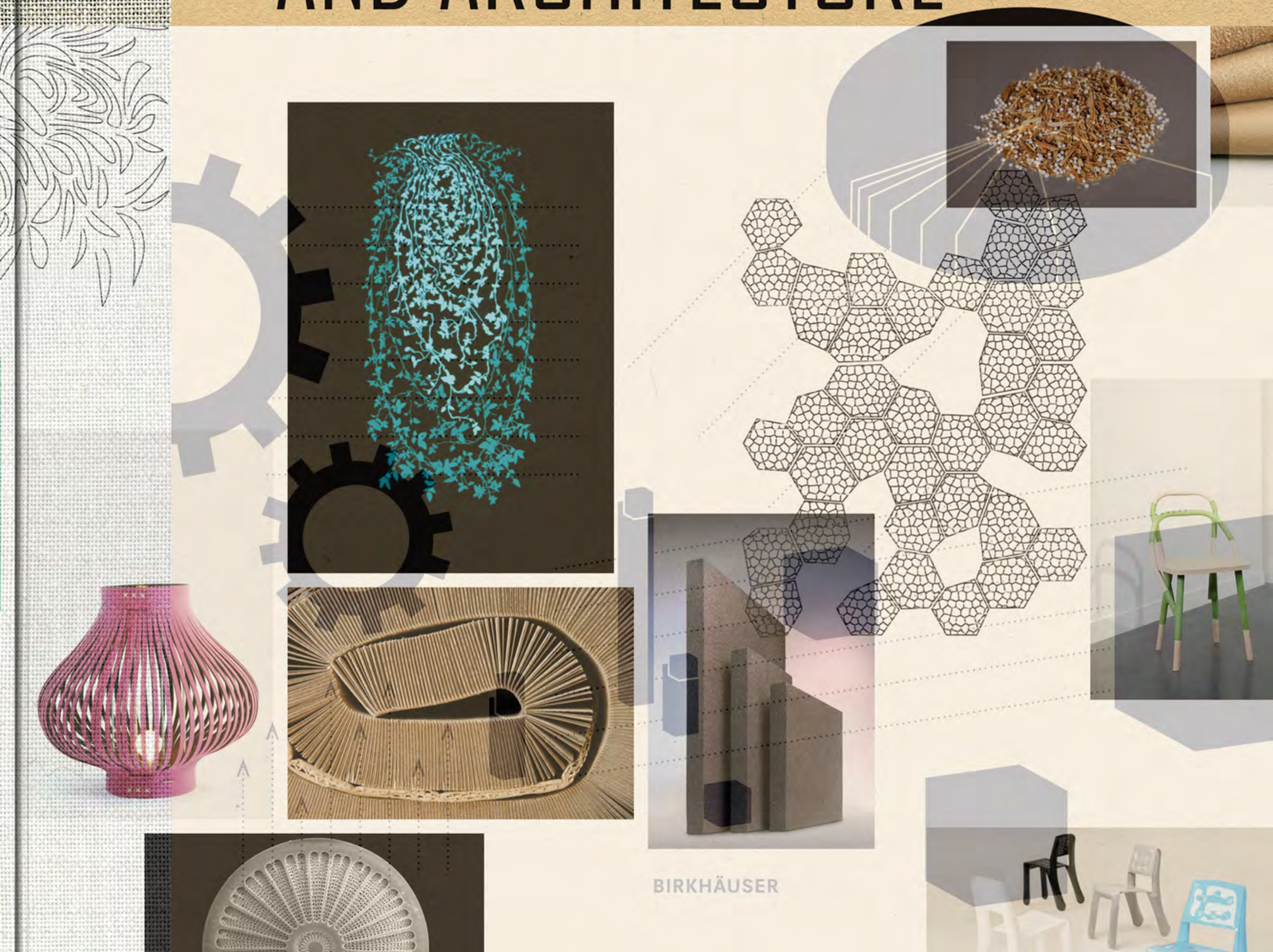
SASCHA PETERS

MATERIAL REVOLUTION

SUSTAINABLE AND MULTI-PURPOSE MATERIALS FOR DESIGN AND ARCHITECTURE



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SUSTAINABLE AND MULTI-FUNCTIONAL INDUSTRIAL MATERIALS
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THE MATERIAL REVOLUTION

Vases made of algae fibers, cell phone casing of tree bark, coffins of almond shells, mosaics of coconuts and bicycle frames of bamboo: These are just some of the most striking examples of a development that will take on a revolutionary character in the near future. Natural materials, recycled industrial materials, and product concepts that are sparing with resources are all gaining ground. The world is seemingly undergoing radical change; or so the ever more frequent environmental problems and the bio-based solutions with a low environmental impact that companies are now touting would lead us to believe. Materials are to be more natural, healthier and more sustainable. Nothing less is at stake than saving our climate, securing our standard of living and creating a basis for life for the next generations.

Bicycle frame made of bamboo (Source: Craig Calfee) → p. 047

At the latest since it was recognized that supplies of fossil energy sources will dwindle in the coming decades and many raw materials be available in limited amounts only, intensive efforts have been made to find alternatives. The material innovations of the twentieth century, whose creation we largely owed to crude oil, will have lost their significance in a few years. Bakelite® (a duroplastic phenol resin) was used for the housings of the first electrical devices in the 1930s, polyvinylchloride (PVC) for records in the 1950s, polyurethane for body-hugging ski boots in the 1970s, and fiberglass-reinforced plastics for pole vaults. The general consensus was that material innovations with new mechanical properties and functional qualities gave birth to new product solutions.

Cell phone casing made of bark cloth (Source: Bark Cloth®) → p. 058

However, the upcoming meteoric advances in the materials sector will no longer focus on developing new functions. Rather, the aim will shift to producing industrial materials whose employment is sparing on resources, material-efficient and does not pose a danger to people. As consumers are becoming increasingly aware of the eco-friendly handling of materials and of thinking in material cycles, investment in sustainable products is a rewarding business. Indeed, in many areas customers even expect eco-friendly materials with multi-purpose properties and the use of sustainable production methods.

Ski boot with a "Hytrel®RS" bioplastic shaft (Source: DuPont)

Meanwhile the challenges appear to be so immense that political measures need to be taken to accelerate the change. The 2010 Copenhagen Climate Conference might have failed owing to the opposition of the emerging economies but the western industrial nations, and in particular Europe see there now being an opportunity to combine environmental policy necessities with the economic challenges so as to secure innovation competency. Consequently, the European Union has drawn up the 20–20–20 Climate Change Package, under which energy consumption and emissions are to be cut by 20% by 2020 and simultaneously, regenerative energies are to cover one fifth more of total consumption.

Receptacles made of cellulose plastics (Source: Biowert) → p. 038

Companies believe the moment has come to carve out a distinctive image by using new products. For example, the market for bioplastics based on renewable resources such as cornstarch and cellulose, is expected to see an annual expansion of 25–30% in coming years. The chemicals giants and small to mid-sized goods manufacturers have already developed numerous products and the range is increasing constantly. But whether the bio-based and/or biodegradable industrial materials really are climate-neutral has yet to be definitively settled. Generally, we lack reliable information on how many resources, how much water and energy is required in the course of a product lifecycle, from production via transport and use through to disposal. Only gradually are standards and measures emerging that enable objective comparisons to be made. Take the "ecological rucksack": it has established itself as a means of depicting the total amount of resources needed in the manufacture, use and disposal of a product. It is normally employed for ecological balances together with the carbon footprint, which is the sum of all greenhouse gas emissions produced during a product's lifecycle, or the "virtual water" measure, in other words, the amount of water needed to produce a product. When measuring the "ecological rucksack" of materials, we talk of factor 5 for polymers. This means that it takes about five kilos of resources to produce one kilo of plastic. As some 85 kilos of resources are needed to produce aluminum and an amazing 500 kilos for copper, recycling can no longer be ignored, especially for these mass materials. It will probably take some time, however, until reliable data on the most important materials exists.

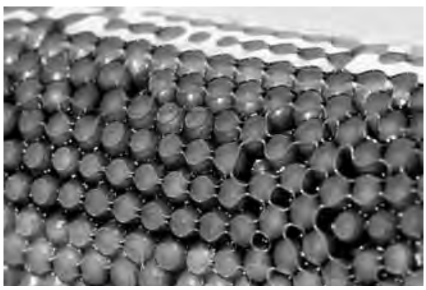
Sheet material made of
100 % recycled glass
(Source: Coverings Etc)
→ p. 079

Until such time as we have access to materials that have no negative impact either on the climate or the environment the key aim must be to make the best possible use of existing resources and select the most suitable material for any given purpose. It follows that enhancing material efficiency is a major aim of current research activities. For instance, coating systems in nano- or micro dimensions have been developed that optimize material properties, guarantee them over a longer period, and enable additional features such as high scratch resistance and easy-to-clean properties.

Similarly, several manufacturers have pushed forward the development of materials based on recycled raw materials. Products are now available in almost every industrial material class, which considerably extend the use of resources. Metals, plastics and paper made of recycled industrial materials can almost be described as classics. They have recently been joined by new materials made of recycled glass, recycled textiles, or mineral industrial materials, as well as by a collection system.

Fungus-based hard foam for packaging (Source: ecovative design) → p. 054

Research is being conducted into new production methods modeled on natural growth processes, which see the creation of material as a biological process. Moreover, agricultural waste products serve to replace conventional components in composite materials, thereby reducing the amount of resources needed. People now even expect materials that do not land on a rubbish dump on completion of their service life but can be used to produce materials for a new product.



Lightweight structure, based on metallic hollow spheres (Source: hollomet) → p. 113

Given the long distances products and materials must travel from manufacturer to consumer, low-weight industrial materials and composite materials are gaining importance. Not only do they incur lower energy consumption during road or air transport, they also make assembly and handling easier. In architecture, using lightweight materials translates into less construction work and subsequently less material to realize buildings.

Given global warming, those materials with CO_2 storing properties will in future assume ever greater importance. Since some 40% of global consumer energy goes on the consumption and operation of buildings, energy-saving potential in the construction industry is enormous. Increasing importance will be attached to improving heat insulation. In this context, those materials that turn sunlight directly into electricity, can store heat and moisture and can contribute to natural air conditioning are of particular interest to designers and architects.

With its entry to the 2007 and 2009 Solar Decathlons in Washington, Darmstadt Technical University proved what immense opportunities can be tapped by using innovative materials and new construction techniques. The team headed by Prof. Hegger employed a combination of vacuum insulating panels, cutting-edge solar technology, and climate-altering phase-change materials in a house that produced more energy than it consumed, and won first prize in the competition.

Team Germany, 2009
Solar Decathlon
(Source: TU Darmstadt)
→ p. 149

While some manufacturers seek to reduce the environmental impact of their products by using renewable and natural resources, others are adopting a totally different approach. They develop materials that boast other qualities, alongside their mechanical functions. These include the ability to respond to environmental influences by changing shape or color, to store water while retaining a dry surface, or to repel soiling owing to surface properties. Recently many designers have expressed their interest in particular in materials capable of altering their shape; when a certain temperature is exceeded they automatically return to their original geometry. Nor should we forget the options created by material surfaces that can eliminate harmful gases and odors from the air, have an anti-bacterial effect or anti-reflection properties.

It would seem that the classic mechanized understanding of materiality is giving way to a new materials culture, in which materials reveal multi-functional potential: they can be lightweight or dirt repellent, can change color or are retro-reflecting. But they all share a single purpose: to achieve a more responsible use of our global resources.

Pulp Collection by Jo Meesters
Recycling paper // Recycling materials
→ p. 089

Hood with in-sewn shape memory alloys designed by Max Schäth
Shape memory alloys (SMAs) // Shape-changing materials
→ pp. 125/126

“Mossy Hill” installation by Makoto Azuma
Moss // Multifunctional materials
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“Mossy Hill” installation by Makoto Azuma
Moss // Multifunctional materials
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BIO-BASED
MATERIALS

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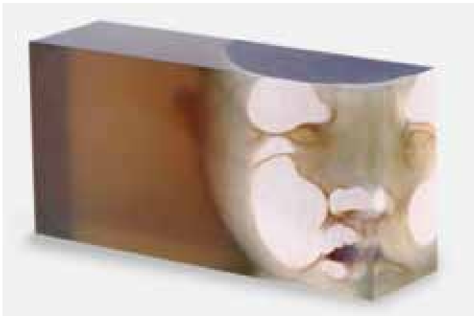
BIO-BASED MATERIALS

Foams based on castor oil, disposable crockery from potato starch or plastics with carrot fiber reinforcement: intriguing examples of how bio-materials can be employed. In recent years these materials have experienced a meteoric development. They are made up completely or to at least 20% of renewable resources. As a result, in coming years crude oil in particular will lose its significance as the base for plastics production. For bioplastics alone, through 2020, annual growth rates of 25–30% and a rise in production capacity of around 3 million tons (currently 350,000 tons) are expected.

In packaging in particular, thermoplasts made from petrochemicals such as polystyrene, polyethylene or polypropylene will be replaced in the medium term by biopolymers. The raw materials involved in these diverse developments are natural polymers such as starch, rubber, and sugar. The lion's share is taken by thermoplastic starch (80%). That said, substances such as lignin, cellulose, chitin, casein, gelatin and vegetable oils will also be used to produce bioplastics. Polylactides and polyhydroxybutyric acids are sourced from natural polymers and already employed in totally different sectors.

Alongside bioplastics, biocomposites represent another important group of bio-materials. These include plastics reinforced with natural fibers and wood-plastic composites (WPCs). Thanks to their special surface structure, as well as sound and vibration-absorbing properties, cork-polymer composites are being used for sports articles and interior work.



“Fragments” sculpture using bio resin
(Source: Galerie Adler;
artist: Gregor Gaida)

Disposable PLA-based beaker
(Source: NatureWorks®)

Processing foils made of bio-
plastics (Source: alesco)

Classification of bioplastics by origin
RRM = renewable raw materials

from RRM, though not degradable, e.g. from castor oil	from RRM, biologically degradable	from fossil raw materials, biological degradable, e.g., polyvinyl alcohol
↓ Micro organic origin e.g., polyactic acid	↓ Vegetable origin	↓ Animal origin e.g., chitin
↓ Cellulose	↓ Lignin	↓ Starch

Forecast trend in bioplastics up to 2020

	PACKAGING AND FOOD INDUSTRY	AGRICULTURE, HORTICULTURE AND LANDSCAPING	CONSUMER GOODS INDUSTRY	AUTOMOTIVE INDUSTRY
Total market 2005	3.5 mio tons plastic packaging 1.8 mio tons short-life products	230,000 tons total market farming market. Of which approx. 30,000 tons specially suited to substitution	1.8 to 2.7 mio tons plastic consumer goods	Total amount plastic in vehicles 800,000 tons Approx. 400,000 tons plastic as interior vehicle fittings
Bioplastics	2005: < 15,000 t Forecast 2010: 110,000 tons (5 % of short-life plastics) Forecast 2020: 520,000 tons (20 % of short-life plastics)	2005: < 100 tons Forecast 2010: 3,500 tons (10 % specially suited to substitution) Forecast 2020: 130,000 tons (30 % specially suited to substitution)	2005: < 100 tons Forecast 2010: 24,000 tons (1 % of total market) Forecast 2020: 290,000 tons (10 % of total market)	2005: < 10 tons Forecast 2010: 48,000 tons (10 % of vehicle interior fittings) Forecast 2020: 230,000 tons (40 % of vehicle interior fittings)
Bioplastics	2005: < € 45 mio 2010: € 165 mio 2020: € 780 mio	2005: < € 300,000 2010: € 5 mio 2020: € 20 mio	2005: < € 300,000 2010: € 35 mio 2020: € 440 mio	2005: < € 30,000 2010: € 72 mio 2020: € 350 mio
Market growth	2005–2010: > 30 % 2010–2020: approx. 16 %	2005–2010: > 70 % 2010–2020: approx. 15 %	2005–2010: > 160 % 2010–2020: approx. 29 %	2005–2010: > 380 % 2010–2020: approx. 17 %

Properties similar property profile to PET // low permeability for gases // water-repellent surface // transparent // relatively low heat-stability of just over 60°C

Sustainability aspects based on renewable resources // can be recycled // can be composted in industrial plants

BIOPLASTICS BASED ON POLYLACTIC ACID

Polylactic acid or polylactide (PLA) is one of the most important bio crude plastics in the current sustainability debate, as its properties are comparable with those of PET. Generally speaking, bio crude plastics cannot be used directly, but through compounding are mixed with aggregates and additives to suit their specific purpose. Although the material was discovered as early as the 1930s, it has only recently been produced on a large scale, by NatureWorks®.

MATERIAL CONCEPT AND PROPERTIES

PLA is produced either by fermenting **viscous sugar syrup** or by the **bacterial fermentation** of starch or any kind of sugar. The raw material is colorless, shiny, and reminiscent of polystyrene. It is completely biodegradable. The low migration behavior for oxygen or steam makes PLA an interesting alternative for food packaging. A disadvantage is that some polylactides soften at very low temperatures compared with alternative plastics. The mechanical resistance in particular can be improved by adding fibers. PLA surfaces are water-repellent. Depending on its composition the material is either quickly biodegradable or remains stable for several years. Even though PLA is sourced from renewable resources the **CO_2 footprint** for its production is relatively high. It requires a similar level of energy as the manufacture of polypropylene. Compared with the typical mass plastics the production of PLA is still much more cost-intensive; the price is higher than for PET.

USE AND PROCESSING

In recent times bioplastics have carved out a niche in particular in the packaging industry e.g., for foils and yogurt cartons. Given that their properties are similar to PET, polylactic acids are expected to increase their stake in the packaging market in the medium term. Moreover, companies in the automobile and entertainment industries are also showing a great interest in using PLA. The fact that it is biodegradable makes the material interesting for use in **geo-textiles** in the agricultural sector and landscape work. Its use in technical products also seems feasible in the guise of fiber reinforcement. Biocompatible qualities also makes PLA suitable for various medical technology applications – for instance, it can be injected in cosmetic surgery to fill out wrinkles. Its low density is a decisive criterion for its use in lightweight constructions.

PLA blends can be shaped and formed using customary techniques such as injection molding, thermoforming or blow molding (temperatures: 170–210°C). Foils are extruded. Welding or

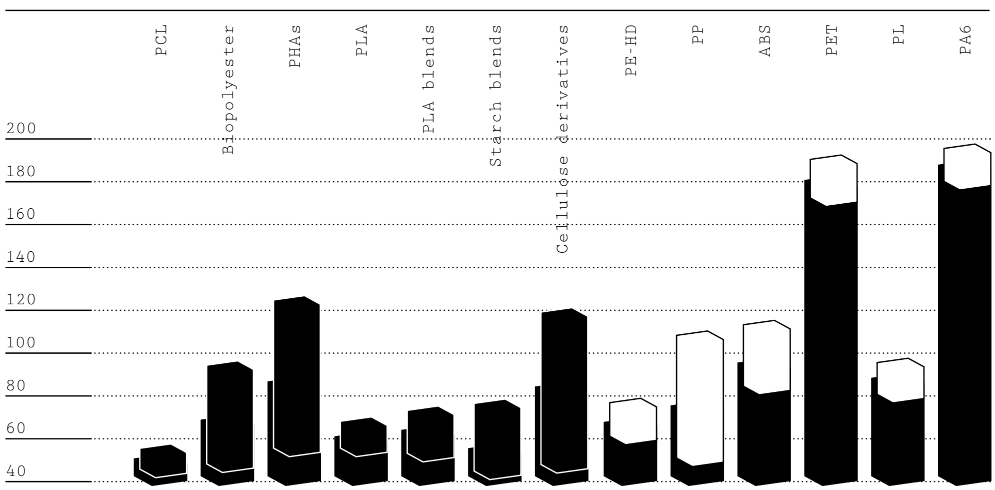
Cell phone holder made of PLA bioplastics
(Source: NatureWorks®)

PLA food packaging
(Source: NatureWorks®)

PLA foil packaging
(Source: NatureWorks®)

Making foil using blow extrusion
(Source: FKuR)

Heat-stability of biopolymers



VST B50 [°C]

Vicat temperature of various polymers
in comparison with conventional plastics

sticking is used to produce joints. PLA semi-finished products can be processed using the techniques normally applied for processing wood and metal.

PRODUCTS

NatureWorks®-Polymer
Since 2002 NatureWorks® has been the world's largest producer of the bio crude plastic polylactic acid (PLA). The company has developed a method for transforming the sugar occurring naturally in plants into a patented polylactide polymer, which is sold under the brands NatureWorks®-Polymer and Ingeo™-fiber.

Ecovio®
Ecovio® is the first plastic blend by BASF, which is produced on the basis of renewable resources and is biodegradable. The main constituent with a proportion of 45% is polylactic acid (PLA). On account of its special properties it is especially suitable for packaging. The material can be printed in eight colors and has a high mechanical resistance. Special modifications can be processed using injection molding and extrusion.

Bioflex®
Bioflex® is a PLA-based co-polyester blend, which, depending on the required property profile, consists almost entirely of renewable resources. It is especially suited for the manufacture of thin-walled foils with high tear resistance, and has similar properties to the classic packaging plastics PE, PP and PS. Bioflex® can be dyed and printed, is approved for contact with foods and its elasticity can be adjusted as required.

Ecogehr®PLA
In summer 2008 the GEHR plastics plant became the first manufacturer worldwide of technical semi-finished biopolymer-based products. All the materials based on polylactides are grouped together under the Ecogehr®PLA brand. Depending on the requirements the program includes blends of polylactides with lignin or wooden fibers with various qualities. The materials are physiologically harmless and can be composted or burned.

Ingeo™
Salewa was one of the first sports clothing makers to bring to market outdoor clothing made of PLA-fibers by NatureWorks®, which are biodegradable. Another advantage over conventional polyester fibers is that they do not simply absorb sweat but transport it away from the body.

Semi-finished products made of Ecogehr®PLA (Source: GEHR Kunststoffwerk)

Helmet made using PLA fiber material (Source: NatureWorks®)

BIOPLASTICS BASED ON POLYHYDROXYBUTRIC ACID

The second heavyweight amongst the bio crude plastics is polyhydroxybutric acid (PHB), as its property profile is similar to that of the widely employed polypropylene (PP). Discovered in France just under 90 years ago, the polyester is produced in almost every living organism, from sugar to starch and oils. It is the most important representative of the polyhydroxyalcanoates (PHA).

At present, high production costs hinder the mass deployment of bioplastics. That said, various efforts are being made to lower these costs. In particular companies from the South American sugar industry are getting involved in the industrial production of PHB. According to estimates microbes can transform three kilos of sugar into one kilo of bioplastics.

Properties similar property profile to PP // low oxygen diffusion // UV stability // biocompatible qualities // high fracture susceptibility // PHB melts at temperatures above 130°C

Sustainability aspects based on renewable resources // biodegradable without harmful residues

MATERIAL CONCEPT AND PROPERTIES

Polyhydroxybutric acid is a non-transparent **biopolymer**. In particular its tensile strength is comparable with that of polypropylene. PHB is a thermoplast and melts at a range of 170–180°C, which means it can be processed using the methods customarily employed in the plastics industry. As a material it has constant properties at temperatures between -30 and +120°C. Polyhydroxybutric acid is insoluble in solvents or water and remains stable when exposed to ultraviolet light. It offers very low oxygen diffusion. On account of its biocompatible qualities PHB can be used to produce medical products. A disadvantage compared with polypropylene is its high fracture susceptibility. To enhance its mechanical properties PHB is mixed with other substances such as **cellulose acetate**, **cork** or anorganic materials to produce blends.

USE AND PROCESSING

It is expected that polypropylene will be replaced by PHB in several sectors in coming years. Extensive application options are envisaged primarily in the automotive field, in the consumer goods industry, and in packaging. Depending on the mixing proportions PHB blends can also be used as adhesives or hard rubber. PHB can be processed using the techniques typically employed in the plastics industry. These include injection molding and extrusion. Owing to the danger of depolymerization a processing temperature of 195°C should not be exceeded. Very rapid processing speeds can be achieved thanks to the clear transition from fluid to solid. Deforming techniques are difficult given the high fracture susceptibility.

Missile body made of PHB
(Source: Biomer®)

"Immunostick" diagnostic tool for medical applications made of PHB
(Source: Biomer®)

PRODUCTS

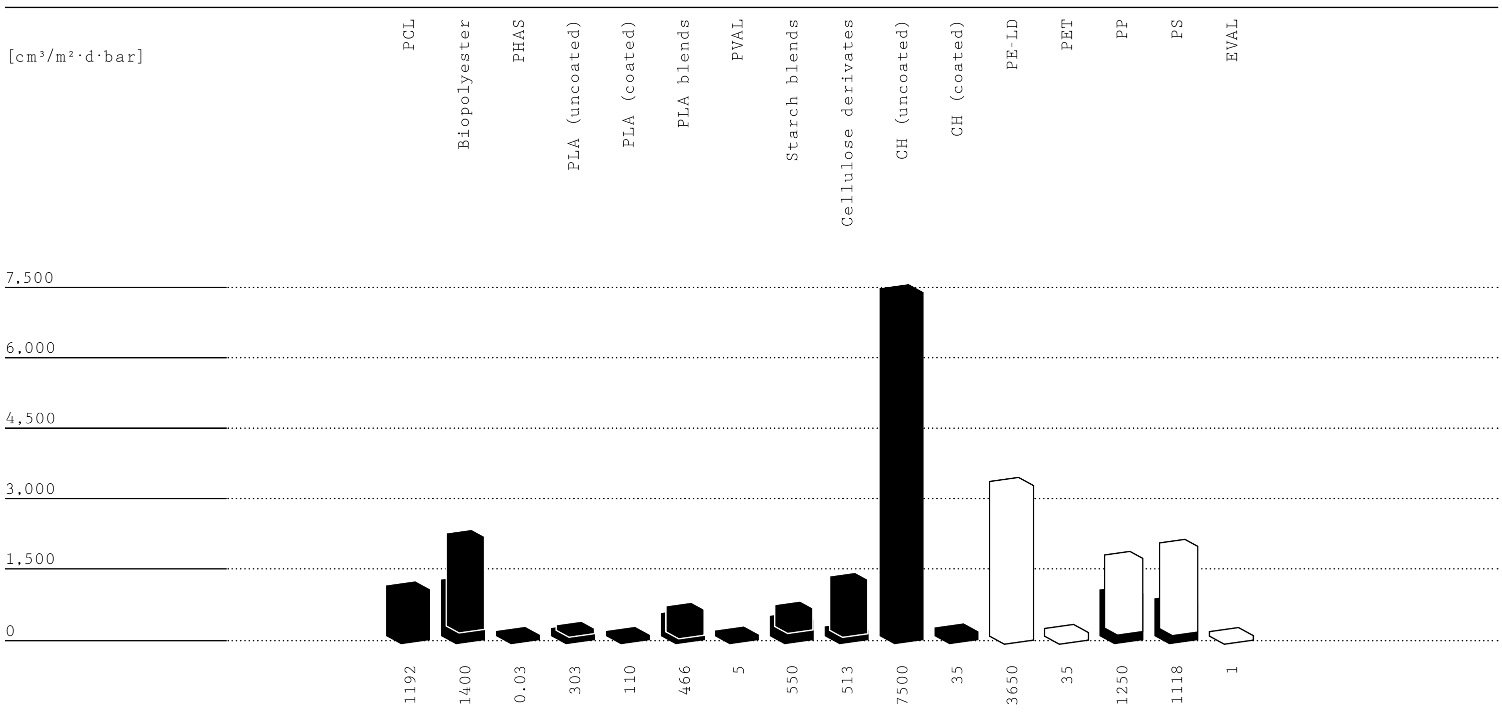
Biomer®

Biomer® thermoplasts are polyesters based on polyhydroxybutric acid. Components made of the material are heat-resistant, waterproof and completely biodegradable. The granules can be processed in conventional machines and transformed into thin-walled components with a complex geometry.

Natureplast®

The French manufacturer specializes in the production of bioplastics such as polylactic and polyhydroxybutric acids. Aside from PLA and PHA, it also produces polymers based on thermoplastic starches (TPS).

Oxygen permeability of biopolymers in accordance with DIN 53380, ISO 15105-2 at 23°C, 0–5 % relative humidity, film thickness: 50 μm



Oxygen permeability of various polymers in comparison with various conventional forms of packaging

Polymers based on thermoplastic starch (TPS) make up the lion's share (just under 80%) of global bioplastics production. Sourced from corn, grains and potatoes, they are available everywhere and good value for money.

Properties ability to absorb liquids // good value for money // mechanical qualities between LDPE and PS // excellent gas barrier properties // energy-efficient production

Sustainability aspects based on renewable resources // excellent biodegradable quality // energy-efficient production

BIOPLASTICS BASED ON THERMOPLASTIC STARCH

MATERIAL CONCEPT AND PROPERTIES

Since thermoplastic starch exhibits the unfavorable property of absorbing water (**hygroscopy**), it is just one component in plastics production. The other is a biodegradable polymer such as **polyvinyl alcohol** or **polyester**, which makes up the water-insoluble part of the **plastic blend**. The respective composition of the mixture is developed according to the specific application. This means that **TPS blends** have a broad applications spectrum. Natural **glycerin** can be added to increase flexibility during processing.

USE AND PROCESSING

The ability of thermoplastic starch to absorb liquid substances is exploited primarily in the pharmaceuticals industry for the production of medication capsules. Other possible applications lie in those fields typical for bioplastics, namely the packaging industry and in hygiene articles. Specific products include disposable cutlery, packaging foils, yogurt cartons, plant pots, plastic bags, and coated cardboard. TPS blends can be injection molded or extruded just like conventional plastics (processing temperature: 120–180°C). For printing and coating those techniques commonly used in the plastics industry can be employed.

PRODUCTS

Biomax®TPS

The developers at DuPont in Neu-Isenburg are spearheading the employment of bioplastics in technical constructions. Biomax® TPS, a thermoplastic starch based on bio resources, is suited to packaging, the manufacture of containers, and other molds for plastic injection molding. Extruded foils are also available.

Sorona®

Sorona® is a plaster based on **cornstarch**, whose properties resemble those of the technical plastic **PBT**. Alongside high sturdiness and rigidity it is first and foremost the improved surface quality, the high shine, and excellent dimension stability that make the material attractive for a great many industrial and consumer goods, not to mention electronic components.

Biopar®

This naturally degradable thermoplastic is made entirely from potato starch. Its properties make it a competitor to polyethylene, polypropylene and PVC. Thanks to its particular barrier properties for gases it is especially suited to packaging. It can be worked on foil blow and injection molding systems. Its production and processing require just 1/3rd of the energy needed for conventional plastics.

BioplastTPS®

The French company Bioplast specializes in the development of thermoplastic plastics made of **potato starch**. They are edible, water-soluble and 100% biodegradable. BioplastTPS® also exhibits extremely good permeability for steam and offers excellent barrier qualities against oxygen and carbon dioxide. This makes the bioplastic ideal as an external packaging for food; it is also foamed into dishes for fast-food packaging or into water-soluble foils. Since it comes as a granulate it can either be used on its own or as a single component blended with other polymers.

Foil packaging made of Biopar®

Injection-molded parts made of Biomax®TPS

BIOPLASTICS BASED ON CELLULOSE

Cellulose is the most common organic compound in the world since it is found in the cell walls of every plant. Like starch it is a natural biopolymer that is ideally suited to producing thermoplastic bioplastics for translucent components. The most important examples are cellulose acetate (CA) and cellulose triacetate (CTA).

Properties good mechanical properties (like PS) // optical transparency // self-polishing properties // good thermal resistance // normally requires a softener for processing

Sustainability aspects based on renewable resources // can be recycled but not biodegradable

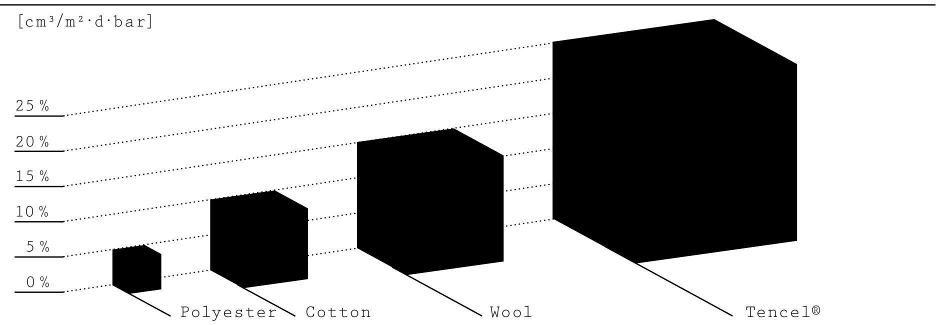
MATERIAL CONCEPT AND PROPERTIES

Plastics based on cellulose can achieve light permeability of up to 90%. Cellulose acetate was first processed as long as 90 years ago. Thanks to their self-polishing surface, silky sheen and excellent dyeing quality, cellulose plastics have always been potentially attractive for the manufacture of a large range of products. However, they must not come into contact with food. Mixing with other plastics can produce polymer blends with diverse properties.

USE AND PROCESSING

Typical application areas for **cellulose acetate**: the grips of writing utensils, umbrella handles, spectacle frames, cigarette filters, diving goggles, vehicle steering wheel covers, lampshades, toothbrush handles, toys and tool handles. As they do not catch fire easily they can be used in interesting safety applications. **CA foils** occur in flat screen monitors and displays. In the field of textiles they replace **natural silk**.
Since cellulose molecules are very stiff, the extent to which they can be processed depends on the amount of softener added. Fundamentally, CA and CAB can be very well injection molded and extruded. The processing temperatures lie between 190 and 240°C. Cellulose ether surfaces can be printed, varnished or metalized.

Comparative moisture absorption



PRODUCTS

Moniflex®

Insulating panels made of cellulose were used for the first time as long as over 60 years ago, as insulation in Scandinavian railroad carriages. Since then the lightweight building material has formed the core of formwork elements in carriage constructions. Moniflex® is translucent, bend-resistant, long-lasting and biodegradable. It can be worked using the customary techniques.

Zelfo®

This material is made completely from cellulose fibers of plant origin (e.g., hemp, flax, waste paper). It is transformed into a pliable mass without the addition of water or adhesives and can then be injection molded, extruded or compression molded. The material is already used to manufacture musical instruments, luminaires, furniture and furnishing items.

Biograde®

This thermoplastic bioplastic was developed especially for injection molding and extrusion plants. It contains a high proportion of cellulose, exhibits excellent shape retention under heat up to a temperature of 122°C and has similar properties to polystyrene. It can also come into contact with food.

AgriPlast^{BW}

In Brensbach in the Odenwald region of Germany, Biowert Industrie GmbH operates a grass refining plant, which is based on the principles of "green bio-refinery" and transforms moist biomass containing fibers to a composite granulate, without the use of chemical additives or solvents. Some 50–75% of the granulate is cellulose fibers, 25–50% is polyethylene or polypropylene. Components made of AgriPlast^{BW} are 20% lighter than their counterparts in PP. The firm also supplies AgriCell^{BM}, an insulating material based on natural biomass.

Tencel®

Tencel® is a textile fiber based on cellulose with extremely strong moisture absorption for ideal climatic conditions. This hydrophile quality results from an innovative nanostructure, which enables Tencel® textiles to absorb some 50% more moisture than comparable cotton products. The cellulose stems from **Eucalyptus timber**.

Arboform®

The thermoplastic bioplastic Arboform® was developed as early as 1998 and consists largely of lignin and cellulose. The latter stems from waste from the paper industry. During production it is blended with other natural fibers such as hemp, flax, **Chinese silver grass**, as well as natural additives. The bioplastic can be worked using injection molding or extrusion and can be recycled.

Containers made of Arboblend® containing cellulose (Source: Tecnaro)

“Liga” chair made of Zelfo® (Source: Elise Gabriel & TheGreenFactory)

Storage boxes made of cellulose plastics (Source: Biowert)

Beakers made of Biograde® cellulose plastics (Source: Biowert)

Lampshade made of Zelfo® (Source: TheGreenFactory)

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SELECTED PUBLICATIONS BY THE AUTHOR

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10/2010
"Revolution der Materie: Das Ende des petrochemischen Zeitalters steht uns bevor," in: Zukunftsletter, ed. by Verlag für die Deutsche Wirtschaft.

9/2010
"High-tech glass," in: form 234, Basel: Birkhäuser.

7/2010
"Material formt Produkt – Schneller in den Markt mit neuen Werkstoffen," Hessen Nano-Tech series, ed. by Hessisches Ministerium für Wirtschaft, Verkehr und Landesentwicklung.

7/2010
"A new dimension of fibers," form 233, Basel: Birkhäuser.

5/2010
"Translucent materials," form 232, Basel: Birkhäuser.

4/2010
"Sophisticated techniques," in: imm visions cologne, published by Koelnmesse and Birkhäuser.

3/2010
"Bioplastics," form 231, Basel: Birkhäuser.

1/2010
"Phase-change materials," form 230, Basel: Birkhäuser.

11/2009
"A world full of fabrics," form 229, cover story, Basel: Birkhäuser.

11/2009
"Full of 'Hot' Air," form 229, Basel: Birkhäuser.

9/2009
"Textile functioning worlds," form 228, Basel: Birkhäuser.

7/2009
"Injection molded decoration," form 227, Basel: Birkhäuser.

5/2009
"Smart Materials," form 226, leader in the special issue: The Magic of Materials, Basel: Birkhäuser.

3/2009
"In Zukunft ohne Öl," form 225, Basel: Birkhäuser.

1/2009
"**New nano-papers,**" form 224, Basel: Birkhäuser.

11/2008
"High Tech meets Low Tech," form 223, leader in the special issue: Designing with Materials, Basel: Birkhäuser.

10/2008
Format **"Wissenswertes,"** background information about metals, synthetic materials, wood, paper, textiles and composite materials, modulor catalog 2009/2010.

7/2008
"Adhesives," form 221, Basel: Birkhäuser.

5/2008
"As pliable as granite," form 220, Basel: Birkhäuser.

3/2008
"My own factory," form 219, Basel: Birkhäuser.

2/2008
"Nanotechnology and product design," essay in "Nano Materials in Architecture, Interior Architecture and Design," Basel: Birkhäuser.

1/2008
"Sharp light," form 218, Basel: Birkhäuser.

11/2007
"New material Solutions," form 217, leader in the special issue The Magic of Materials, Basel: Birkhäuser.

7/2007
"Plastics go mobile," form 215, Basel: Birkhäuser.

5/2007
"Useful particles," form 214, Basel: Birkhäuser.

1/2007
"Kommunikation im Wandel ... Kreative Industrien erschließen Zukunftsmärkte im Web 2.0," Magazin für Moderne Märkte, Bielefeld: ARGUZ Publishing.

8/2006
"Handbuch für technisches Produktdesign – Material und Fertigung, Entscheidungskriterien für Designer und Ingenieure," ed. by Kalweit, A.; Paul, C.; Peters, S; Wallbaum, R. Berlin, Heidelberg, New York: Springer.

7/2004
"Modell zur Beschreibung der kreativen Prozesse im Design vor dem Hintergrund ingenieurspezifischer Semantik." Dissertation: University of Duisburg-Essen, Department of Industrial Design.

6/2003
with Pfeifer, T.; Voigt, T.: **"Interdisziplinäre Kooperation im kreativen Entwicklungsprozess – Die Qualität der Kooperation zwischen Design und Engineering wird zu einer neuen Herausforderung für das Qualitätsmanagement,"** in: QZ – Qualität und Zuverlässigkeit in Industrie und Dienstleistung. Munich: Hanser.

4/2003
with Klocke, F.: **"Potentiale generativer Verfahren für die Individualisierung von Produkten,"** in: Zukunftschance Individualisierung. Berlin, Heidelberg, New York: Springer.

3/2003
with Voigt, T.: **"DEGAP – Closing the gap between designers, engineers and marketers in product development processes in enterprises,"** research project in the context of the "Innovation & SMEs" program of the European Union.

3/2003
"Was ist Kreativität – Zusammenarbeit von Designern und Ingenieuren," commentary in: Der Konstrukteur, Mainz: Vereinigte Fachverlage.

11/2000
with Klocke, F.: **"Wie Designer und Techniker ein Team werden,"** in: ke konstruktion + engineering, Landsberg: mi Verlag Moderne Industrie.

6/2000
"Produktionstechnologien und Strategien für die kundenindividuelle Massenproduktion – Wettbewerbsvorteile durch Individualisierung von Produkten," research project in the context of the "strategische Eigenforschungsprojekte SEF" program of the Fraunhofer-Gesellschaft.

12/1999
with Klocke, F.; Freyer, C.; Wagner, C.: **"Selektives Lasersintern – neue Werkstoffe und neue Perspektiven,"** in: VDI-Z, Düsseldorf: Springer-VDI.

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SELECTED LECTURES BY THE AUTHOR

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November 16, 2010
"Das Design einer revolutionären Materialkultur," VDID Berlin-Brandenburg.

November 5, 2010
"Materials as the motor for innovation," Design Attack Festival, Krakow/Poland.

October 27, 2010
"Nachhaltige Materialien und Multifunktionswerkstoffe für Designer," Folkwang University, Essen.

June 11, 2010
"Metallische Hohlkugel- und Schaumstrukturen für Design und Architektur," 8th International Design Festival Berlin.

January 28, 2010
"Zukunft entwickeln zwischen CO_2-Speicherung und autonomer Robotik," Hochschule für Gestaltung Offenbach.

December 5, 2009
"Materials drive Innovation – Schneller zum marktfähigen Produkt," lecture, design+engineering forum, Euromold 2009, Frankfurt/Main.

November 16, 2009
"The Significance of Creative Professional for Material Based Innovation Process: from technological push to creative pull!" DRnetwork, Berlin.

November 13, 2009
with Hungerbach, W.: **"Vom Material zum Produkt – Metallschäume und Hohlkugelstrukturen in der Markteinführung,"** face2face 9, Ludwigsburg.

October 7, 2009
"Die Bedeutung von Designern für technische Innovationsprozesse," 1. Design symposium on occasion of the award of the Lilienthal Designpreis 2009, Ministry of Economics, Labor and Tourism Mecklenburg-Western Pomerania, Wismar.

September 30, 2009
"Smart, Intelligent, Kommunikativ – Materialien in neuen Dimensionen," 2009 viscom conference, Düsseldorf.

September 24, 2009
"The Impact of Creative Professional on technical Innovations," Stockholm School of Economics in Riga.

July 3, 2009
"Material und Innovation," lecture, VDID NRW, Cologne.

June 24, 2009
"Revolution der Materie – Neue Werkstoffe für Designer," Hochschule für Gestaltung, Schwäbisch Gmünd.

June 17, 2009
"Auf dem Weg zur marktfähigen Innovation," Material Vision 2009, Frankfurt/Main.

May 16, 2009
"70% aller neuen Produkte basieren auf neuen Materialien," experts' forum at the 2009 Interzum, Cologne.

April 17, 2009
"Die Bedeutung von Designern für technische Innovationsprozesse," 3rd Technisches Design symposium, Dresden.

February 17, 2009
"Material as the Motor of Innovation – The impact of creative professionals on technical innovations," keynote speaker, 3rd International Conference on Design Principles and Practices, Berlin.

October 16, 2008
"Das Jahrzehnt der Materialien – Vom Technologie- zum Innovationsstandort dank professioneller Kreativer", lecture at the conference "Creative Industries – Made by Design," Zollverein World Heritage Site, Essen.

February 15, 2007
"Kreative Industrien als Impulsgeber für eine erfolgreiche Innovationskultur," keynote lecture, conference: "Erfolgsfaktor Design & Engineering," Kommunikationsverband Baden-Württemberg, Stuttgart.

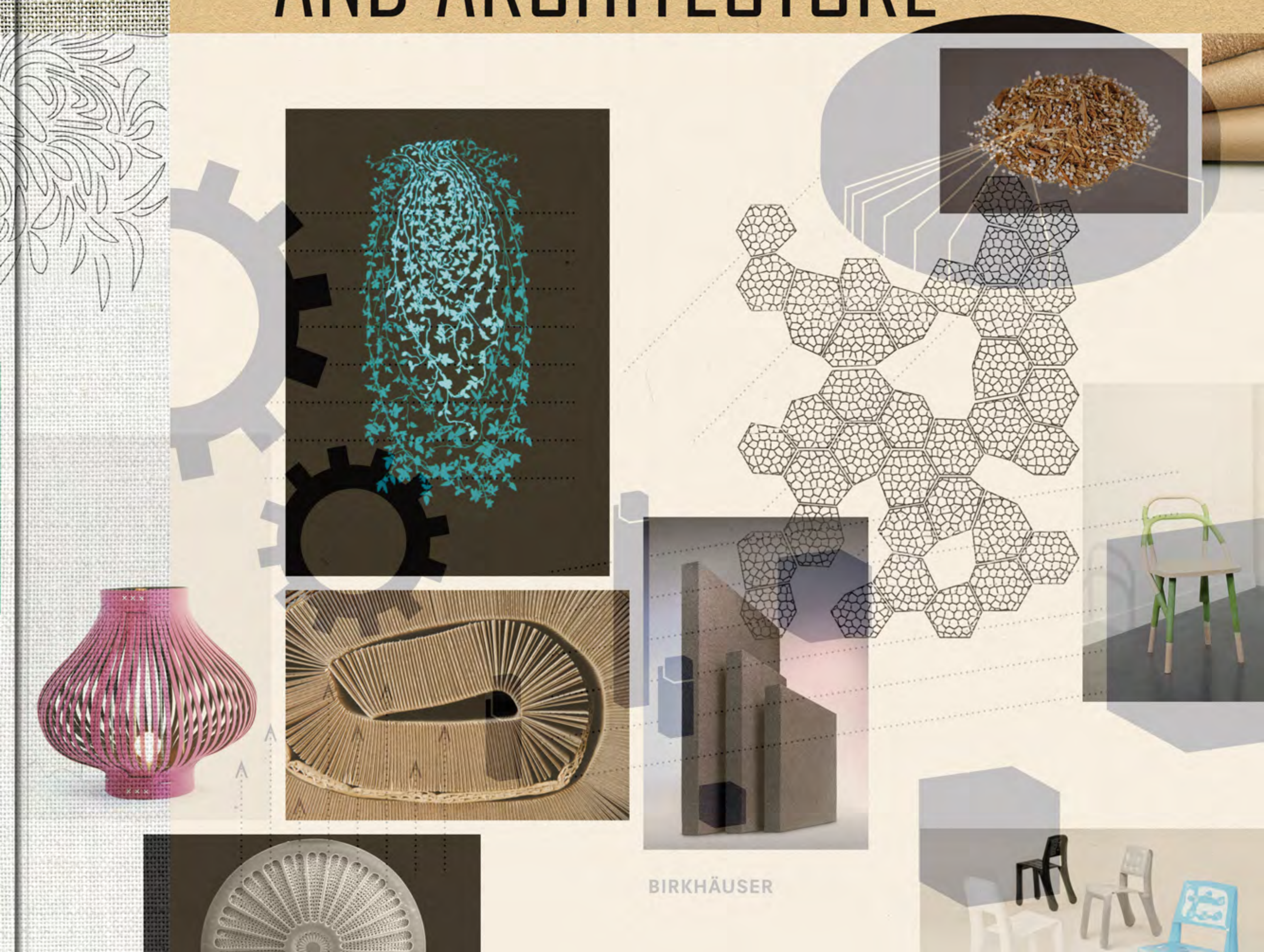
November 29, 2006
"Materialien und Fertigungsverfahren für Designer in der Automobilindustrie," Euromold 2006, Frankfurt/Main.

March 30, 2006
"Generative Verfahren im Design," talk at the RPZ symposium "Rapid Prototyping und Design," Speicher XI, Bremen.

SASCHA PETERS

MATERIAL REVOLUTION

SUSTAINABLE AND MULTI-PURPOSE MATERIALS FOR DESIGN AND ARCHITECTURE



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