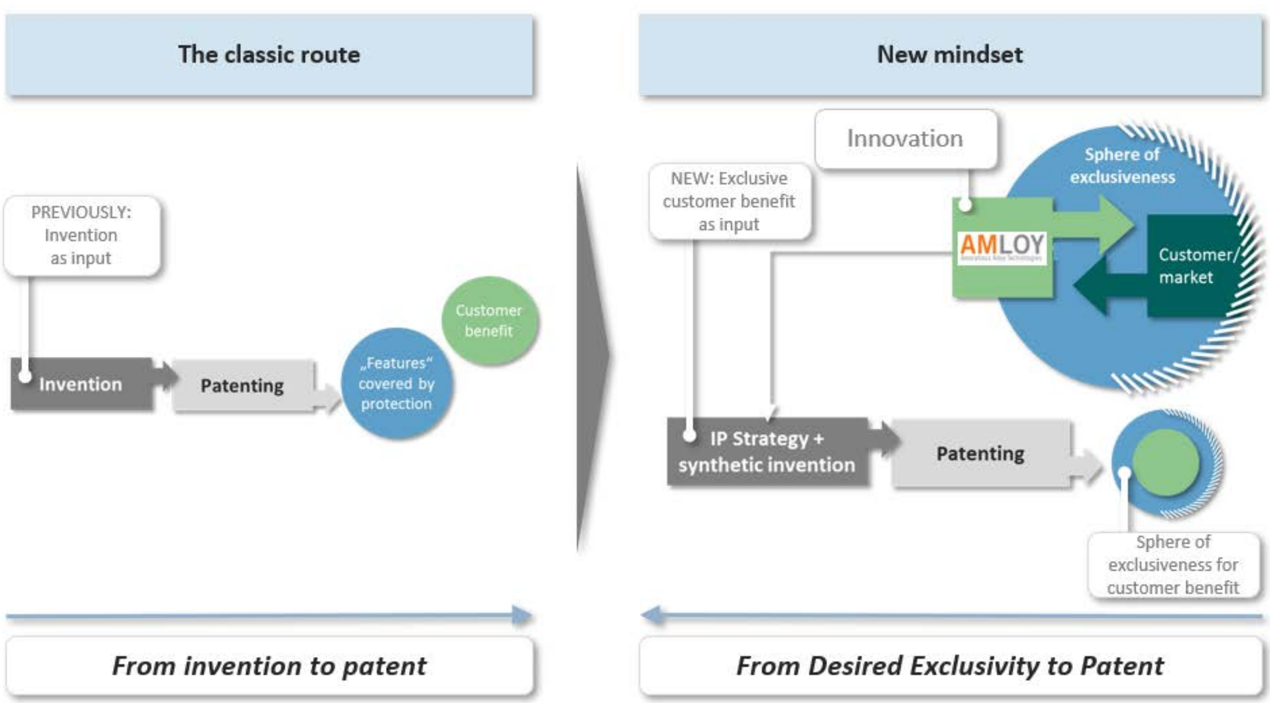
overcoming silo thinking, thinking faster and in a more agile way, and thus taking advantage of the opportunities offered by the digital complexity.

Leadership means setting clear goals and providing guidance for staff members. In today's global economy, competition no longer only takes place between goods and services, but increasingly also between people. To achieve growth, people are needed worldwide in order to develop new ideas and technologies.

Managers must lead the way to success.

- What needs to be done to achieve the set goals?
- What measures are necessary in order to achieve them?
- Which support do staff members need to achieve these goals?

Digitization is a management task.



Digitization means flatter hierarchies and decentralized authority. And management must change, too. Through the creation of new and more flexible teams and organizational structures, the manager's role is changing from that of a general to that of a navigator.

Agility and superior speed are achieved through virtual teams and structured communication. Digitization leads to greater complexity, and networking means that significantly wider system boundaries must be taken into account when developing services and business models. Heraeus Amloy has internalized these principles and implements them in everyday practice.

IP design is a way to structure problems and work them out systematically in multidisciplinary teams. IP design is a structured creative process, a method of developing innovative products, services, processes, and business models as a team – especially for digital topics.

IP design makes “waiting for inventions” from the R&D department a thing of the past. With IP design, IP is actively developed to meet the needs of business development. The ultimate goal of IP design is to achieve legally enforceable exclusivity for the business model.

IP design provides executives with a toolbox for an efficient way of working. IP design helps Heraeus Amloy to live and breathe the five most important leadership tasks in digital leadership:

1. IP design drives change within the enterprise. IP design shows staff members in the IP design teams that the new digital environment is not a burden but an opportunity. Change is understood as a positive space of possibilities. Designing rights prohibiting third-party access to their own business model options allows businesses to think through their options for action and protect them for their own further development. Disruptive scenarios can likewise be blocked for the competition by a company’s own patent positions.
2. IP design helps to make staff performance transparent and enables recognition. Rapid changes in constellations can be dealt with and protected promptly. The IP design toolbox allows the documentation of contributions and provides a structure for solution-oriented and efficient collaboration within multidisciplinary teams.
3. IP design promotes cooperation. The tools of IP design help to facilitate efficient collaboration and to systematically collect and analyze large amounts of data, e.g. by monitoring digital business models of the competition and observing rapid changes in the digital environment. Multidisciplinary teams enable the integration of the market and digital side into the on-demand creation of IP.
4. IP design supports staff development. High-speed innovation and change become possible through the targeted use of creativity. IP design removes the shackles of having to produce one’s own developments today in order to have freedom of action in the future. It does not start with a company’s own R&D efforts, but rather with describing and protecting the ultimate goal.
5. IP design provides orientation. Among the multitude of trends and possibilities, the essential options for future markets, products, and services must be identified and evaluated. IP design is a process which enables this, and encourages and empowers stakeholders to engage in constant internal and external reflection.

Heraeus Amloy has developed and protected various know-how-based business model scenarios by using IP design. The point of departure was Amloy's unique expertise, starting with the material itself and the various possible manufacturing processes, through to the desired properties of the finished component or product in its application. This was accompanied by a change in the significance of Amloy to potential customers. Amloy is no longer just a materials and processing expert, but rather a competent end-to-end partner for its customers, from alloy composition to application properties, thus bridging potential competence gaps in the industrial value chain. This bridging and integration of the various stages along the value chain is enabled by the use of digital technologies, which provide the basis for documenting, learning, optimizing, and giving advice based on a large number of projects.

How does IP design work as a management tool?

IP design is a tool for designing creative processes. Staff members are encouraged to apply their creative skills in a focused and targeted manner in order to think through and protect digital business models. The IP design process is divided into two main stages. During the first stage, the business model is used in order to derive what IP is needed. During the second stage, the identified IP needs are met.

A methodological structure ensures that the desired outcomes are achieved in a transparent and comprehensible manner during the individual steps. Positive thinking in terms of options and alternatives motivates team members to get involved. IP generation is decoupled from technical R&D in order to make it agile, thus using the digital complexity to shape opportunities in potential ecosystems. Step-by-step process execution increases the controllability of the creative output and the predictability of the results. Ultimately, it is sufficient to describe the solution in order to create prohibitive positions. Developing it is not necessary. This means that positions can be protected today which might be used in real-world business model development in the future. Especially in the case of digital eco-systems, the early occupation of strategic positions is important as the competition also needs nothing more than a description of the solution in order to obtain prohibitive rights.

How can IP design be used by executives?

The key success factor of IP design as a management tool is a systematic focus on business models as the starting point for designing prohibitive rights, as IP design sets the direction and goals in order to make visions and scenarios thinkable. The conventional use of patents is aimed at the inventor. With digital and software-oriented technologies, the business model becomes the starting point for IP generation. As a prohibitive right, intellectual property has entirely different effects on the resource and market sides of business models.

On the resource side, IP is used in such a way that so-called VRIN resources are created. VRIN is an acronym which stands for the characteristics of key resources: valuable, rare, imperfectly imitable, and non-substitutable. On the market side, IP is used to influence market forces, i.e. the rivalry between competitors, and the bargaining power of suppliers and customers. In addition, the market entry of competitors and the introduction of alternatives to the patent owner's own products or services in the eyes of the customer are to be prevented.

IP design helps to describe the business model in such a way that IP can be used directly to achieve strategic goals. Team members can contribute their respective expertise and thus complete the holistic picture of future positions in the eco-system.

IP design for developing and protecting business models

The Heraeus start-up structure, which focuses on developing new technologies and business models, acts as the group's innovation hub. The deliberations on business models have also triggered a debate on success factors and typifications of business models as such, as well as their constituent elements. Descriptions of these deliberations in the context of digital business models have been emerging especially since the beginning of the so-called "New Economy". All business models based on Amloy data are digital business models, given that their success essentially depends on the targeted and business model-oriented processing of data.

Business models can be understood as an economically meaningful framework coordinating the independent action of individual employees. The constituent elements of business models are recurrent and are applied recombinantly in business practice. Digital business models can be understood as recombinant models combining similar structural components in novel ways in order to leverage different success factors.

The resource-based approach allows us to understand the company as a set of resources, which constantly adapts to changing framework conditions such as the above-mentioned developments in the construction industry. On the resource side, patents can be understood as tools for creating a VRIN quality for valuable resources. Within the resource-based view, patents ensure that resources which contribute relevant value are rare, difficult to imitate, and difficult to circumvent by the competition.

On the market side, patents can be understood in such a way that their barrier effect is used to influence market forces with respect to a company's own market position. Within the scope of the market-based view, patents ensure the suppression of substitute solutions for a company's own offerings, the creation of market entry barriers, and the undermining of the bargaining power of suppliers and customers.

Depending on the business model element in question, the exclusivity achieved by the barrier effect of a patent results in different degrees of value added within the scope of the business model as a whole. From a patent point of view, the business model is an appropriation mechanism for internalizing the prohibitive effect. In analogy to the typification of the economic effects of patents, it is also common to typify the inventive subject matter and the challenges leading to the generation of inventions, as well as the claim structures of patents. The basic approach to arriving at explanatory descriptions of the real world is to recognize recurring patterns in creative thinking and business model design.

In terms of their inventive subject matter, digital patents relate to the elements of a digital business model and the barrier effects internalized in the context of this business model. Their typification relies on recurrent objects and economic effects. Digital patent types are inherently digital to the extent that they can be used in order to protect digital business models from imitation. Descriptions of digital patent types are neither a systemization of inventive subject matters nor a classification according to claim structures (as would be the case with computer-implemented inventions). The classification of digital patents serves the purpose of identifying recurrent elements in digital business models which can be protected by means of patents and are suitable for suppressing the imitation of the business model by means of appropriately designed barrier effects.

The structure of digital patents follows the logic of business models used in Industry 4.0 approaches. A fundamental principle in this respect is the application of four distinguishable dominant logics which are used to generate economic advantages in the business models:

- competence logic
- data and information logic
- simulation and representation logic
- networking logic

These logics constitute the cognitive map of companies implementing Industry 4.0 business models. The dominant logic determines the relevant activities of the companies implementing these logics, e.g. the ways in which Heraeus meets customer needs. Eight different technical concepts can be applied based on these dominant logics:

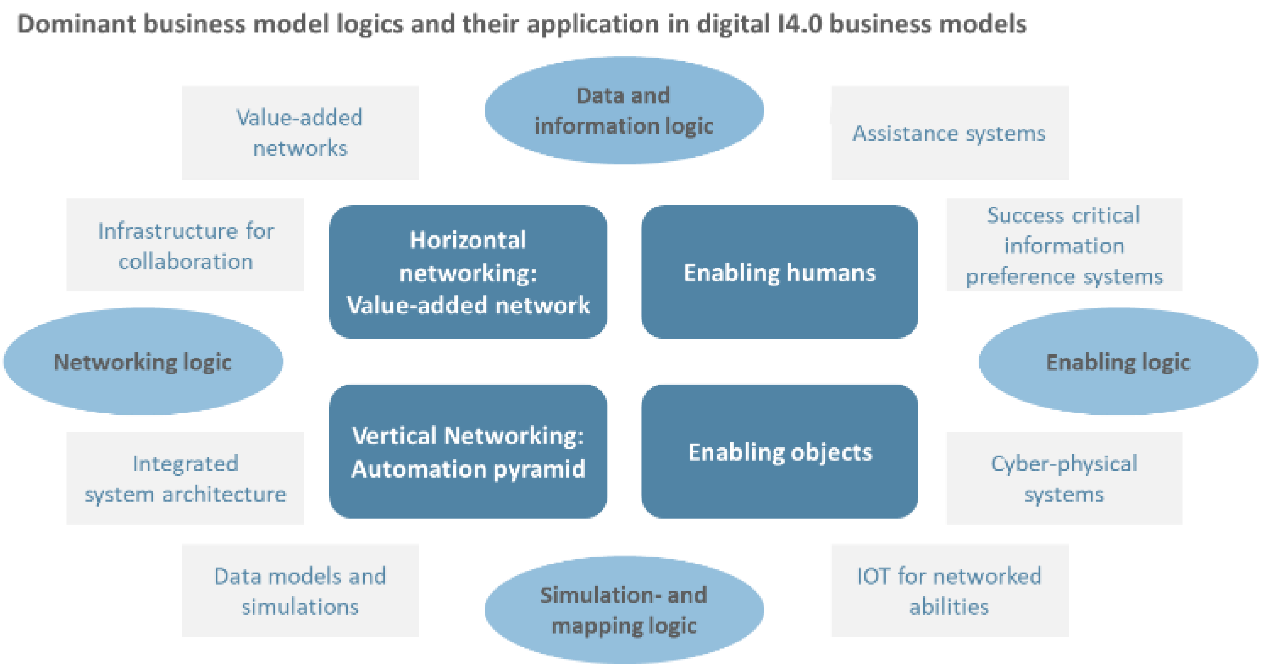
- Success-critical preference systems
- Assistance systems
- Cyber-physical systems
- IoT systems for networked empowerment
- Value added networks
- Collaborative infrastructure
- Data model and simulation concepts
- Integrated system architectures

The application of these concepts, which were applied in an integrated manner in the case of Heraeus, leads to different efficiency and effectiveness-based added benefits for customers and user groups in business models:

- Human empowerment (effectiveness increase)
- Object empowerment (effectiveness increase)
- Horizontal networking in value added networks (efficiency increase)

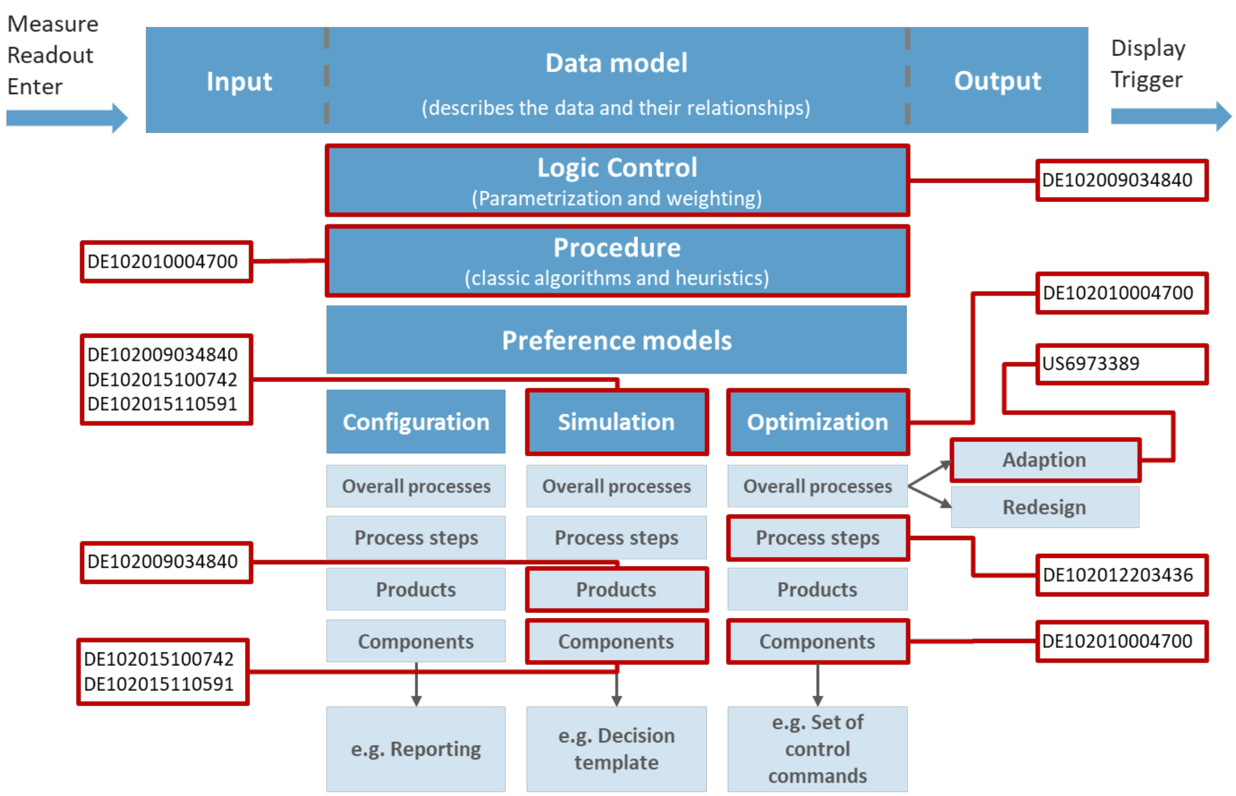
- Vertical networking within the automation pyramid (efficiency increase)

The figure below illustrates the systematics between the dominant business model logics, the technical concepts used, and the efficiency and effectiveness increases for customers and user groups.



These empirical findings result in a taxonomy of digital patents. This taxonomy is based on the dominant logics and their technical implementation in digital business models. The taxonomy presented here is a highly abstract rough structure of the typically applied digital patents, aimed at achieving greatest possible systematic consistency with the logics of business models. The figure below shows a number of examples for applicable patent types for the above-mentioned business model scenarios.

The direction of Heraeus's patent activities was complemented by strategic positioning and market design. In addition to preventing the infringement of third-party patent positions and suppressing the imitation of the company's own developments, strategic positioning is primarily aimed at marketing and product management, and at the desired positions of exclusivity in terms of the customer benefit of future business models. With this IP-strategic approach, prohibitive rights no longer result from direct proprietary R&D results, but rather from the business model and the business objectives.



PART III

Summary: Success factors and benefits for Heraeus

Heraeus is one of the world leaders in putting to work material and technology know-how for industrial purposes. With Heraeus Amloy, the company is becoming pivotal in shaping the digitization of materials science. This leads to productivity gains and extensive improvements by using innovative materials such as amorphous metals, combined with outstanding process control. This transformation is not solely understood as a technological challenge at Heraeus. Digitization is also a challenge for corporate culture and requires the design of new business models. With Heraeus Amloy, the group of companies has created an instrument for developing new business models. The introduction of IP design has made available an instrument that allows new business models to be developed and protected in different scenarios. IP design helps management to implement the five most important leadership tasks of digital leadership in daily practice: driving change, making staff contributions transparent and enabling recognition, promoting interdisciplinary cooperation, promoting staff development, and providing orientation.

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What is the MIPLM?

The 21st century marks a new era as our economies increasingly rely on knowledge-based production processes and services. Consequently, the institutions responsible for education and research in the field of intellectual property law in Europe must provide appropriate training for staff from the respective professional environments to acquire or reinforce their ability to initiate, control, protect, exploit and increase the value of intangible assets. The knowledge-based economy integrates research and development activities, innovation, industrialization and the marketing of products and services including intangible assets and completely revolutionizes enterprise management. It creates new professions specialized in dealing with intangible assets: this branch of law attracts consultants and intellectual property experts from among managers, jurists and lawyers. Indeed, every innovation process generated by new economic activities assumes the intervention of the law, the installation of tools and structures for developing or planning in order to control the intangible assets and to optimize their valorization. It has therefore been the duty of CEIPI, University of Strasbourg, as a leading center for Intellectual Property Studies in Europe, to propose a master program on "IP Law and Management" (MIPLM) since 2005, which complements the existing training course for engineers, scientists and lawyers. This "European" master program features a continuous training scheme aimed at experts in the field of intellectual property. It provides a genuine education program based on an investigation carried out in large enterprises in Europe. The teaching staff comprises academics and experts from various countries, renowned for their work and competence in dealing with the impact of intellectual property on the policy of enterprises.

M. Yann Basire
Director General of CEIPI.

Intellectual property has become a crucial factor and driving force in the knowledge-based economy. The economic development and the competitiveness of companies increasingly depend on the generation and exploitation of knowledge. Intellectual property can convert investment in corporate knowledge creation into economic benefits. Thus IP-based appropriation strategies form the basis for creating wealth and competitive advantages for companies from their R&D and innovation activities. The development and implementation of sustainable strategies for IP exploitation require a concerted integration of the disciplines involved in order to achieve an interdisciplinary perspective on IP. In a knowledge-based economy, companies can only achieve a competitive edge by combining the economic, legal and technological sciences. IP management within such a holistic approach provides optimized appropriation strategies and thus essentially contributes to the creation of wealth within a company. Accordingly, IP management needs skilled managers who can combine the economics of intangible assets in an intellectualized environment with multidisciplinary knowledge in order to maximize the benefits of IP. A new type of competencies, skills and underlying knowledge enters the arena of management and management education. The increasing impact of intellectualized wealth creation by investment in knowledge, R&D and innovation followed by its exploitation and IP-based appropriation calls for seminal new education concepts. The CEIPI program "Master of IP Law and Management" offers such a new type of management education. It follows an intrinsically multidisciplinary approach to meet the challenges and requirements of the knowledge-based economy. This master program combines legal, economic and management sciences and includes lectures from leading scholars in the field of IP law and management. Its ultimate objective is to qualify experienced IP professionals for acting as practically-skilled IP managers with a sound knowledge of the principles of wealth creation in our knowledge-based economy.

Alexander J. Wurzer
Director of Studies, CEIPI | Adjunct Professor
Director of the Steinbeis Transfer Institute Intellectual Property Management

Concepts of the Studies

Intellectual property and economics in the present context are two disciplines that exist in parallel.

Experts are found in each discipline, but with a lack of mutual understanding and training. Both "worlds" are nowadays bridged by experts, called IP managers, who link both disciplines through knowledge and experience. The CEIPI studies pursue a holistic approach and engage experts for the developing market of an IP economy. They are experts for basic economic management processes with specific assets. Management is understood in the broad sense of an overall company management and accordingly divided into six general functions:

- 1. Strategy
- 2. Decision
- 3. Implementation
- 4. Organization
- 5. Leadership
- 6. Business Development

On the basis of this differentiation skills should be allocated to management functions, and relevant knowledge to the functions and skills. The teaching concept focuses on both areas, skills and knowledge, as relevant to business with intellectual property.

Skills can be allocated to the specific management functions as relevant to the practical work within IP management. The skills are thus determined by the daily challenges and tasks an IP manager encounters.

For example, the "Decision" function includes skills such as "valuation and portfolio analysis techniques", and "Organization" as a function requires skills to manage IP exploitation and licensing including economic aspects as well as contractual design and international trade regulations with IP assets.

Special knowledge of economy and law is required in order to implement and deploy these skills in business. This includes knowledge of economic basics such as function of markets and internal and external influence factors. Additional management knowledge is also included such as value-added and value-chain concepts.

The legal knowledge includes contractual and competition law, and special attention will be paid to European and international IP and trade law, e. g. litigation, licensing, dispute resolution. Following this concept, IP law and management can be combined in clusters formed of specific skills and knowledge defined within each management function.

The lectures have a high international standard; the lecturers possess a high reputation and long experience in the teaching subject with academic and practical backgrounds.

The top-level experts come from the fields of law, economics and technology. The experts and the students work closely together during the seminar periods. Exchange of experience and, as a consequence, networking are common follow-ups.

Participants & their Benefits

This European master's program was designed especially for European patent attorneys, lawyers and other experienced IP professionals.

Its ultimate objective is to qualify experienced IP professionals to act as IP managers with the practical skills and knowledge to deal with the new challenges of wealth creation and profit generation. Participants acquire first and foremost a new understanding of how intellectual property works in business models and are conveyed the necessary skills to achieve the systematic alignment of IP management and business objectives.

The course provides an international networking platform for IP managers and in addition enables participants to build long-lasting relationships and to further develop relevant topics within the field of IP management. Being part of this international alumni network also offers new job opportunities and publication possibilities.

Past lecturers and academics

Prof. Jacques de Werra, University of Geneva

Prof. Estelle Derclaye, University of Nottingham

Prof. Christoph Geiger, University of Strasbourg

Prof. Jonathan Griffiths, School of Law, Queen Mary, University of London

Dr. Henning Grosse Ruse-Kahn, Faculty of Law, University of Cambridge

Prof. Christian Ohly, University of Bayreuth

Prof. Christian Osterrith, University of Constance

Prof. Yann, Ménière, CERNA, École des mines de Paris

Prof. Cees Mulder, University of Maastricht

Prof. Julien Penin, University of Strasbourg, BETA

Prof. Nicolas Petit, University of Liege

Prof. Alexander Peukert, Goethe University, Frankfurt/Main

Prof. Jens Schovsbo, University of Copenhagen

Prof. Martin Senftleben, University of Amsterdam

Prof. Bruno van Pottelsberghe, Solvay Business School

Prof. Guido Westkamp, Queen Mary University London

Prof. Alexander Wurzer, Steinbeis University Berlin

Prof. Estelle Derclaye, University of Nottingham

Prof. Ulf Petrusson, Göteborg University

Past lecturers and speakers, practitioners and institutions

Arian Duijvestijn, SVP BG Lighting Philips

Kees Schüller, Nestlé S.A.

Thierry Sueur, Air Liquide

Heinz Polsterer, T-Mobile International

Dr. Fabirama Niang, Total Group

Philipp Hammans, Jenoptik AG

Dr. Lorenz Kaiser, Fraunhofer-Gesellschaft

Leo Longauer, UBS AG

Nikolaus Thum, European Patent Office

Bojan Pretnar, World Intellectual Property Organization

Romain Girtanner, Watson, Farley & Williams

Peter Bittner, Peter Bittner & Partner

Prof. Didier Intès, Cabinet Beau de Loménie, Paris

Malte Köllner, Köllner & Partner Patentanwälte

Dr. Dorit Weikert, KPMG

Keith Bergelt, Open Innovention Network

Selected companies

3M Europe S.A.
ABB Corporate Research Center
ABB Motors and Generators
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Agfa Graphics
Air Liquide
Airbus Defence and Space
Akzo Nobel NV
BASF Construction Chemicals
Boehringer Ingelheim Pharma
British Telecom
Clyde Bergemann Power Group
Danisco/Dupont
DSM Nederland
Fresenius Medical Care
Groupe Danone
Jenoptik
Kenwood
Nestec Ltd
Novartis AG
Philips
Pilkington
PSA Peugeot Citroen
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SAP SE
Schlumberger Etude&Production
ST-Ericsson
Tarkett GDL
Total S.A.
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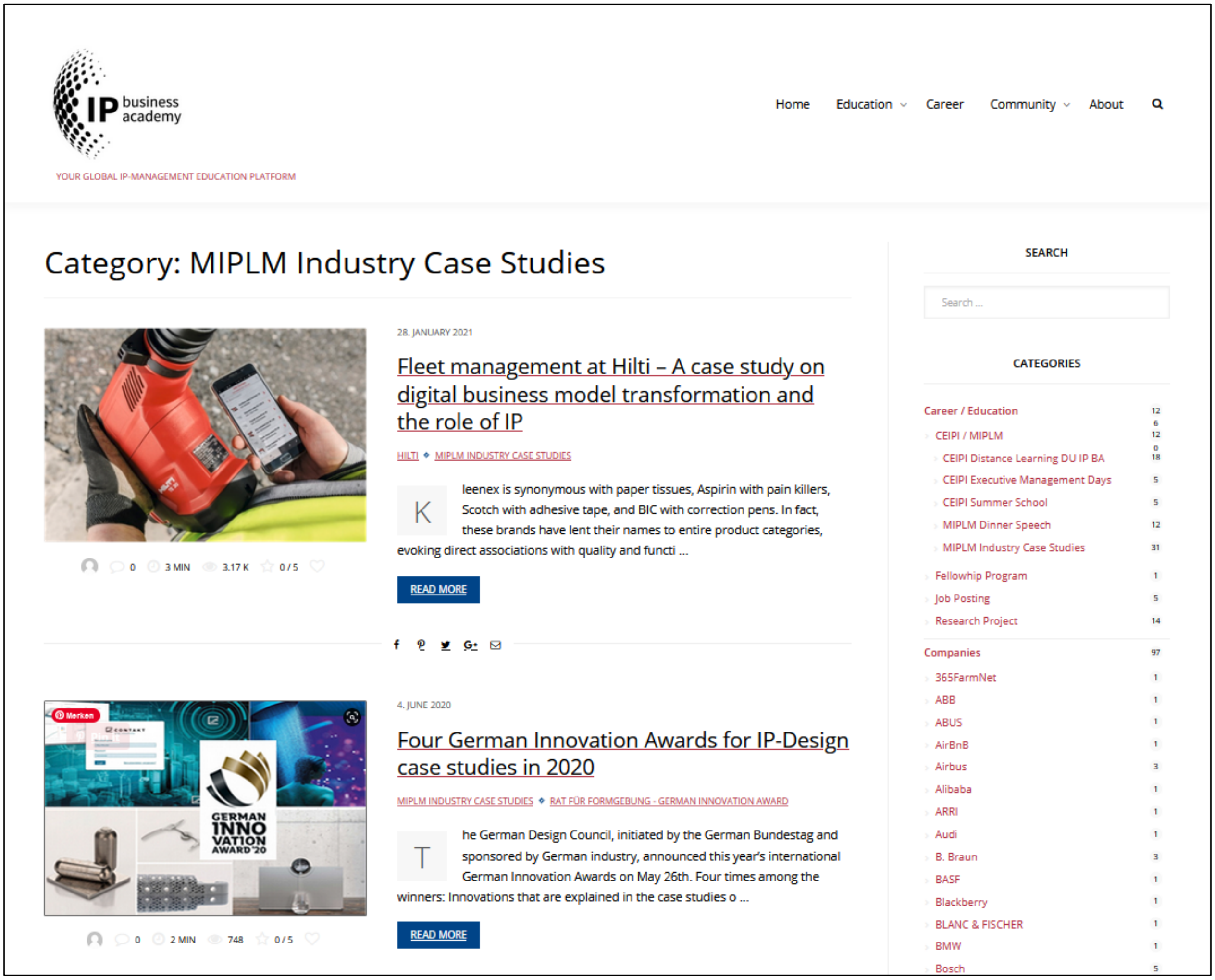

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